ABUSIVE ADVERTISING: SCRUTINIZING SOCIALLY RELEVANT ALGORITHMS IN A BLACK BOX ANALYSIS TO EXAMINE THEIR IMPACT ON VULNERABLE PATIENT GROUPS IN THE HEALTH SECTOR

Master Thesis

by

Martin Reber

March 2, 2020

Technische Universität Kaiserslautern,
Department of Computer Science,
67653 Kaiserslautern,
Germany

Examiner: Prof. Dr. Katharina Zweig
Tobias Krafft
Eigenständigkeitserklärung

Hiermit versichere ich, dass ich die von mir vorgelegte Arbeit mit dem Thema Abusive Advertising: Scrutinizing socially relevant algorithms in a Black Box analysis to examine their impact on vulnerable patient groups in the health sector selbstständig verfasst habe, dass ich die verwendeten Quellen und Hilfsmittel vollständig angegeben habe und dass ich die Stellen der Arbeit - einschließlich Tabellen und Abbildungen -, die anderen Werken oder dem Internet im Wortlaut oder dem Sinn nach entnommen sind unter Angabe der Quelle als Entlehnung kenntlich gemacht habe.

Kaiserslautern, den 2.3.2020

[Signature]

Martin Reber
Abstract

The targeted direct-to-customer marketing of unapproved stem cell treatments by a questionable online industry is directed at vulnerable users who search the Internet in the hope of a cure. This behavior especially poses a threat to individuals who find themselves in hopeless and desperate phases in their lives. They might show low reluctance to try therapies that solely promise a cure but are not scientifically proven to do so. In the worst case, they suffer serious side-effects. Therefore, this thesis examines the display of advertisements of unapproved stem cell treatments for Parkinson’s Disease, Multiple Sclerosis, Diabetes on Google’s results page. The company announced a policy change in September 2019 that was meant to prohibit and ban the practices in question. However, there was evidence that those ads were still being delivered. A browser extension for Firefox and Chrome was developed and distributed to conduct a crowdsourced Black Box analysis. It was delivered to volunteers and virtual machines in Australia, Canada, the USA and the UK. Data on search results, advertisements and top stories was collected and analyzed. The results showed that there still is questionable advertising even though Google announced to purge it from its platform.
Zusammenfassung

Die Direktvermarktung von nicht zugelassenen Stammzellbehandlungen von der fragwürdigen Online-Industrie dahinter zielt auf Patienten, die das Internet in der Hoffnung auf Heilung durchsuchen. Dieses Verhalten stellt eine besondere Gefahr für Menschen dar, die sich in verzweifelten Phasen in ihrem Leben befinden. Sie könnten wenig Zurückhaltung zeigen, die beworbenen Therapien auszuprobieren, die zwar eine Heilung versprechen, diese aber nicht durch anerkannte klinische Tests belegen können. Im schlimmsten Fall erwarten die Patienten schwerwiegende Nebenwirkungen.

Daher untersucht diese Theis die oben genannten Werbeanzeigen auf der Ergebnisseite der Online-Suchmaschine Google nach einer Änderung der Plattformrichtlinien im September 2019. Besonders ging es dabei um Anzeigen bezüglich Behandlungen von Parkinson, Multipler Sklerose und Diabetes, die in den Verhaltensregeln ausdrücklich verboten wurden.

Browsererweiterungen für Firefox und Chrome wurden entwickelt und verteilt, um damit eine crowdsourced Black Box Analyse durchzuführen. Freiwillige Teilnehmer und virtuelle Maschinen in Australien, Kanada, den USA und Großbritannien wurden rekrutiert. Es wurden Daten zu Suchergebnissen, Werbung und Schlagzeilen auf der Ergebnisseite von Google gesammelt. Die Analyse derer ergab, dass es trotz des expliziten Verbots dieser Praktiken noch immer fragwürdige Werbung gab.
Contents

List of Figures vii

1. Introduction 1
   1.1. Motivation .............................................. 2
   1.2. Outline .................................................. 4

2. Fundamentals 5
   2.1. Information .............................................. 5
   2.2. Models .................................................... 6
   2.3. Socially Relevant Algorithms ......................... 7
      2.3.1. Algorithms .......................................... 7
      2.3.2. Social Relevance ................................... 9
   2.4. Communication ........................................ 11
      2.4.1. Shannon’s technical Model of Communication ...... 12
      2.4.2. Watzlawick’s psychological Communication Model . 13
      2.4.3. Context-oriented Communication Model ........... 14
   2.5. Socio-technical Systems ................................ 18
      2.5.1. Technical System ................................... 19
      2.5.2. Social System ....................................... 20
      2.5.3. Kienle and Kunau’s Socio-Technical System ...... 21
   2.6. Data Economy and advertising .......................... 22
      2.6.1. Web-tracking and data collection .................. 22
      2.6.2. Tracking protection .................................. 24
      2.6.3. Targeted advertising ................................. 24
   2.7. Integrated Search Engines: Google as an advertisement enabler 26
      2.7.1. Integrated Search Engines .......................... 27
      2.7.2. Web Advertisement ................................... 29
      2.7.3. Business Models ..................................... 30
      2.7.4. The Integrated Search Engine’s role as an intermediary 34
   2.8. Application to Web Search .............................. 37

3. Related Work 41
   3.1. Digitalized Health in the Realm of Stem-Cell-Tourism ...... 41
   3.2. Governance ............................................... 46
      3.2.1. The need for control .................................. 46
      3.2.2. Proposals of governance .............................. 48
      3.2.3. Challenges ............................................ 52
   3.3. Algorithm Accountability ................................. 53
      3.3.1. Transparency .......................................... 54
      3.3.2. Responsibility ......................................... 55
## List of Figures

1.1. Sample SERP before policy change I .......................... 3
1.2. Sample SERP before policy change II ......................... 4

2.1. Shannon’s Communication Model ............................... 12
2.2. Luhmann’s triple selection ..................................... 15
2.3. Kienle & Kunau’s Communication Model ....................... 16
2.4. Kienle’s sender activities ...................................... 17
2.5. Organic vs. sponsored search .................................. 29
2.6. Yuan et al.’s online ad ecosystem ............................ 31
2.7. Muthukrishan’s ad paths ....................................... 32
2.8. WSS communication processes ................................. 38
2.9. STS of web search and advertising .......................... 39

3.1. Lessig’s four forces ............................................ 50
3.2. Zweig’s Chain of Responsibility ............................... 58
3.3. Black Box Chain of Responsibility ........................... 63
3.4. Krafft’s Black Box Concept ................................... 64

4.1. Plugin-Server-Communication .................................. 72
4.2. EDD Registration .............................................. 74
4.3. EDD collection process ........................................ 75
4.4. Overview all studies ........................................... 76
4.5. Overview of PD studies ........................................ 77
4.6. Donations over time ............................................ 78
4.7. Daily donation distribution ..................................... 78
4.8. Donation events ................................................ 79
4.9. Donations by individual participant and cumulative submissions ........................................ 79
4.10. Histogram of donor’s donation distributions ............... 80
4.11. Advertiser histogram .......................................... 80
4.12. Top 20 advertisers ............................................. 83
4.13. Critical actors in host categories ............................ 84
4.14. Overview of donation statistics .............................. 85
4.15. Proportion of critical ads ...................................... 86
4.16. Critical ads by group .......................................... 87
4.17. Critical ads by keyword ....................................... 87
4.18. Typical examples for swissmedica advertisement creatives ........................................ 88
4.19. Keyword suggestions ........................................... 90
4.20. Krafft’s Black Box Concept .................................. 92
4.21. Security incidents ................................................ 94

A.1. On-bording Process ............................................. 136
List of Figures

A.2. Description of crawled elements ......................................... 140
B.1. Firefox plugin statistics ..................................................... 141
B.2. Daily chrome users ......................................................... 142
B.3. Cumulative Chrome registrations ......................................... 142
B.4. Donations by group ......................................................... 143
B.5. Absolute Number of advertisements per group ...................... 143
B.6. Fraction of Prescription Treatment Advertisements per group . 144
1. Introduction

Digitalization has changed mankind in many ways. One technology that has grown to be indispensable is the search engine. They serve as an entry point to the WWW separating the websites most relevant to a user from noise. Most search engines provide their service to Internet users at no monetary cost. They finance their operation through advertisements (or short: ads) displayed along with search results on the search engine’s result page (SERP). They call this sponsored or affiliated search. These integrated search engines (ISEs) combine search utility with the capabilities of an advertising exchange and thus connect advertisers, content providers and searchers. However, most ISEs are privately operated Internet platforms. They rose to be powerful intermediaries that take the role of algorithmic gatekeepers. Not only do they control the flow of communication between users and content providers. On their platform, they also organize ad distribution and direct attention. Concurrently, they get to retain transaction data of all involved participants, e.g. user data, website content, ad efficacy, conversion costs of businesses.

In some domains, misconfiguration of algorithms has only minor consequences, like irrelevant search results or dysfunctional technical components. When it comes to medicine and health though, digitalization is probably going to have the “most immediate and profound personal and social consequences” (Petersen, Tanner, et al., 2019, p.368). ISEs and their advertising partners combine various personal data to explore “the most intimate aspects of our selves” (Petersen, Tanner, et al., 2019, p.368). In the realm of health, they can have immediate effect on the well-being of citizens and their surroundings.

Although society is heavily affected by privately-operated Internet-based platforms it cannot assess the functionality and safety of those software systems. A Guardian journalist describes this situation as “operating on blind, ignorant, misplaced trust” (Goldacre, 2014) and adds that choices in algorithm design are generally being made without citizens noticing. To counter-balance problematic and business-driven development of algorithms, the concept of “algorithmic accountability” arose. It describes the aspiration to scrutinize the mechanisms of opaque algorithms and understand how and why they produce a certain output. It also demands for institutions to be held responsible for the algorithms they produce (USACM, 2017). This can be achieved with means like the Black Box analysis portrayed in this thesis. In this context, a Black Box denotes an “opaque technical device of which only the inputs and outputs are known” (Bucher, 2016, p. 83).
1.1. Motivation

The motivation of this project has come from the work of Anna Couturier who holds the dual role of PhD researcher in Science, Technology and Innovation Studies at the University of Edinburgh and Digital Manager at EuroStemCell. In this secondary role, she has observed the impact of targeted advertisement and Google as an intermediary on inquiries made to the EuroStemCell project by patients and carers looking for information about stem cell treatments and serious conditions and diseases online. This master’s thesis contributes to a deeper analysis of stem cell treatments and digital health information as part of a collaboration between the University of Edinburgh and the Algorithm Accountability Lab (AALAB). At the project’s completion, the findings will be handed over to a number of patient organizations including the Anne Rowling Clinic, Parkinson’s UK, the Centre for Regenerative Medicine and EuroStemCell fosters an interdisciplinary network of scientists and patient groups to research and communicate the subjects surrounding stem cells. They fill the role as a professional medical organization to “counteract the uncontrolled and premature commercialization of stem cell interventions.” (Weiss et al., 2018). From these tight partnerships (and academic literature alike), evidence arose that patients diagnosed with Parkinson’s Disease or Multiple Sclerosis were exposed to questionable advertisement when searching the web on Google. They were questionable and problematic in a sense that they advertised scientifically unproven stem cell treatments (SCT) (Enserink, 2006; ISSCR, 2019) to affected Internet users that might be looking for a cure to their disease. Figure 1.2 shows examples of problematic ads. The motivation of this thesis was to examine whether vulnerable user groups (patients of severe diseases) were specifically targeted by advertisement on the Google search engine result page (SERP). This research would have been especially concerned with the promotion of unproven stem cell treatments for Parkinson’s disease, Multiple Sclerosis and Diabetes (Type I and II) on Google’s web search platform. This is important as the presumably targeted users represent a vulnerable group whose exploitation can have severe consequences. We picked Google because it is a popular integrated search engine (ISE) with large market share (Ratcliff, 2019). Most

---

1 EuroStemCell is an organization dedicated to educate European citizens about stem cells (Website: https://www.Eurostemcell.org/about-EuroStemCell)
2 Website: https://www.ed.ac.uk/
3 The AALAB strives to establish ethics in programming, especially in socially sensitive applications, automated decision making systems (ADMs) and artificial intelligence (AI)
4 Website: https://www.annerowlingclinic.org/ https://www.parkinsons.org.uk/ www.crm.ed.ac.uk http://www.stemcellsaustralia.edu.au/
5 To my knowledge, stem cell-related treatments are only clinically tested and empirically proved to be helpful for diseases concerning the blood and immune system with advances in the area of skin and cornea (eye) (Eurostemcell, 2020b; Food and Drug Administration, 2019). Thus, in this thesis, by “questionable SCT” I denote those treatments that use stem cell-related practices that are NOT yet approved by medical authorities. These questionable procedures are not yet approved and possibly dangerous.
1.1. Motivation

Figure 1.1.: Sample screenshots of advertisements presented at a typical Google search result page (SERP) (30.9.2019) before the policy change, courtesy of Anna Couturier

Figure 1.2.: Single ad of questionable stem cell treatment provider (30.9.2019) before the policy change, courtesy of Anna Couturier
importantly, anecdotal evidence suggested that the problematic phenomena appeared on Google, which supposedly handles promotion of unproven treatments very strictly according to their advertising policy. They claim to ban all ads concerned with speculative and experimental medical treatments, specifically including stem cell therapy (Biddings, 2019b; Google, 2019n).

This thesis presents a browser plugin associated with a client-server software system to crawl the Google SERP and store results, ads and top stories in a database for further analysis. The goal was to find out whether the problematic advertisements were still being delivered over Google’s ISE. Google’s announcement to implement adaptive measures from the beginning of October 2019 pressured this project to engineer a lightweight, flexible and practical solution on the fast track. Thus, many potentials for improvement could not be considered (see Section 4.3).

A qualitative analysis of advertisements on Google’s SERP is presented and a general assessment of the Black Box approach is conducted. The analyses showed that there still is questionable advertising of unapproved SCT practices. Furthermore, they showed that a variety of actors compete for attention in the advertising ecosystem surrounding SCT.

The assessment of our Black Box approach produced interesting insights for future work concerning methodology and requirements of such analyses.

1.2. Outline

Chapter 2 introduces fundamentals that are required to follow the reasoning in this work. In Section 2.1 and 2.2 the notions of information and modelling are explored. Section 2.3.1 discusses algorithms in general to deduce how ISEs operate and whether a programming artifact can be responsible for its outcomes. Systems theory will be explored to draw models of communication and the socio-technical system of web-search in Section 2.4 and Section 2.5, respectively. Because this thesis elaborates on the workings of Integrated Search Engines and web-advertisement, Sections 2.6 and 2.7 elaborate on the respective topics. Then the socio-technical system will be applied to web search to explain the interactions of ISEs and their users in Section 2.8.

In the second part, Chapter 3 describes the context in which this work was embedded and examines the notion of digitalized health in Section 3.1. Section 3.3 further discusses how algorithms can be assessed regarding their accountability. The chapter closes with a closer look at Black Box analysis as means to analyze undisclosed algorithms in information systems (Section 3.4) and approaches to their governance (Section 3.2). Finally, Chapter 4 describes the EuroStemCell Data Donation that took place in 2019. Its goal was to verify the impact of policy changes Google initiated after anecdotal evidence about ads on unproved therapies arose.9

9see (Biddings, 2019b) for Google’s announcement.
2. Fundamentals

This chapter describes the required key concepts on which the following parts of this thesis are based on. Because the conceptions of these terms differ greatly depending on the domain, there is a need to define and contrast some of them. First, this thesis describes multidimensionality of information in Section 2.1. Then, it will be situated in the communication process in Section 2.4. This lays foundations for the introduction of socially relevant algorithms in Section 2.3.1. It makes use of several examples to show the considerable impact of these artifacts of information technology on our society. Based on this, technical and social systems and ultimately, the socio-technical system are referenced in Section 2.5. The derivation of the concept of socio-technical system is based on (Kienle & Kunau, 2014). To illustrate how the theoretical model of socio-technical systems finds its real-world application in Section 2.8, the advertising ecosystem as well as integrated search engines are reviewed in Section 2.6 and Section 2.7 respectively.

2.1. Information

Information is defined as meaningful part of a message or a set of symbols (Meadow & Yuan, 1997). This distinguishes it from data, which has “little or no meaning to a recipient” (Meadow & Yuan, 1997, p.701) and underlines how the notion of information is strongly dependent on the recipient’s context. In (Meadow & Yuan, 1997), Meadow and Yuan claim that there cannot be information overload through too much data. They argue that data is only considered informative if it was received and comprehended. They also require it to ultimately change the knowledge state of the recipient.

This reflects a search engine’s capability to crawl the web (composed of data) and extract only those webpages that it deems worthy to present to a user (information). The users on the other hand perceive the results as potential information and subjectively judge which data gets their attention. Meadow assumes recipients determine relevance regarding understandability, redundancy and alignment with subjective beliefs (Meadow & Yuan, 1997). Madden lists geographical, cultural and social as well as educational and professional (area of interest and level of experience) factors(Madden, 2000) that

---

1From German: “Derjenige Anteil einer Nachricht, der für den Empfänger einen Wert besitzt” (Siepermann, Markus, Lackes, Richard et al., 2019)

2“Knowledge is the accumulation and integration of information received and processed by a recipient” (Meadow & Yuan, 1997, p. 701)

3Meadow offers three interpretations of data, one of which explains it as “set of symbols in which the individual symbols have potential for meaning but may not be meaningful to a given recipient” (Meadow & Yuan, 1997, p. 704).
contribute to perceived relevance.

However, this thesis follows Belkin’s argumentation in (Belkin, 1978) concerning the usefulness of a definition of information. He argues that by dropping the compulsion to define, one is enabled to choose a useful interpretation that caters ones needs. Consequently, he suggests accepting diverse concepts as a way of looking at a phenomenon rather than squeezing all applications into one definition. Hence, the following paragraph depicts how scholars summarize the conceptualizations of information. According to McCreadie and Rice (McCreadi & Rice, 1999), information can be:

- **Representation of knowledge:** Information stored on a medium (e.g. a website or a database),
- **Data in an environment:** signals obtained from the environment, including unintentional communication,
- **Resource or commodity:** “A message, a commodity, something that can be produced, purchased, replicated, distributed, sold, traded, manipulated, passed along, controlled” (McCreadi & Rice, 1999, p.47),
- **Part of process of communication:** Assumes meaning originates from people, not from words, hence context plays an important role.

The concepts above help to describe the manifold manifestations of transmitted information in the communication processes of the socio-technical system. This thesis is mainly concerned with information as part of a process of communication\(^4\). The suggestive nature of SCT-related advertising only unfolds in the context of patients or carers desperately searching for support. The informational character of the promotional message arises from the subjective relevance for users affected by a medical condition. The following section deals with the specifics of communication and Section 2.8 relates the methodology of information concepts to the web search and advertising context.

### 2.2. Models

In the following, Weisberg’s elaborations on modeling in (Weisberg, 2013) are described. This is required to understand the premises on which the following models are constructed on. He distinguishes physical, mathematical and computational models. They are “potential representations of a target system” (Weisberg, 2013, p. 171) that differ in their representational capability. Each model consists of a structure and its construal (interpretation). The latter defines the assignments of real entities to structural elements and the intended scope. The scope limits the model’s expressiveness to some specific

\(^4\)However, all other forms are present as well. The creative of ads constitutes a representation of knowledge, be it legitimate or questionable. Data in the environment of the human-computer interaction are constantly being extracted through tracking and exploited by analysis services. Usage data and user profiles are regularly traded as a commodity at low per-unit prices(see Section 2.6).
2.3. Socially Relevant Algorithms

aspects of a phenomenon. Finally, the fidelity criteria describe the standards by which a model’s representational qualities can be judged. However, this work only presents descriptions of models. They are distinct from the models themselves and from the target system. The target system is constructed by the modeler through abstraction of a real-world phenomenon. This abstraction intentionally reduces complexity while preserving similarity with respect to a certain subject of interest. It does so by reducing it to the most relevant aspects.

Due to vagueness or ignorance, these descriptions may specify more than one distinct model or a family of models (Weisberg, 2013, p. 172). This is important to acknowledge, because the web search and advertising ecosystem is a highly complex and opaque agglomeration of a multitude of actors. Thus, a modeler must find a balance between simplification and explanatory power of a model.

2.3. Socially Relevant Algorithms

This thesis highlights the importance to scrutinize Socially Relevant Algorithms (SRAs) like the ones deployed in web search and advertising systems. It is required to understand the basic categories of algorithms and how they can express bias.

2.3.1. Algorithms

Integrated search engines like Google’s platform are operated by algorithms. By integrated search engine we denote an information system that combines search engine and ad exchange. An information system consists of humans and machines that create information and who are interrelated through communication processes which generally describes a computer-assisted system designed for a special purpose (Gabriel, 2016). Zwass for example describes it as “an integrated set of components for collecting, storing, and processing data and for providing information, knowledge, and digital products” (Zwass, 2016).

An algorithm is a finite set of rules that yield a sequence of well-defined instructions which need to be followed to solve a class of problems or produce a distinct outcome from an input in finite time (Introna, 2016; Knuth, 1968). It consists of a logic component that describes the domain-specific problem and

---

5Even though I present the “models” of communication and socio-technical systems I am aware that they are rather models’ descriptions than a model themselves. However, I use the term “model” to refer to their respective descriptions for the sake of readability.
6For a detailed description, see Section 2.7.2 for web advertisement and Appendix C for search engines, respectively.
7Knuth also lists effectiveness as an equally important future. However, he deems an algorithm effective when it can be fulfilled by a human using pen and paper only. A definition that does not realistically hold with today’s advanced algorithms. Another notable fact is that Knuth means reasonable duration, when he speaks of finite time. Acceptable running times for algorithms naturally are a moving target due to technological advancement.
data structures and a control component dedicated to the problem-solving strategy (Kowalski, 1979). This allows to separate the efficiency-centered control from the functional logic. The latter is solely concerned with functional aspects. For example, to ask the right question, modeling a suitable representation, use appropriate data and find an adequate solution. This work addresses the logic components of ISEs and examines it all along the development axis. This is where companies and developers make conscious decisions about how an algorithms is designed and how outcomes are computed.

Algorithms can be arbitrarily complicated. They range from simple algebraic calculations via computational heuristics to applications of artificial intelligence (AI)\footnote{The interest of AI is in “the synthesis and analysis of computational agents that act intelligently” (D. L. Poole & Mackworth, 2010). Some scholars prefer the term computational intelligence to emphasize that the agency is based on computation (D. Poole et al., 1998).}. Trivial algorithms dedicated to simple algebraic calculations, sorting or other unsophisticated operations are not deemed socially relevant. Only if their outcomes have repercussions on individual humans or society as a whole, their actions must be evaluated from a societal perspective. Admittedly, this is a fuzzy distinction as socially relevant algorithms can be composed of other trivial algorithms. Additionally, the above description strongly depends on the deployment context. Nevertheless, several algorithm classes are at risk to discriminate those affected (even unintentionally through their respective choice of criteria, training data, semantics, and interpretation (Diakopoulos, 2013a)). Discrimination can occur through an advertiser’s malicious intent, the targeting process or the targeted audience (the eventual outcome) (Speicher et al., 2018). This can make users subject to bias, manipulation, constrained freedom, surveillance, discrimination, commercial or political influence, or loss of sovereignty (Gillespie, 2014; Saurwein et al., 2017). They are distinguished by (World Wide Web Foundation, 2017) according to the way they process information. Below, the categories are listed along with the respective pitfalls.

**Prioritization** Rank or score entities based on certain characteristics. The choice of these characteristics and the underlying values and norms have immediate impact on the order of results which could falsify the original intention.

**Classification** Categorize an entity and assign it to a group due to its features. A faulty classifier might wrongfully label an entity with severe consequences.

**Association** Establish relationships between entities. They are deduced semantically, through similarity or connotation, thus not necessarily reasonable or real.

**Filtering** Exercising choice about what to consider relevant, possibly without revealing the criteria this decision is based on and applying possibly biased filters.
According to (D. L. Poole & Mackworth, 2010), algorithms are agents because they act in an environment. Going by Max Weber’s definition, to act means internal or external “doing” that is premised on subjective purpose or deliberate intention (Arbeitsgruppe Soziologie, 1978).

Algorithms that power Internet-based platforms like Google’s platform fulfill Poole’s requirements to be intelligent agents (D. L. Poole & Mackworth, 2010) which are derived from Turing’s approach to intelligence in (Turing, 2009). His notion explains intelligence by behavior. Following Skinner, behavior is any externally observable action (or doing) by an organism if it happens with reference to its environment (Skinner, 1938). Baum notes how behavior is generally aimed at a goal and a result of deliberate choice of actions that considers future consequences (Baum, 2013). Because actions are intended behavior (Kienle & Kunau, 2014), inanimate entities like algorithms are capable to behave within the boundaries of their defined actions. On top of that, technical components and the repercussions of their actions affect both social and technical entities in the socio-technical system. Thus, they have a strong relational aspect when they facilitate communication processes (see Section 2.5). Thus, they can be seen as agents of collective agency (in Section 2.3.1). This explains why Google’s platform qualifies as intelligent agent by fulfilling Poole’s requirements (D. L. Poole & Mackworth, 2010). It emphasizes the capability of their algorithms to act appropriately with respect to circumstance and goal. Furthermore, the intelligent algorithmic actors is flexible pertaining to resources (computational space and time) and learning experiences.

The paragraphs above explained how ISE’s algorithms construct an information system that is designed for a certain purpose and to interact with humans through distinct technical components or computational artifacts, namely algorithms. Introna claims that “[a]lgorithmic action has become a significant form of action (actor) in contemporary society” (Introna, 2016, p. 37).

In Section 3.3 algorithms and particularly those that act intelligently are described as agents that are able to perform self-sufficiently in their environment. Nonetheless, they cannot be perceived as self-sufficient moral agents of their doing. They can be judged by the decisions that were made along the chain of instructions and the output they generate which constitutes their actions.

2.3.2. Social Relevance

Socially Relevant Algorithms constitute the technical components in socio-technical systems (STS, see Section 2.5). They have a significant impact on a social system and can mostly be found in human-computer interaction, for example, when a human searches the World Wide Web (WWW) using a search

---

9Herein, the terms agent and actor are used interchangeably to describe subjects or entities that act.
10Unfortunately, this does not allow to observe and scrutinize technical components by their behavior as they are not alive in the original sense. Nonetheless, a technical system can be seen as an (non-biological) organism that is comprised of different organs (its components) and pursues a certain goal.
engine and is computationally targeted with advertising. Here, human and 
computer engage in mutual communication. The idea to evaluate algorithms 
as part of a greater system is a perspective that expands the boundaries of 
computer science beyond the realms of bare construction of computers and 
algorithms design. It addresses accountability and responsibility concerning 
the development, implementation and use of algorithms that play a significant 
role in socio-technical systems. It addresses long-term effects and emergent 
behavior as well as a wider scope of stakeholders. Sometimes, the outcomes 
of these algorithms are accompanied by discrimination, induce manipulation 
or express other unwanted side-effects. Basically, all classes of algorithms as 
denoted in Section 2.3.1 can suffer from biases. Below, SRAs are listed that 
showed significant impact on either individuals or society, some problematic 
or at least questionable others merely thought-provoking.11

- Scoring credit risk (Citron & Pasquale, 2014), recidivism (Larson et al., 
2016) and social behavior (Kühreich, 2017; Stanley, 2015)
- Nation-wide face recognition (Chen, 2017) and predictive policing (Pe-
teranderl, 2017)
- Fake News (Albright, 2017) and emotional manipulation in social net-
works (Kramer et al., 2014)
- Racial ad delivery (Angwin & Parris Jr., 2016; Sweeney, 2013) and sexist 
recruitment (Reuters, 2018)
- Home automation (Peterson, 2020) and automotive software (Gelles et 
al., 2015; Koscher et al., 2010)
- Dubious autoplay feeds (Maheshwari, 2017; Max Fisher & Amanda 
Taub, 2019a, 2019b)
- Art performances (Weckert, 2020)

Another critical application domain is the search engine. Search engines act 
as the entry portal to the WWW, creating comprehensiveness in humongous 
mass of websites out there and satisfy users’ information need. Users confi-
dently trust a search engine to answer their query and rank results by true 
relevance (Pan et al., 2007). They allow an algorithm to deem some infor-
mation more worthy than other. Thus, researchers claim that search engines 
have the power to shape public opinion (Zittrain, 2014), disseminate conspir-
acy theories (Ballatore, 2015), redefine history (Grimmelmann, 2008), perpet-
uate negative stereotypes (Baker & Potts, 2013; Kay et al., 2015), manipulate 

11 This list intends to give a rough overview of SRAs to demonstrate their widespread ap-
lication in all sorts of domains of everyday live. The compilation includes scientific as 
well as journalistic sources and is in no means exhaustive.
12 This study was widely criticized by popular media (Chambers, 2014; Grohol, 2018) and 
academia alike (Jouki et al., 2016; Shaw, 2016) for including uninformed participants 
on a large scale and basing marginal findings on antique research methods.
13 Weckert created a virtual traffic jam on Google Maps by pulling a wagon full of cell phones 
down an empty road.
2.4. Communication

An attempt to describe these effects is made by Gillespie in (Gillespie, 2014). He distinguishes six dimensions of algorithmic impact on society. Patterns of inclusion, the evaluation of relevance and the promise of algorithmic objectivity all relate to the functionality of search engines as an unbiased information provider that delivers relevant answers from an objective selection of knowledge to users. The cycles of anticipation, entanglement with practice and production of calculated publics describes how algorithms analyze and target users and how these inferences and the users’ respective expectations rebound to society. Further down, we will see how the practices of integrated search engines like Google are subject to all of them.

These alarming consequences are not necessarily intended by their developers but usually emerge as unwanted side effects, unexpectedly and through interaction with society. Algorithms may indirectly disadvantage users in ways that are not necessarily illegal or intended by their developers. Once they exercise socially problematic behavior, they should be scrutinized by the public (Sandvig et al., 2014).

This thesis defines Socially Relevant Algorithms as algorithms that have an immediate effect on a social system through their close coupling with social processes (communication). They are part of a socio-technical system where they constitute the technical part.

2.4. Communication

To examine the characteristics of interaction between humans and computers, this chapter contemplates different models of communication.

In the course of years, several models have gained popularity. This chapter discusses three popular models of interaction to describe the interactions in the process of communication between a human and a technical agent. First, both extremes of the human-computer spectrum will be explored. Shannon’s model of tech-focused communication in the context of electrical communication engineering is to be contrasted with Watzlawick’s approach of human psychology. Lastly, a context-conscious model by Kienle will be evaluated. The comparison should illustrate why the subject of human-computer interaction present in web search and advertising requires a specific approach to communication. In order to fully explain the nature of the web search and advertising ecosystem, any arbitrary model might be insufficient. Consequently, an appropriate model must be able to reflect the system’s properties and

---

14 Although (Epstein & Robertson, 2013, 2015) are widely referenced, the studies are equally harsh criticized due to their miscalculations, exaggeration and sensational claims, for example in (Algorithm Watch, 2017).

15 See Section 2.5.

16 Watzlawick et al. define interaction as mutual exchange of messages between two or more persons (Watzlawick et al., 2007).
Chapter 2: Fundamentals

means of interaction. The following critique is mainly based on (Kienle & Kunau, 2014) with specific examples by the author of this thesis to illustrate the inapplicability or fitness of the respective model’s characteristics to web search.

2.4.1. Shannon’s technical Model of Communication

Figure 2.1.: Schematic diagram of a general communication system, illustration from (Shannon, 1948, p. 381)

Figure 2.1 shows a communication model dedicated to describing the exchange of information between two partners via telegraph or any wired connection. A source submits a message to a transmitter that encodes the message and sends a signal on a channel. During transmission, it may be affected by a noise source. The possibly corrupted message is then received and decoded by a receiver, which typically applies the inverse function of that done by the transmitter. After reconstructing the original message, it is delivered to its destination. (Shannon, 1948)

This model falls short of many aspects that are essential for human-computer interaction in web search. (Kienle & Kunau, 2014) enumerates the following shortcomings that are then adapted to the web search context. First, Shannon reduces the content of the message to its syntax only. The value of received information only depends on not-yet transmitted signals. The more of a message has been received, the lower is the informational value of residual signals. This is a wrong assumption in the context of web search. Even though searchers may have reviewed numerous results, the single most relevant result or advertisement that they eventually accept has higher informational value than the preceding signals. Shannon further assumes that all messages are equivalently important for all destinations. This falls short of describing a web search scenario, where searchers have a unique background or context and expect a custom answer for a specific question. Users only consider the subjective value of advertisements and search results. Nonetheless, in this thesis the notion of sender, message and receiver is retained to describe the agent who initiates the communication, the transferred information and the addressed person.

17Herein, the partners denote agents involved in mutual communication.
2.4.2. Watzlawick’s psychological Communication Model

Other models emphasize inter-human communication and add an empathic aspect. Watzlawick et al. present their psychological approach in (Watzlawick et al., 2007). His model is concerned with two human communication partners that are situated in vicinity to each other (possibly in one room). He interprets the entirety of behavior as means to transmit a multipartite message. The model is strictly restricted to observable actions and its trajectory depends on the subjective interpretation of the course of actions.

Watzlawick et al. formulated five axioms based on their experience as therapists in (Watzlawick et al., 2007, pp. 53–70). Below, they are enumerated and subject to discussion with respect to their applicability to the human-computer interaction of web search.

1. **Axiom** Non-communication is impossible.

2. **Axiom** All communication includes a content and a relational aspect such that the latter determines the former, which forms a meta-communication.

3. **Axiom** The nature of a relationship is determined by the succession of communication perceived by the parties or their interpunction thereof.

4. **Axiom** Human communication utilizes analogue and digital modes.

5. **Axiom** Course of inter-human communication is either symmetrical or complementary.

For the first axiom to hold, Watzlawick presumes the analogous human communicators to be in one room. Obviously, this cannot be guaranteed with Internet-based service. Furthermore, remote communication offers many ways to not communicate, most of which pertain to not initiating a communication process online (not sending a message, not clicking a button). Through the technical communication channel (the Internet), the intention of non-communication remains shrouded and cannot be evaluated unlike other than with a passive agent in human-to-human interaction.

As to the second axiom, Determining a relationship between conversational partners over Internet-based services is difficult. Internet intermediaries such as platforms, search engines and ad exchanges complicate finding the true source of information. Imbalance of power over the communication channel (which is dictated by the platform) and a disparate state of knowledge about the respective partner usually leave users in the dark about the workings of the communication and the intentions of their counterpart.

With respect to static websites like most search engine result pages, the third axiom cannot be applied, too. Usually Internet-based services respond to user queries, the interchange accurately logged in files of the web server. There is no ambiguity to the course of communication. Users often perceive the Internet-based service’s response to a user query, as a direct answer. However,

---

18 Translated from German from (Watzlawick et al., 2007, pp. 53–70)
the user query alone is not the only input to a search engine for example. Its algorithm organizes a plethora of information about the user and leverages background information in a way that the users can never be sure, when their communication with the platform provider actually started. As most users are unaware of the unobtrusive and constant tracking, testing and adapting of web-services, they are also ignorant about the entirety of exchanges in a communication.

The depiction of analogue modes of communication as non-verbal can be sustained as claimed in the fourth axiom. However, gestures and facial expressions do no (yet) play a role in web search. Instead, background information in the form of data about a user and knowledge about context influence the communication. Kienle and Kunau note that this can explain reduced communicative capability of interacting with and via technical systems (Kienle & Kunau, 2014, p. 59). Watzlawick argues that especially in human-computer interaction, it is important to provide meta-information along with a message so the communication partners can negotiate their relationship and the interpretation of the message (Watzlawick et al., 2007, p. 55).

Interestingly, the last axiom allows a two-tiered interpretation. At first, the role of interrogator (users) and respondent (search engine) are very clear and fulfill the requirements of complementary communication with mutual reinforcements of this distinct relationship. Nonetheless, one could see the search engine providers’ learning strategies as a symmetrical approach to the question-answer-dialog. By learning more about the users, their intentions and the context in which a query is formulated, there is a notion of reciprocal learning, though on different levels and orchestrated with a distinct intention. The users’ learning is objective-oriented with respect to their information need, the focus of the search engine’s learning however is subject-based and on the users and its own means to serve them. In conclusion, even though this model is well suited to illustrate direct human communication, yet again it cannot be applied to human-computer communication without flaws.

### 2.4.3. Context-oriented Communication Model

The context-oriented communication model by Kienle (Kienle, 2003, pp. 22–27) depicts communication differently. It is no longer an unidirectional automatic process pushing a message from a sender to a receiver. Now, all involved parties are responsible for a common understanding (H. H. Clark & Brennan, 1991). Kienle adds that, the involved parties mutually refer to or react to each other’s messages (Kienle, 2003, p. 17). It is based on the notion of social action by Luhmann. He describes it as action whose intention includes the supposed or expected attitudes of other people who are involved in the communication (Arbeitsgruppe Soziologie, 1978, p. 129). Kienle calls these assumptions context and assigns to it the part of an environment that affects individuals’ actions during interaction and facilitates mutual understanding (Kienle, 2003, p. 22). Kienle’s model interchangeably assigns the roles of sender and receiver to the communication partners. Her model allows for switched positions and for technical entities to participate as long as they can fulfill the tasks involved.
2.4. Communication

Figure 2.2.: Luhmann’s triple selection in social actions, from (Kienle & Kunau, 2014, p. 71)

Luhmann derives his model from the idea that humans can only cope with complexity through selection (Luhmann, 1984, p. 48). Thus, he proposes a communication process that passes through several selections (see Figure 2.2). First, the information to be communicated is selected among many alternatives, secondly the form of transmission is chosen (the kind of message), then the recipient evaluates how to understand the message. Eventually, the persons addressed select how the new “information difference” affects their behavior (Luhmann, 1984, 194ff). We see these steps in web search as well. A search engine selects only a fraction of available information and specifically chooses a personalized subset thereof to answer the users’ queries. Then, the results are presented in the most meaningful way. Based on their subjective assessment, users accept a relevant result, reformulate queries or reject the output, exhibiting a degree of satisfaction. Finally, they may or may not act by clicking on an organic or paid search result.

In Kienle’s model in (Kienle, 2003) and (Kienle & Kunau, 2014), these selections also take place, though they are influenced by internal and external context of the agents. According to her, internal context includes knowledge, emotions and assumptions (especially about the partner).

While the internal context is invisible for the counterpart, the external context is shared. It is based on common perceptions and experiences, as well as mutual beliefs. Extra-communicational behavior is adapted to the context and enriches the verbal (direct) communication. In this model, context has a significant function.

First, shared context supports success monitoring with respect to the intended outcome of the communication.

Second, the explicit message can omit information that can be inferred from context. In the end, a consistent inner context about the counterpart’s attitude and common belief or shared assumptions about an outer context are the premises for successful communication.

The development of search engine capabilities featured in Appendix C ex-
Figure 2.3.: Context-oriented communication model (Kontext-orientiertes Kommunikationsmodell), from [Kienle, 2003, S. 35]
2.4. Communication

(a) Face-to-face situation (Kienle, 2003, p. 37)

(b) Computer-mediated situation (Kienle, 2003, p. 44)

Figure 2.4.: Sender activities in the context-oriented communication model, from (Kienle, 2003)

hibit a tendency of to concentrate on user intent and context. Apparently, the ambiguity of textual queries degrades the result quality like verbal-only communication without contextual knowledge. Thus, it is vital for a technical agent to identify the respective human’s context, attitudes and intentions to fully grasp the nature of the communication and answer accordingly. Both the inner and the outer context are explored through data-supported user modeling and predictive analysis.

Kienle’s consideration of the sender’s activities is especially interesting regarding web search. In the face-to-face situation depicted in Figure 2.4a, many of the activities listed can be effortlessly applied to ISEs. They try to evaluate and estimate a searcher’s background, intentions and knowledge through profiling and computational models (see Appendix C and Section 2.6). ISEs also exclude irrelevant advertisements and search results through selection and personalized ranking on the ad exchange. Then the algorithms determine appropriate descriptions and provide different forms of presentation through Knowledge Graphs and infoboxes. After that, they steer attention through a structured search result page and ads on the bottom or top of the SERP.

Finally, an ISE validates success with click-through analysis (L. Granka et al., 2004; Joachims et al., 2007). They only fail at making context deducible. The context-attributes used in the selection and delivery process remain undisclosed. Thus, a receiver might find a message relevant and useful. But users can never fully grasp why a subset of ads or results is shown. Nowadays, ISEs make this context explicit, at least pertaining to advertisements when they give reasons as to why an advertisement was shown. Google gives users some information on why they see a certain ad. Naturally, these explanations are only vague (Google, 2020d).

With a computational agent as an intermediary, the communication process

\[\text{See Appendix C for an introduction to both}\]
changes. A technical system transmits the message, reducing the choices available in the selection of medium (see the second step in Luhmann’s three-fold selection, Figure 2.2). The communication situation cannot be immediately experienced since there is usually a significant distance between sender and receiver. Context blurs or perishes making interaction more tedious. Now, communication partners must consider the limited means of expression. Extra-communicative behavior can no longer be directly observed, and the partners cannot necessarily assume a shared context. Thus, context information has to be made explicit if it contains useful information for a recipient. This entails a change in senders’ activities, as seen in the transformation from Figure 2.4a to Figure 2.4b. In computer-mediated communication instead of implicitly referring to context, context has to be made explicit to a degree that it supports the sender’s intentions and the receiver’s ability to understand and accept information. Kienle supposes to use different illustrations and cues to facilitate comprehension. (Kienle, 2003) (Kienle & Kunau, 2014)

Based on the argumentation above, this thesis understands communication as Kienle defines it and illustrates it in her model: Interaction encoded in symbols, regarding the mutual context. We need this extended perspective on communication to comprehend the interaction between users, advertisers and integrated search engines. Below, the nature of the communication’s content is discussed, and Section 2.7 explains how search engines achieve context awareness without engaging in face-to-face communication.

2.5. Socio-technical Systems

The notion of socio-technical systems represents the idea that social, psychological and technical factors can be tightly connected in a way that they can only be understood in combination as an integrated whole (Kienle & Kunau, 2014, p.81). It originated from a very analogue mining context (Trist & Bamforth K.W., 1954) and was applied to modern software engineering (Sommerville, 2016) using the systems theory below. In the discipline of informatics or computer science this change of mind emphasizes, that not only the design and implementation of algorithms should be of concern, but also their impact on individuals and society as a whole. It is reflected by the constantly changing efforts of the discipline to self-define. Coy shows how the trajectory of definitions changes over the years and shows how there is a growing conscience for applications and implications of algorithms (Coy, 2013). Coy quotes Wilfried Brauer twice over a decade, showing the scope of informatics grew from data processing by means of digital computers towards “theory,
2.5. Socio-technical Systems

methodology, analysis and construction, application (and) consequences of deployment” (Coy, 2013, p.489).

Kneer and Nassehi define a system as “the entirety of a set of entities and their mutual relations” (Kneer & Nassehi, 1993, p.25). Anything not included in a system’s definition is called environment (Kienle & Kunau, 2014). Sommerville extends this definition with a purpose the system is dedicated to. From his Software Engineering perspective, he adds that the components of a system cooperate to deliver a set of services to a user (Sommerville, 2016, p.556).

2.5.1. Technical System

Following the definition above, technical systems consist of interrelated technical components. They constitute the entities. Luhmann describes those components as coupling of causal elements (Luhmann, 2000, p. 370) which may include human behavior, if it happens in an automatic and determined manner and not through arbitrary decisions (Luhmann, 2000, p.370). This reflects the connectedness of the discrete computational instructions that drive an algorithm. Further, he argues that technical systems are allopoetic. This means, they were constructed by an external force and are not self-sufficient. Thus, they cannot reproduce or renew themselves which means they are autonomous but not autarkic. They rely on external resources (like energy, replacement parts or activation through signals) what makes them non-autarkic. However, they autonomously carry out their operations in a self-determined manner. They halt operation when they receive no further input from their environment. Thus, Luhmann concludes that technical systems are externally controlled and organized (Luhmann, 2000). This applies to algorithms in so far as they are created from the outside through programmers and they rely on hardware and energy to operate. They perform their predetermined actions according to their instructions. They do not compute for the sake of computation but to enact their creator’s intentions through performativity (Section 3.3) which denotes the outcomes that emerge from an algorithm’s deployment rather than the written code.

Following Kienle and Kunau, technical systems are deemed faulty, if not they do not behave as intended by its constructors (Kienle & Kunau, 2014). Here, we can observe a possible discrepancy between the purpose-directed actions and the eventual outcomes of an algorithm. The latter can deviate from the expected results even though a technical agent only performs as intended by its developers. This opens the space for discussion about what separates intentional functionality from undesired side-effects that algorithms can produce in a socio-technical system.

23 Translated from German (Coy, 2013, p.489)
24 Alongside entities, this thesis interchangeably refers to the constituent parts of a system as elements.
25 allo, Greek for “different, other” and poiesis for “An act or process of creation”, see https://en.wiktionary.org/wiki/allopoiesis
2.5.2. Social System

According to Luhmann, not humans but communications constitute a social system (Kneer & Nasseri, 1993, p. 65). Thus, Kneer and Nasseri define the social system as systems that recursively generate communication from communication in a continuous manner until the system perishes. Its constituent elements are communications, that reference each other. The relations describe the kind of dependence between them (Kneer & Nasseri, 1993, p. 80).

In contrast to technical systems, social systems are autopoietic (Luhmann, 2000). They are self-sufficient as they proliferate through succeeding operations from the elements within. Only if newly created communication can reasonably connect to existing communication, the social system lives on (Klymenko, 2012). Additionally, they are self-describing in a sense that they constitute themselves through differentiation from their respective environment. This operational closedness ensures that social systems develop their own structure based on intrinsic operations alone. These operations are not determined by the system’s environment, but by a selective choice of environmental influences, at the system’s discretion. Hereby, the social system can compose its own structure by selectively reacting to an arbitrarily complex environment. It observes the environment and creates its identity by distinguishing between inside and outside in its communications (Luhmann, 1998; Mayr, 2012). By determining what communication is acceptable within the system, it can differentiate between system, other systems and environment. This emergent behavior is a result of the three-fold selection process in the creation of communication by Luhmann (Luhmann, 1984; see Section 2.4). Through this self-description, the system can be observed, described and analyzed from the outside (Kienle & Kunau, 2014; Kunau, 2006). This way, subsystem can arrive at functional differentiation (Mayr, 2012). Similar to its technical counterpart, social systems are autonomous but not autarkic. Even though they sustain themselves through recursive communication (which makes them autonomous), they are not immune to impulses from the outside (their environment) and are subject to boundary conditions. Nonetheless, the social system sovereignly decides on how to incorporate impulses from the outside (Kienle & Kunau, 2014).

Hence, Luhmann deduces that society itself must be the ultimate social system, including the entirety of all social communication (Luhmann, 1984, p. 555). Klymenko points out that, according to Luhmann, this super-system can be partitioned into subsystems with their respective environments. Through self-description these fragments can distinguish themselves from other subsystems. Consequently, systems can recursively consist of interrelated systems. This allows us to treat society as an amalgamation of multiple social subsystems, each with its own communications. Today, this separation happens on a functional basis, so those sub-societies are shaped by their specific form of communication (Klymenko, 2012). Drawing from this distinction, we can make out the social system of online advertising that is comprised of the subsystems

26Greek for “self-produced, self-organized”, see https://en.wiktionary.org/wiki/autopoiesis
2.5. Socio-technical Systems

of users, advertiser and search engine providers.

2.5.3. Kienle and Kunau’s Socio-technical System

To describe and analyze social systems that sustain a tight relationship with a technical system, Kienle and Kunau came up with a new definition to merge both. According to them (Kienle & Kunau, [2014] p.97), a social system constitutes a socio-technical system (STS) if:

1. The technical system supports the social system’s communication processes,

2. There is mutual influence,
   a. The technical system influences the social system,
   b. The social system shapes the technical system,

3. The technical system becomes part of the social system’s self-description.

This underlines the interrelation of both. Now the social system is actively designing and constructing the technical system. This, in turn, is woven into the communication processes that sustain the social system. Eventually, it becomes indispensable, so the social system integrates it into its self-description.

The model characteristics with respect to Weisberg’s “model of models” can be described as follows. The structure of the STS is composed of a technical and a social system. Furthermore, it comprises communication processes of the social system that are affected by influences of the technical system. Additionally, there are creative and manipulating actions towards the technical system. Its intended scope is to explain a specific phenomenon that requires to involve both technical and social agents. It allows to analyze the mutual interferences and the technical adoptions that are integrated in a social systems self-description. The (unspoken) fidelity criteria is the capability of the modeler to somehow restrict the boundaries of said systems and narrow the significant variables.

In Section 2.8 this model will be applied to the web advertising ecosystem. It will describe how the social system of advertiser, users, engineers and society as a whole interact through the technical system and integrate it in their self-description.
2.6. Data Economy and advertising

“The predominant economic model behind most Internet services is to offer the service for free, attract users, collect information about and monitor these users, and monetize this information.” (Mikians et al., 2012)

Some Internet platforms exploit basic human needs like socializing with others, information seeking and communication to hoard personal data and capitalize on the analysis of this information (Petersen, Tanner, et al., 2019). A soon as customers are profiled and recognized online, they can be targeted with personalized advertising and search results (Google, 2019q) in real time (Steel & Angwin, 2010). “[I]f an ad network is able to accurately target users, we can deduce that the ad network is able to determine user characteristics” (Guha et al., 2010, p. 1), Guha concludes.

The sections below describe the methods and merits as well as a critique of data collection and targeted advertising. In the context of this work, it is important to understand them as the foundation for modern online advertising. Some problems that emerge from the technical systems in web search and advertising have their roots here.

2.6.1. Web-tracking and data collection

Today, information that was seemingly meaningless alone is enriched through the amalgamation of data from different sources. There seems to be no such thing as useless data. According to (Federal Trade Commission, 2014), some of those companies have 3000 data segments for almost all U.S. consumers. Data brokers buy and sell information in packages that include overhead which was not ordered in the first place but are part of the deal (Federal Trade Commission, 2014). Some user data segments are sold off for less than $0.0005 on average, because user data is so widely available (Olejnik et al., 2013[27]). This data is collected through web tracking. There are two kinds of online tracking. Stateful technologies use cookies, cache, HTML5 properties and session IDs to identify users. Stateless technologies or fingerprinting on the other hand, combine properties of hardware, operating system, browser and the configuration thereof to identify a user (Laperdrix et al., 2019). While active fingerprinting is performed by scripts and plugins and therefore can be inhibited by prohibiting their execution, passive fingerprinting can be derived from network traffic and thus remains unseen and untouched by the user (Mayer & Mitchell, 2012, p. 421).

Web tracking enables companies to reveal users’ demographics (Hu et al., 2007), location, purchasing decisions and interests as well as some sensitive information about them like health conditions, political or religious views (Bi

---

[27] Study was conducted 2013, so prices may have changed. Nonetheless, as there are more networked entities today, the amount of data most likely increased, with the price of an individual bit of information consequently decreasing.
et al., 2013), sexual orientation (Mistree, 2009) and relationship status (Backstrom & Kleinberg, 2014) through their online activities (Mayer & Mitchell, 2012). This amalgamation of data from various sources allows companies specialized in data-collection, -analysis and -fusion to derive PII from at first user-neutral data (Krishnamurthy & Wills, 2009b). Sparse individualized data like browsing histories or product ratings are sufficient to de-anonymize users in an approach presented in (Narayanan & Shmatikov, 2008). Browsing behavior also suffices to learn about a user’s demographics (Goel et al., 2012). This even includes offline behavior such as movement, speech or geolocation (Lane et al., 2011) (H. Lu et al., 2012). Technological progress benefits this development. Social media entices users to unveil intimate details about themselves, digital communication can be crawled, mobile technology reveals geospatial data (Yuan et al., 2012). Machine Learning renders manual or explicit classification superfluous. Consequently, user profiles are no longer composed by query similarity and classified in groups of equal interest and purchase decisions. Modern approaches derive clusters and semantic relationships from user behavior (X. Wu et al., 2009).

Profiling can generate problematic categories and unwanted side-effects that allow discrimination or questionable targeting of users. Angwin et al. showed how Facebook allowed to target “jew haters” (Angwin et al., 2017) or exclude users by race (Angwin & Parris Jr., 2016). Speicher et al. scrutinized different targeting methods used by advertising-based platforms and found three major methods: attribute-based targeting, PII-based (custom) audience targeting and look-alike audience targeting (Speicher et al., 2018). These methods can discriminate users or groups of users. Speicher et al. further showed that selectable categories on Facebook correlate with sensitive attributes of users (like ethnicity) (Speicher et al., 2018). Further, through the use of look-alike audiences bias is propagated to the selection of new subjects. Lastly, the wide availability of personal data and the efficacy of combination and analysis thereof facilitates discrimination by PII.

Because data brokers and the industries that tap into their resources are generally customer-oriented but not consumer-oriented, it remains laborious for individuals to inquire about their data, their origin, sourcing techniques and usage (Federal Trade Commission, 2014; Marwick, 2014). In 2015, Datta et al. found that users could not review all data that was used by Google to create their profile. Furthermore, protected attributes carrying sensitive personal information were used in the profiling process. This potentially exposes

---

28 Tufekci distinguishes profiling and modeling. According to him, profiling only aggregates data about individuals and categorizes them, whereas modelling infers attributes and intentions beyond the former knowledge with the help of data and computational methods (Tufekci, 2014b). However, as this distinction is not at the heart of this work, it uses the terms interchangeably.

29 Attribute based: Determining the target audience by selection of attributes that users must express.

30 PII-based targeting: Specifying distinct users by their PII.

31 Look-alike targeting: Targeting an audience similar to an existing sample customer base, also known as remarketing.
users to discrimination and deters the ability to comprehend the reason behind ad choices (Datta et al., 2015). The opacity may lead to distrust with respect to unaccountable data sources (Pasquale, 2008) that leaves users in the dark about the origin of a computation. This can lead to users losing confidence in an algorithmic system.

Today, agency is passed onto privacy policies, Terms & Conditions and the like to a degree that they deteriorate to “defaults” (Introna, 2016). Apparently, they are usually skipped or skimmed and only read if coerced to (Steinfeld, 2016). This questions the concepts of fair conduct and informed consent in this interconnected socio-technical system. Ambiguous and misleading privacy policies further the collection as they are incomprehensible to an average Internet user and grant vaguely defined rights to first- and third-parties (Reidenberg et al., 2015). Eventually, giving truly informed consent to data collection may be hampered by the design of the decision process as people’s capabilities with respect to memory load and concentration are challenged (Veltri & Ivchenko, 2017). In (Federal Trade Commission, 2014), authorities voice recommendations that would allow citizens to easily identify data brokers that trade their data and require those businesses to disclose if and how they deduce from raw data. Specifically the categories or profiles that they attach to a consumer should be revealed, so concerned users can scrutinize and correct this information. In this sense, EU’s GDPR (General Data Protection Regulation)(European Parliament & EU Council, 2016) allows subjects of data collection at least theoretically to demand details about the data stored on them.

Through third-party tracking technologies that are embedded into websites, personally identifiable information (PII) is transferred to entities other than the first-party website a user originally intended to visit (Krishnamurthy & Wills, 2009a). Tracking providers’ services span across a wide variety of first-party websites. Hence, they are able to aggregate usage data from multiple sources to create a user profile (Krishnamurthy & Wills, 2006) that allows inferences about the personality of a user (Lambiotte & Kosinski, 2014). Acquisitions and technological advance realize a “potential of significant growth in aggregate data” (Krishnamurthy et al., 2007, p. 548), for example, when Google acquired DoubleClick in 2007 (Google, 2007). This diffusion or leakage of PII (Krishnamurthy & Wills, 2009b) leads to an imbalance of power as users cannot easily examine the usage of their data.

This shows how intermediary platforms agglomerate data sources and collection utilities to enhance their services and horizontally integrate technologies that allow them to analyze and target specific users. Through the complex tracking networks and advanced analysis methods an information asymmetry arises (Tufekci, 2014a). Users are unaware or resigned towards the collection

---

32(Krishnamurthy & Wills, 2009b) showed that 70% of first-party websites were supported by the Top-10 tracking providers in 2008 already.

33Researchers add: “Aggregator nodes in possession of information that can be tracked to individual users could potentially use it in a manner that violates the legitimate privacy expectations of users” (Krishnamurthy & Wills, 2006, p. 1).

24
2.6. Data Economy and advertising

and have to understanding of the tracking imposed on them. Online companies, however, can construct a rich representation of users. As a consequence, some users try to protect themselves from tracking.

2.6.2. Tracking protection

Whenever a citizen leaves a digital footprint, it can be added to their path. Avoidance is practically impossible due to the high degree of digitalization and the technological divide that separates tech companies from the average user’s capabilities to fend off attempts of tracking. On top of that, organizational structures in advertising ecosystems are hard to decipher, which makes blocking malicious content cumbersome (Krishnamurthy & Wills, 2006). Researchers suggest that efficacy of tracking protection techniques are inversely correlated with page quality or browsing experience strongly impede web browsing experience (Krishnamurthy et al., 2007). The better the protection, the more features are unavailable ant the less comfortable the web browsing experience (Krishnamurthy et al., 2007). A study from 2010 showed that the vast majority of tested browsers could uniquely be identified, even after a fingerprint has changed (Eckersley, 2010).

Still, there are some technical and behavioral measures that can reduce the dissemination of personal identifying information, for example using the TOR browser35 or the NoScript browser extension36 as well as various tools to block ads (Eckersley, 2010) (Krishnamurthy et al., 2007). Ultimately, some scholars discuss obfuscation and misleading actions like entering ambiguous and false data as a last resort to privacy (Brunton & Nissenbaum, 2011). Because they see the free web’s business model at stake, some scholars suggest tools like MyAdChoices. This browser extensions detects behavioral advertising and allows fine-grained control over what information is shared with advertisers (Parra-Arnau et al., 2017). Toch summarizes different approaches to preserve both privacy and online advertising including but not limited to aggregated profiles, client-side distribution of PII or supply-side user controls (Toch et al., 2012).

The paragraphs above showed how tracking protection can actually facilitate tracking. One way or another, some users can be identified through associated data and a profile is compiled. Then, they can be subject to targeted or personalized advertising.

2.6.3. Targeted advertising

Marketing does no longer serve a large audience but can be tailored to individuals by deducing knowledge about them, that they were not necessarily willing to expose (Tufekci, 2014b). Behavioral targeting of ads is increasing

34Ironically, adding protection measures to a browser can help to identify an individual client (Eckersley, 2010).
35https://www.torproject.org/
36https://addons.mozilla.org/de/firefox/addon/noscript/
their click-through rate significantly compared to non-targeting controls an ad-
dresses similar users of a distinct audience (Yan et al., 2009). It also enhances
persuasion and motivates purchases (Matz et al., 2017).

In 2010 already, Gauzente suggests that most of the Internet users are
aware of sponsored ads on SERPs, with an increasing tendency (Gauzente,
2010). Moreover she finds that a positive attitude towards them improves
click-through-rate. Users feelings towards targeted behavioral advertising and
the heavy use of user data to identify customers and audiences are still man-
ifold, undecided and ambiguous. They oppose persistent tracking, intrusive
analysis and overly personal advertising, yet expect time-relevant and inter-
est based advertisement (Ur et al., 2012) (Ruckenstein & Granroth, 2019).
Schumann et al. suggest that users may accept targeted advertising due to
either perceived utility they of a website or an act of reciprocity with respect
to the free service they receive. In doing so, they balance the negative loss of
sensitive information against the benefits of the transaction (Schumann et al.,
2014). Users may have different mental models of the Internet and its threats
to privacy, however they do not express an increased effort to protect against
privacy invasion if they are more literate (Kang et al., 2015).

This underlines how citizens are generally aware of data collection and tar-
geting but mostly resign with respect to those practices (Hargittai & Marwick,
2016). In accordance with that, (kim tami et al., 2019) claims that trans-
parency about data collection practices increases user acceptance if they are
deemed acceptable.

Google disallows misconduct on their platform and enumerates prohibited
practices on its Advertising Policy Help website (Google, 2019o). In the
context of this work the prohibition of misleading content is most interesting.
Google outlaws false statements about qualifications and claims that promise
unrealistic results. These two rules inhibit most of the practices documented
in Section 3.1.

2.7. Integrated Search Engines: Google as an
advertisement enabler

Our mission is to organize the world’s information and make it
universally accessible and useful.–Google in 2020 (Google, 2019a)

We expect that advertising funded search engines will be inher-
ently biased towards the advertisers and away from the needs of
the consumers.–Sergej Brin in 1999 (Brin & Page, 1999)

37 The study in (Kang et al., 2015) was conducted in an university setting mostly with
participants in their 20s (students). However, that is already worrisome.
38 Forbidden practices include omitting relevant information (payment model, legal or fi-
nancial details), promoting unavailable offers (products not in stock, inactive deals),
misleading content (specified above), unclear relevance (ads unrelated to the search key-
word) and unacceptable business practices (fraud, unduly conduct of business). (Google,
2019o)
Mission statements like the one above show the aspiration of ISE operators to make sense of the world wide web and put the chaos in order. Market leaders in this field have arrived at monopolistic scale with the capability to serve billions of users at once and satisfy an inexhaustible thirst for knowledge (Ratcliff, 2019; StatCounter, 2019b). The following paragraphs deal with the functionality of ISEs and the role they play in a modern society. It further models the online advertising ecosystem and describes the different ways of advertisers to connect to users in Section 2.7.2 and Section 2.7.3.

The selection choices of this information selection process are subject to academic discussion concerned with the power of intermediary platforms to act as editors and the demand of accountability thereof (Bracha & Pasquale, 2008; Edelman, 2011; L. A. Granka, 2010; Grimmelmann, 2010; Introna, 2016). An excerpt of these works is discussed in Section 2.7.4.

This helps to understand how the decisions of an intermediary like Google have significant impact on advertisers and users alike.

### 2.7.1. Integrated Search Engines

According to Battelle, “[…] a search engine connects words you enter (queries) to a database it has created of Web pages (an index) […] then produces a list of URLs (and summaries of content) it believes are most relevant for your query” (Battelle, 2005). This leads to a four-step model of search composed of formulation, action (search), review and refinement that has been established by Shneiderman et al. as early as 1994 and applied to many web search engines today (Shneiderman et al., 1997).

Broder categorizes intentions to search the web into navigational, informational and transactional approaches (Broder, 2002). According to a study from 2007 in (Jansen et al., 2008), over 80% of queries identify as informational. In this context, relevance (or being relevant) is defined as being able to satisfy the needs of the user (Merriam-Webster, 2019) or being related to an event or subject (Cambridge Dictionary, 2019).

**Navigational** queries describe the urge to access a specific site.

**Informational** search includes directed and undirected questions, advice-seeking and requests pertaining to listing and locating on- and offline entities (Rose & Levinson, 2004).

**Transactional** search is concerned with interaction and the intent to “perform some web-mediated activity” (Broder, 2002, p. 5).
tional. In (Rose & Levinson, 2004), Rose and Levinson suggest that naviga-
tional queries represent a minority of web search. Furthermore, they intro-
duced the resource category to replace the transactional one. This should
contain all intentions to find non-informational content online (downloads,
recipes, entertainment, aids to offline tasks such as purchases). This is re-
flected by Ashkan et al.‘s introduction of horizontal categories distin-
guishing commercial from non-commercial query interests (Ashkan et al., 2009) after
scholars learned that frequent queries often originate from the intention to
purchase something (Dai et al., 2006). Later research suggests that search
intentions and strategies significantly vary between demographic groups and
regional affiliation (Weber & Jaimes, 2011) or gender and task (Lorigo et al.,
2006). This shows how users mainly engage with search engines when they
perceive an information need or require resources to base their decisions on.

On top of that, if they consistently search a topic, they are likely pondering a
purchase decision. This can be interpreted as a willingness to spend money.

Google continuously advances and furthered its search engine capabilities
through a plethora of updates, features and patents all in order to improve its
algorithms and thus user satisfaction (Slawski, 2019). According to market
observers, Google rolls out updates multiple times a day to enhance its service
and adapt to changes in search behavior (Dodd, 2017; Moz Resources, 2019).
Observers note that they usually are dedicated to optimize the search engine
for user-oriented quality content, fend off malicious attempts of SEO, under-
stand a searcher’s context and intentions and expand the variety of queries
that can be processed (Vinoth, 2017).

Throughout this evolution, a paradigm shift has been and still is observable.
The search engine matured from only working with bare keyword association
to processing conversational queries (Slawski, 2018; Sullivan, 2013). Semantic
analysis and context play an important role now (Broder, 2002; Halevy et al.,
2018; A. M. Pasca & van Durme, 2014). Furthermore, an intricate knowl-
dge repository, fueled by ontologies (Menzel, 2010; Semturs et al., 2015) and
enriched by the users themselves is employed to make sense of at first incom-
prehensible queries. Additionally, personalization of search results based on a
user’s background, search history and interaction with results seems to play an
important role (Balog & Kenter, 2019; Brukman et al., 2013; Lawrence, 2010;
Zamir et al., 2010) up to the point where some people express their fear of
a “closed-in effect”, that is figuratively named “The Filter Bubble” (Pariser,
2011).

To fund their operations, search engines often display promotional results
along with their organic search results. They are similar styled but marked
as advertisement.

45Moz, a Search Engine Optimization provider writes, without indicating a source: “Each
year, Google makes hundreds of changes to search. In 2018, they reported an incredible
3,234 updates — an average of almost 9 per day, and more than 8 times the number of
updates in 2009.” (Moz Resources, 2019)
46Origin unclear, information is available verbatim on various sites
47“organic” denotes unpaid results on the search engine result page that are listed due to
their relevance to the search query.(Google, 2019)
2.7. Integrated Search Engines: Google as an advertisement enabler

Figure 2.5.: Examples for ads on Google: Above, an organic search result, below a promotional one, denoted by the green marker on the top left

2.7.2. Web Advertisement

Advertisements in its basic understanding refers to “drawing attention to something” (Dyer, 1982, p. 2). This does not necessarily mean a product but can also address an idea, value belief or opinion, for example the claim of a therapy’s superior efficacy (Dyer, 1982).

The field of online advertising makes use of “Information Retrieval, Machine Learning, Data Mining and Analytic, Statistics, Economics, and even Psychology to predict and understand user behavior” (Yuan et al., 2012, p. 1). It quickly matured from merely displaying static promotional web banners in the mid-90s to integrated networks which automatically deliver personalized multi-media advertisements in present days (Rashtchy et al., 2007). The advantages of online advertising over traditional formats are clear: pricing (cost control through different pricing models (Yuan et al., 2012)), optimization (variety of media, real-time display and measurability), reach (virtually unlimited advertising space, no geographical borders, tap into arbitrary demographics) and precisely targeted ads (targeting customers based on arbitrary attributes).

Also, search marketing allows to “brand” search terms (Rashtchy et al., 2007). This can enable advertisers in the health sector to establish legitimacy through association of their brand with popular search terms (e.g. the name for a clinic appears in the top results after searching for stem cell treatments).

The advancement of the Internet as a medium for communication, e-commerce and information allow ISEs to seize a strategic role in connecting advertisers with customers. They guide searchers to their goals and, by the way, place promotion preferably associated with the information need, search intent, product or service that is being searched. Similar to the results, the selected advertisements are to be as relevant to the specific user as possible. Users that express an information need are more likely to engage with advertising relevant to their cause (Yuan et al., 2012).

48 “Search enables advertisers to associate a brand with a term, even a term that is traditionally associated with other companies or industries” (Rashtchy et al., 2007, p. 184).
2.7.3. Business Models

Online ads usually consist of a title, creative (text or media), an URL and a landing page (Yuan et al., 2012) whereas the latter two do not necessarily have to match exactly.

Scholars and professionals alike speak of push and pull or search and display advertising (Rashtchy et al., 2007). The former targets searchers and ushers them to a specific webpage that addresses their information need. The latter is displayed along the web experience and may interrupt the browsing experience, thus annoy a user (Rashtchy et al., 2007).

According to Mayer, six business models compose the online advertisement landscape. Advertising companies, hosting platforms, frontend services, analytics services, social networks and content providers cooperate in arbitrary combinations to deliver promotional messages to Internet users (Mayer & Mitchell, 2012).

With respect to web search Yuan et al. boil this down to a 4-party model to simplify the workings and reduce its constituent parts to the most relevant functional entities. The paragraph below describes this and illustrates how the system of online advertising is composed of ad exchanges, advertisers, publishers and users in Figure 2.6. The descriptions are drawn from (Yuan et al., 2012).

**Publishers** offer advertisement space (the *inventory slots*) on the service they offer to gain revenue. A search engine may opt to show promotional results in a designated space on its SERP. Thus, Yuan et al. argue that, conceptually, ISEs qualify to be a publisher in this model.

**Ad exchanges** handle the negotiation of ad delivery and auctioning of inventory slots. As a broker focused on supply and demand it computes the matching based on keywords and query terms, website content and user data, respectively (Google, 2019). Since these networking agents act as intermediaries, systematic targeting of ads is possible, either based on website specifics (target group, topic, location) or user characteristics (Mayer & Mitchell, 2012). Yuan et al. distinguish between supply-side or demand-side networks, combination of both and data exchanges. However they note, that the lines between them blur as an all-in-one approach popularizes. Nonetheless, data exchanges play a distinct role in delivering user data for behavioral targeting (Yuan et al., 2012). The more an ad exchange can make sense of the relations between keywords in terms of similarity and relevance and the more it learns about users’ search context, the more valuable the service it can provide.

---

49 Hosting services provide utility to easily set up websites while frontend services publish content or support extended functionality via JavaScript libraries or APIs, respectively. Content providers and social networks publish content, media or widgets to increase user engagement and collect usage data through tracking. This data is usually monetized in targeted advertising.
Google is a strong player in this field with 70% market share\(^{50}\) in the online advertisement business (Graham, 2019).

Advertisers are eager to promote their service or product. They bid on inventory slots through the ad exchange. The efficacy of their ads strongly varies with position, context and the number of other ads on the website. Hence, the price varies based on these metrics and the fit of bid phrase and query term or popularity of the keyword. They choose which promotional content to deliver, set up campaign goals, select a billing method and review the ads’ performance.

Users access websites to satisfy their information need. The results they receive from search engines are individually tailored and purely based on relevance. However, which ad they receive, depends on multiple factors. Quality of the match between advertisements and query keywords, bid prices and expected revenue ratios computed by the ad exchange influence the choice (Yuan et al., 2012). Advertisement delivery can also be steered via signals emitted by a search user (Shah, 2019).

Figure 2.6: Online Advertisement Ecosystem, by Yuan, Abidin et al (Yuan et al., 2012)

Figure 2.6 by Yuan et al. shows how the four participants are related. There is a flow of cash between the commercial players in exchange for inventory slots. Users generally are compensated with value with respect to their information need as they receive online services, which usually are free (compared to traditional paper advertising, where magazines must be purchased). They in turn return to the promoted services or products with a commercial interest or even purchase intention. The interactions between users, search

\(^{50}\) Based on ad revenue
Chapter 2: Fundamentals

Figure 2.7.: Ad paths, by Muthukrishnan (Muthukrishnan, 2009a, p. 2), extended by author (addition of ad exchange as a new intermediary)

engine and ad network providers and advertiser constitute the communication in the social system of the STS of web search. The different perspectives on Google’s role therein are discussed in the next part.

There are several different methods to place advertisements on a website (see Figure 2.7). In the traditional Direct Buy pricing model advertisers buy a distinct slot on the first-party website of a publisher to place their promotion (Mayer & Mitchell, 2012). Usually, these ads categorizes as Branding Ads with long-term contracts for distinct slots and no targeting differentiation (Yuan et al., 2012). Yuan et al. describe other business models in web advertisement. For example, publisher networks or ad agencies / advertiser networks operate supply- or demand-side platforms. They act as intermediaries and facilitate their members’ or customers’ advertisement business. In doing so, they organize the entirety of the inventory slots or ads of their customers (Muthukrishnan, 2009a; Yuan et al., 2012). From this duality, ad exchanges like Google AdSense emerged. They manage different kinds of ads, including sponsored search ads and contextual ads. In the first case, ads are matched to users based on keywords (query terms, content on the relevant websites, e.g.) and user-PII and displayed among the search results. The latter describes ads that are targeted based on context (domain, user intent, e.g.) and PII with flexible localization on a publisher’s website. These types of ads can further be differentiated by delivery method, trading place, competition method, pricing model and automation (Yuan et al., 2012).

The principal goal of the Internet-based advertising system is to find “the best match” in terms of both relevance and revenue between a specific user in given context and set of available ads through computation.

51 A summary of differentiations found in (Yuan et al., 2012) is described below:

- **Delivery method**: Forward contract or on the spot
- **Trading place**: Over the counter or on a transparent market (auction)
- **Competition method**: 1st price negotiation, reservation or auction or 2nd price auction in a real-time bidding or pre-set bidding competition
- **Pricing models**: Flat-rated (per time), or cost-wise (per click, mille, action or conversion)
- **Automation**: Manual (mostly in negotiation and campaign planning) or automated (real-time bidding)
2.7. Integrated Search Engines: Google as an advertisement enabler

Muthukrishnan describes the business model of ad exchanges like Google AdSense in (Muthukrishnan, 2009a, p. 2) as follows. A user $u$ visits a website $w$ that allots space to ads. The publisher $p(w)$ requests an ad from the ad exchange $E$ and also denotes a minimum price $p$ for the inventory slot. In this model, it is assumed, that $p(w)$ knows $u$’s characteristics and shares this information with $E$. The ad exchange provider furthermore knows about the ad configuration (Muthukrishnan, 2009b) on the target page. Additionally, it can crawl content on $w$ to make inferences. Then, $E$ requests ads from ad networks $a_1, \ldots, a_m$. It may disclose some information $E(u)$ and $E(w)$ about $u$ and $w$ along with the minimum price to each of them. This could include PII of $u$ or topics of $w$. An ad network may return a bid $b_i > p$ and an ad $d_i$ of one of its customers to display on the slot. In a competition method (see above) determined by the exchange, the inventory slot is sold to the winner who can now serve its ad on the publisher’s website to the user if it fits the configuration. This is called an impression. The winners are notified of their success (and possibly, the losers, too). All of this happens in a matter of milliseconds. (Muthukrishnan, 2009a) Google extends the above model by using AdRank, a measure that influences the position an advertisement can attain. It is influenced by the respective bid, ad-content and landing page quality, competing other ads, search context, relevance and performance. In an auction scenario, the AdRank determines an ads success in an auction and its position on the SERP (Google, 2019b). The dynamically computed AdRank threshold is a score set by Google to determine the minimum price of a specific inventory slot and the rejection level for ads competing for the slot (Google, 2019e).

Google serves both side of the market. The platform AdSense enables publishers to sell inventory slots on their respective sites via Google ad exchange. Google Ads on the other side allows advertisers to bid on advertising space on websites and the search engine to display their creatives (Google, 2019t). Furthermore, it hosts a tracking and analysis service that enables customers to gather information about web site visitors. To use Google Analytics they only have to include a JavaScript snippet or “Google Tag”. Then they have access to a rich set of analysis tools and the opportunity to link insights and statistics to their respective advertising campaigns on the Google Ads. Both, Search-Engine-Advertising (SEA) (listing ads as promotional results along on the SERPs of Google’s search engine or its partners’) and display ads (delivered over the AdSense program to a network of publishers, the Google Display Network) can be purchased (Google, 2019f, 2019i). Google Ads offers both sponsored search and contextual ads in a generalized second price auction.

---

52 The ad configuration includes localization, dimensions, media type of an inventory slot and other conditions determined by the publishers. It is guided by presumptions about ad efficacy and user engagement drawn from empirical data (Muthukrishnan, 2009b).
53 https://www.google.com/adsense
54 https://ads.google.com/
55 Creatives denote the visual appearance of ads, including but not limited to text, images, media and the respective styling.
56 https://www.analytics.google.com
Chapter 2: Fundamentals

(GSP) It allows automation of ad delivery based on specified goals (clicks on the ad, conversions (some intended user action like a purchase or phone call) or impressions (mere display), e.g.) and automated bidding on advertisement slots (Google, 2019c, 2019g). If serving an ad via Google Ads, advertisers have multiple ways of targeting users. They can pick a specific audience (by demographics, affinity, purchase interests, specific behavior, similarity with another audience or by reconnaissance (remarketing)). Besides, they can address searchers by the topics and content of sites they search for or the keywords they type in. On top of that, users in a defined situation can be approached, for example at a distinct life event (marriage) or situation (time, place, mobile) (Google, 2020a, 2020c). Herein, ads can be published automatically in an arbitrary fashion or deliberately on specific sites, apps or media (Google, 2019s). Ultimately, Google allows advertisers to address individual users by “Customer Match”, if it is compliant with privacy policies (Google, 2019d).

Nevertheless, Google inhibits advertisers to imply knowledge of PII in their ads or market to a very narrow audience only. In fact, it also specifically prohibits promotion in sensitive categories such as clinical trials, personal hardships and health (Google, 2019p). Furthermore, there are numerous institutions that should guide advertisers in achieving ethical conduct of business.

The auction process depicted above shows how an ad exchange acts as an intermediary between advertisers and user. Furthermore, we can conclude that based on the insights from Section 2.6, Google qualifies as both an advertising and data exchange. With its tracking services and analysis capabilities it leverages data collected about users and their online interactions to enable behavioral targeting. With this technique, they are able to directly address specific users that they assume to be in their target group. Unfortunately, this may include sensitive categories such as medical conditions. Even though they cannot be neither immediately and the use thereof is prohibited, they can still be targeted through sophisticated combination and computation of user attributes.

2.7.4. The Integrated Search Engine’s role as an intermediary

With their decisions on how to collect, index, rank and present results and advertisements, integrated search engines exercise great power. People turn towards them in search of all sorts of information. They confidently trust a search engine to objectively rank results of a query by true relevance (Pan et al., 2007). They shape searchers’ perceptions of the web and intervene with their behavior online. This can have significant social and commercial implications as it assigns visibility and directs attention (Goldman, 2006).

Grimmelmann enumerates three different views of scholars concerning Google’s role in society (Grimmelmann, 2013, 2014). He contrasts the role as con-
2.7. Integrated Search Engines: Google as an advertisement enabler

duit (Chandler, 2007) with those of an editor (Goldman, 2006; Volokh & Falk, 2012) and an advisor (Grimmelmann, 2014). These roles are described and discussed below. As conduits, ISEs appear as gatekeepers or bottlenecks that mediate between content providers, advertisers and consumers. Thus, a conduit can exercise power through blocking websites or neglecting certain advertising customers (Grimmelmann, 2010). They could refuse to index content, manipulate auctions or introduce bias. In (Chandler, 2007), Chandler juxtaposes speakers and listeners to stress how intermediaries can shape the communication between those parties. Comparing this communication as a form of verbal exchange relates it to the question of free speech as a foundation of fair use. She raises the question of how free speech can be guaranteed if gatekeepers like IREs have the opportunity to deliberately interfere with the interactions conducted on their platforms and automate their business with undisclosed algorithms. Chandler links this to net neutrality, a principle by which selection intermediaries such as search engines and ad exchanges should not discriminate content and exercise bias (Chandler, 2007). This idealistic approach means to maintain free speech online and is based on the idea of functional similarity between search engines and Internet service providers (ISP) and network providers. They all act as bottlenecks in data transmission, they argue, thus need to be treated accordingly. It is vigorously contested by Grimmelmann who argues that fulfilling all principles he derived from the idea of net-neutrality is just unrealistic and renders search useless (Grimmelmann, 2010). Nonetheless, he adds that giving search engine operators free reign is not an option. Granka agrees and elaborates in (L. A. Granka, 2010) how following these principles would hamper quality of search results and competition through malicious manipulation and less market differentiation. In addition, she notes that the most wide-spread components of search engine algorithms are already widely known and well researched. Pasquale summarizes that net neutrality should be imposed on search engines only in regard to transparency concerning business relations, promotional content and paid results (Pasquale, 2008).

The editor describes another perspective on intermediaries. Selection lies in the very nature of ISE. All of their practices constitute a form of editorial judgment. Goldman points out how search engine providers decide upon what data to index, how to rank it and which part of it to eventually present. Even though most of these operations are performed automatically in a seemingly objective-computational rationale, the inner workings of these procedures, their weights and factors, parameters and input are clearly defined. These decisions generate an editorial act along with the manual adjustments that made in response to certain issues, he argues (Goldman, 2006). Herein, the latter may reflect a company’s values and willingness to self-regulate, though...
Chapter 2: Fundamentals

the actual criteria the algorithms ought to comply with usually remain un-
known (Diakopoulos, 2013b). The misuse of editorial power though can
mislead users (Grimmelmann, 2010). Nonetheless, Grimmelmann demands
platforms to take responsibility and moderate content, even manually, in or-
der to cope with the “disturbing demand-driven dynamics” (Grimmelmann,
2018, p. 1) that scourge Internet platforms. He deems this measures nec-
essary as algorithms cannot be conscious or self-aware about the entirety of
consequences that entail their actions.

Grimmelmann notes how there is space left for another form of intermediary
between the objective conduit and the subjective editor. While a conduit’s
job is to “deliver to each website the user traffic to which it is properly enti-
tled” (Grimmelmann, 2014, p.873), the editor only cares to satisfy the audience
and keep it from switching to competitors. In (Grimmelmann, 2014) users are
introduced as the subject of interest, who are actively educating themselves on
a certain topic. This underlines how the two approaches above are combined.
Instead of being a passive audience, users formulate their goals and expect
a specific mix of websites that cater to their needs. According to Grimmel-
mann, the advisory search engine answers to a user’s query in a personalized
way that is “uniquely relevant to the user’s unique interests” (Grimmelmann,
2014, p.874).

The choices Google makes pertaining to ranking are relevant because re-
search suggest that results higher up on the search result page receive more at-
tention and generate higher click through rates (L. Granka et al., 2004) (Lorigo
et al., 2006). Scholars assume that this observation can be attributed to two
different factors. Firstly, search engines by design try to return the most rel-
evant results on top of the list. This is perceived as an indication of quality
which they call trust bias. Users trust the algorithm to deliver the truly sig-
nificant result at first. Secondly, the relevance of an advertisement is assessed
in comparison to other results on the page, leading to a “quality-of-context
bias” (Joachims et al., 2007). This has ramifications for ad delivery as well.
If businesses in the stem cell tourism industry manage to get listed among
approved clinics, governmental agencies and medical authorities in the health
sector, they benefit from the quality-of-context bias. A slot on the SERP
among those entities could be interpreted as a token of legitimacy (see Sec-
ton 3.1). They can also leverage the trust bias as ISEs seemingly convey
objective importance. On top of that, keyword-based advertising campaignns
might claim an association with a topic like emergent stem cell treatments or
a form of therapy. They might try to “brand” a specific search term with their
name and solidify their popularity among searchers in this field.

All of the above is equally relevant for advertising displayed on the SERP.
Ads are located at the top and bottom of the result page and thus are perceived

60In a TechCrunch article, an interviewee points out, how “[t]here are things Google has
demed relevant to the public interest that they’re willing to kind of intervene and
uard against, but there really is not a great understanding of how they’re assessing
that” (Dickey 2017 Robyn Kaplan).
61Both studies were small scale eye-tracking experiments with only 26 and 23 validly report-
ing participants respectively but are widely cited and accepted.
2.8. Application to Web Search

From a constructionist perspective, one can model the socio-technical system of (sponsored) web search and affiliated online advertisement using the elaborations in Section 2.5. Below, this model will be constructed from the insights above.

The social system is represented by the fraction of society that is concerned with web search and online advertising. Herein, this subsystem is denoted the “Web Search Society” (WSS). In this analysis, the WSS consists of communications between four kinds of participants. The WSS is influenced by (1) consumers or users\(^{62}\) that search the web, (2) the companies developing ISE\(^{63}\) and running ad exchanges and search engines and (3) advertisers promoting their products, services and ideas. These influencers embody the WSS’s environment. They can stimulate the communication within the social system. Ultimately, content providers or publishers (website hosts) and governing institutions that regulate the WSS could be included as well. However, this thesis concentrates on the interactions of the first three and only covers the latter to a small extent.

Through the open-minded approach to information in Section 2.1 it is possible to identify communication processes induced by those agents. Below, the four-fold approach is reviewed with respect to web search.

- **Representation of knowledge:** Website content, Knowledge Graph, algorithms
- **Data in an environment:** User data, implicit user feedback, WWW structural data, semantic ontologies
- **Part of process of communication:** Query semantics, advertisements, editorial selection, online behavior
- **Resource or commodity:** Ads, websites, user data, attention

Along these assignments, the communication processes in the WSS can be sketched. Figure 2.8 shows them schematically, connecting the agents in the environment of the WSS through their mutual communication. The direction indicates sender and receiver, the arrows are labeled according to the information the respective communication carries.

---

\(^{62}\)This thesis refers to users when it considers humans involved in a human-computer interaction (here: searching the web via a search engine). They conduct searches, review results and act based on the information they retrieved. In contrast, citizens are concerned with their role and relationships within a society. Their perspective includes policies and governance issues and how the socio-technical system can be shaped.

\(^{63}\)A platform that combines search engine and ad exchanges
The technical system (TS) manifests in an integrated search engine (ISE) which supports the above communication processes. The ISE comprises algorithms that enable web search, collect and analyze data and organize online advertisement. These algorithms constitute the entities or components of the technical system. The communication processes it supports are evaluated and fed back into the system to re-calibrate its workings. Herein, users seek to satisfy an information need and inquire about a subject. They want to find an informational resource on the WWW. They do so by inquiring the search engine providers via the search engine’s web interface. The company running the search engines executes algorithms to find relevant search results. First, it crawls the web and collects websites by publishers. Then, it indexes the collection. Eventually, it displays a ranked list of findings on the search engine result page to answer the user. Through selective presentation of publisher’s content along with ads to users in a comprehensible way, Google Web Search supports the communication between publishers (producers), advertisers and users (consumers). This allows users to satisfy their information need, advertisers to target consumers and publishers to reach their audience. Concurrently, it facilitates negotiations and auctions about inventory slots on Google Ads’ ad exchange. This also enables advertisers to place their promotional message on the SERPs or third-party sites which are eventually displayed to users through Google AdSense. Furthermore, it collects and merges data from different sources. It computationally draws conclusions about the outer context of the web search ecosystem and the inner context of users with Google Analytics. This influences the capability of the communication partners to bridge the digital gap and base their interaction on more or less mutual context.

The technical system strongly influences the WSS. Through its editorial
2.8. Application to Web Search

choices it determines what people perceive as relevant and shapes users’ ways of formulating their questions. It furthermore dictates the code of conduct with respect to ad’s and websites’ quality in form and function. Through its dominant position in the market as a major search engine that accumulates a plethora of data and its actions have significant repercussions on the online experience of society. It also impacts individuals’ sense of privacy since the dissemination of user data and targeted advertising are part of the technical mechanisms and social communications alike (Hargittai & Marwick, 2016).

As shown above, the WSS includes the technical system in various aspects of its communication as required by Kunau in (Kunau, 2006). Additionally, the WSS incorporates the mechanics of the ISE in its self-description. These include but are not limited to characteristics like instant answers, targeted advertising, realtime bidding on ads, as seen in Figure 2.9. Hence, without the traditional ISEs there would be no online search as we know it. The emergence of the term “to google” (Duden, 2020; Merriam Webster, 2020) reflects this, as well as the rise of an online advertising industry (Evans, 2009) in the last decades and the comprehensive research in the field of search engine technology (see Section 2.7 and Appendix C and online behavior).

Figure 2.9.: A model of the socio technical system of web search and advertising, own illustration adapted from (Kienle & Kunau, 2014)

In this work, the focus lies on the communication between IRE and user, as it is the only immediately observable interaction. However, the analysis below tries to infer about the inner context of the intermediary and the motives of advertisers (the selection of ads).

(Hargittai & Marwick, 2016) is from 2014 but remains relevant, with respect to the widespread use of social networks among young users and networked devices on one side and the evolution of tracking techniques on the other.
3. Related Work

In academia, accusations of discriminatory and biased algorithms are not uncommon (Sweeney, 2013). Consequently, there have been numerous attempts by scholars of various disciplines to reverse engineer or scrutinize privately operated information systems that have social impact. For example, researchers investigated:

- Web search (Hannak et al., 2013; Willis & Tatar, 2012) and advertising (Guha et al., 2010; Speicher et al., 2018; Sweeney, 2013),
- E-commerce (Hannak et al., 2014; Mikians et al., 2012; Valentino-DeVries et al., 2012) and reviews (Mukherjee et al., 2013),
- Text completion (Diakopoulos, 2013; Keller, 2013) and detection (Sap et al., 2019),
- Perception of online environments (Hannak et al., 2014; Krafft et al., 2017; Larson & Shaw, 2012),
- Finance (Lazer et al., 2014; Pulliam & Barry, 2012).

This chapter discusses literature related to my analysis of direct-to-customer marketing of stem cell-related services on integrated search engines.

First, in Section 3.1 the realm of stem cell tourism is explored with its implications for patients and caretakers. This helps to understand how our investigations can contribute to the protection of vulnerable user groups like patients. Then Section 3.2 presents different approaches to regulation of Internet-based services. This is meant to emphasize the role that society plays in technological assessment. Next, the concepts of algorithmic accountability with respect to transparency and responsibility are explored in Section 3.3. This is important as it enables to designate moral agency of SRAs. Lastly, Black Box analysis are described in Section 3.4. In this thesis, it is the method of choice to scrutinize opaque SREs.

3.1. Digitalized Health in the Realm of Stem-Cell-Tourism

The health sector offers a growing number of opportunities to deploy digital technologies. Health-related online research (specialized vertical search engines or websites for both novices and experts) is widely accessible to Internet users. Social networking platforms host research communities, patient discussion forums, crowdfunding campaigns and lobby groups that strive for medical
progress in one way or another. Digitalization includes wearable devices that allow individuals to monitor or track the functions of their body (Lupton, 2012). It also encompasses gadgets and technical devices that record and analyze usage (e.g. “smart” toothbrushes). Digital technologies allow stakeholders to actively engage in open discussion, lobby for progress, be involved in patient groups and steer public opinion as well as raise awareness or political attention (Petersen, Tanner, et al., 2019). The improved access to health related resources and social networks of people affected by a condition is especially important to individuals who are in any way “incapacitated, immobile and socially isolated through illness or disability” (Petersen, Tanner, et al., 2019, p.3). It allows patients to engage actively in periods of near-hopelessness, when survival itself may be at stake (Novas, 2006).

This active stance reflects patients’ desire to take control and achieve subjectively significant improvements through SCTs, though most of them do not expect miraculous recoveries but merely slight improvements of their conditions. (Petersen et al., 2013). These technologies eventually provide a commodity to an increasingly large market that trades personal data and infers far reaching conclusions from it (Petersen, Tanner, et al., 2019; A. Tanner, 2018).

Unfortunately, this also includes an emerging black market with medical data being a casualty of data breaches (V. Liu et al., 2015; Tindera, 2018). Research suggests, health care providers were most often breached in the US from 2010 until 2017 (they accounted for 70%). In this period, the frequency of incidents increased almost every year (McCoy & Perlis, 2018). Recent regulations have pushed for commercial access to health records through questionable “empowerment” of patients which will further the dissemination of health-related data. This reinforces the imbalance between institutions with commercial interests and individuals concerned with their health (Ebeling, 2019). Concurrently, major Internet-based corporations tap into the market of health-related products to expand their portfolio. We see platforms like Amazon and Google acquire businesses that grant access to millions of people’s health data (Farr, 2019; Scott, 2019) or provide web services to health care institutions (Royal Free London, 2017). Observers predict, operations like those will likely reshape the health care landscape (C. Tanner et al., 2019). Ultimately, online marketing is an important aspect of the digitalization of the health sector. It allows offerors of health-care services to directly identify potential consumers and approach them in a personalized fashion through data amalgamated from different sources.

The development of health-related online activities is fueled by a new form of patient activism (Petersen, Schermuly, et al., 2019) and the right to try that was already passed as a law in 36 US-states in 2017. It gave patients who suffered from “intractable or incurable conditions the opportunity to sample almost any last-gasp therapy without interference from government regulators” (Hiltzik, 2017). It is assumed that patients turn towards the Internet in search of information and counseling about SCT due to the Internet-based

---

1Lupton mainly discusses the implications of constant surveillance through mobile health trackers on the individual subject and society.
nature of the stem cell tourism industry (Master et al., 2014). Patients may not be aware of the risks involved in the advertised treatments and ignorant of the information they need to gather (Connolly et al., 2014).

Unfortunately, the Internet is the place, where the “politics of evidence” enfold, as Tanner puts it (C. Tanner et al., 2019). He means, that it is hard to obtain reliable information and find credible advice among all the hype stories and anecdotal evidence (in crowdfunding abstracts, patient blogs e.g.3). A recent study found that there is a need for comprehensive information and active campaigning of medical authorities and professional organizations to meet the expectations that patients have when they conduct research on stem cell treatments (Zarzeczny et al., 2019). Some institutions issued advice on this topic to guide patients seeking to try experimental treatments (Eurostemcell, 2020a; International Society of Stem Cell Research, 2019). Observers see a rise in crowdfunding campaigns concerned with unproven stem cell treatments (Petersen, Tanner, et al., 2019; C. Tanner et al., 2019) due to insurers refusal to cover expenses for experimental treatments (Snyder & Turner, 2019). This way, they can circumvent scrutiny by professional medical institutions.

Stem cell clinics and affiliated businesses also list their treatments on popular platforms that register clinical trials4 to promote their unapproved therapies. Researchers found out that most of these studies are lacking scientific, ethical or regulatory review, charge patients for participation and are conducted with an unjustifiable risk (Turner, 2017). These phenomena amplify the narrative of stem cells treatments being a novel and universal cure and falsely grant them a scientific character. On top of that, it enables marketers and providers of unproven treatments to advertise directly to consumers, circumventing regulation, expert review and professional oversight (Petersen, Tanner, et al., 2019).

For patients with severe conditions this poses a threat as they may be lured towards unproven treatments in the best case and fake medicine or dubious practices in the worst case. All of which come with possibly disastrous consequences such as physical harm, psychological distress and financial loss for the patients themselves or their caretakers (Amariglio et al., 2009; Lysaght et al., 2017; Nagy & Quaggin, 2010; L. O’Donnell et al., 2016). Furthermore, this leaves responsibility in the hands of a layman as patients must judge the validity of cutting-edge technology and emerging medical therapies with their limited understanding of the subject (Petersen, Tanner, et al., 2019).

Providers of questionable SCT argue that freedom of choice and patient autonomy can be achieved through direct-to-customer marketing. However, they disregard the idea of informed-consent if they assume patients to make decisions based on unreliable and implausible claims or tokens (Turner, 2018). Online communication of SCTs mostly lacks medical information and truthful disclosure about a treatments details and efficacy (Connolly et al., 2014). Clinics and agencies concerned with either travel, advertisement, marketing, health or all of the aforesaid capitalize on tokens of legitimacy (Sipp et al.,

\footnote{2} whose creation is encouraged by clinics themselves according to (Ryan et al., 2010)

\footnote{3} e.g. https://www.clinicaltrials.gov
Chapter 3: Related Work

The mostly private companies claim to be registered or certified in some way, assure the absence ethical or health concerns, refer to experts in charge and memberships in professional organizations and provide both testimonial and publications (Lysaght et al., 2018; Munsie et al., 2017). On top of that, partisans often downplay risks, ignore warnings and do not emphasize patients’ informed consent (Enserink, 2006; Master et al., 2014; Ryan et al., 2010). The advertised therapies themselves usually lack clinical trials, evidence of safety or efficacy, thorough patient information and follow-up and a clear process description (Enserink, 2006; L. O’Donnell et al., 2016; Ryan et al., 2010). They rarely publish actual data about their processes and the success rates (Gilbert, 2018). The studies they do point to, are generally poorly conducted with respect participant structure and study design (Turner, 2018). Since the questionable businesses involved in stem cell tourism use similar advertising techniques like legitimate medical authorities and facilities, it is hard for patients to distinguish malicious from lawful (Sipp et al., 2017). The tokens of legitimacy listed above have a persuasive influence on patients that seek treatment (Snyder & Turner, 2018). This probably explains why online direct-to-customer marketing is becoming the channel of choice when it comes to medical advertising (Mackey et al., 2015).

The direct-to-customer marketing of SCT is seen as problematic as it leverages a narrative of hope, rides the hype of regenerative medicine and is mostly based on anecdotal success stories (Enserink, 2006). Medical travel meanwhile arrives at a new scale since it became a competitive online-based market with willing customers that seek health services abroad. Some of these services are experimental procedures in less regulated environments as well as treatments exclusive to only a group of patients (Hiltzik, 2017; Whittaker et al., 2010). This industry has already flourished in the last years, with marketing and clinic networks spanning around the globe featuring hundreds of clinics worldwide (Munsie et al., 2017). The global market for stem cell therapies (SCTs) is expected to grow by almost 28% in the next ten years making it a multi-billion dollar business (BIS Research, 2019). It comprises institutions from travel, advertisement, marketing, health and government (Turner, 2007).

This “stem cell tourism” is described as an online, direct-to-consumer advertised Internet-based industry where patients and carers cross geographical or jurisdictional boundaries to receive stem cell treatments for which there exists little to no clinical evidence of safety or benefit (Master et al., 2014; Petersen et al., 2017). While the mainstream research community assumed the providers of SCTs to operate from Asia, Mexico and the Caribbean, there is evidence that the market is increasingly served by US firms and other middle men alike who strongly advertise their services online (Turner & Knoepfler, 2016).

---

[Mackey et al., 2015] shows that marketing expenditure for Internet direct-to-customer marketing doubled from 2005 to 2009.

[Turner identified 351 businesses engaged in direct-to-customer advertising and 570 clinics offering stem cell interventions in (Turner & Knoepfler, 2016) and 432 businesses and 716 clinics in (Turner, 2018), respectively.]
3.1. Digitalized Health in the Realm of Stem-Cell-Tourism

Many of those US companies advertise a plethora of unlicensed interventions for sundry conditions, some promote SCTs for more than 30 different diseases (Taylor-Weiner & Graff Zivin, 2015; Turner, 2018; Turner & Knopfler, 2016). Unfortunately, local businesses involved with stem cell tourism are not yet subject to regulation concerning the therapies they promote the facilitating services they provide (Turner, 2015).

Research suggests that people with poor health are not also newcomers to the web but also use it more frequently (Houston & Allison, 2002; Li et al., 2016). Over the years, this correlation remained stable but overall online information seeking decreased, possibly due to concerns about false information (Li et al., 2016). Trust plays an important role in this activity, especially with elder users (Miller & Bell, 2012). This raises concern as researchers found that low digital literacy leads to online behavior that entails potential harm. In detail, Gangadharan worries that marginal users struggle with adoption of online activities. They could be discriminated and exploited because they are unable to identify malicious actors and distinguish promotional from organic content (Gangadharan, 2017).

Already, we see how algorithms in health care endanger parts of the population. In New York, for instance, black patients were deterred from high-quality health-care thanks to a biased algorithm that falsely inferred good health from low health-care spending. Contrary to that interpretation, it was bad access and distrust in institutions that made the discriminated groups to spend less on health care and treatments (Akhtar, 2019; Obermeyer et al., 2019). With respect to SCT and medical travel, Turner criticizes in (Turner, 2018) how neither government nor professional authorities (like the FDA) can oversee and regulate the market. Sipp et al. conclude that stem cell tourism further grows even though scientific communities, media and governmental authorities issue warning (Sipp et al., 2017). Additionally, scholars point out that the financial and social implications are unpredictable, hence not included in today’s discussions on how digital technologies should advance (Petersen, Tanner, et al., 2019). The direct-to-customer marketing seems to be a crucial aspect of this industry. It leverages the insights from data collection and analysis that is enabled by digital technologies like web tracking and computational modeling. It allows SCT-providers to individually address potential candidates for stem cell treatments without publicly exposing their marketing efforts. The increasingly personalized nature of these Internet services might undermine the notion of a public opinion on the subject of SCT as users can be individually targeted with pseudo-informational content (Tufekci, 2014b).

Thus, some organizations demand to discuss algorithmic accountability (awareness of an algorithm’s potential risks) and algorithmic justice (compensation for harm done by an algorithm) (World Wide Web Foundation, 2017) before developing socially relevant algorithms in a sensitive field like health care. Below, in Section 3.3 these ideas will be discussed more thoroughly.

6By marginal users, the author means members of historically marginalized or discriminated groups, like poor people, ethnic minorities or other groups at the fringe of society.
3.2. Governance

This section elaborates on different approaches to regulation of technologies like stem cell treatments of web advertisement. They are gathered from scholars of various domains. However, their universal applicability can support the analysis of the forming effects that actors in the socio-technical system express.

3.2.1. The need for control

A mix of laissez-faire attitude, unwillingness and wide-eyed astonishment has allowed tech companies to impose their algorithms, packaged in business models onto the world and its populations (Mager, 2012). The history of search engine related cases shows that the interests of stakeholders are not aligned with policies and legislation, yet (Gasser, 2006). Some authorities responded “perfunctory” (Gasser, 2006) to technological progress and deferred policies until the market has already created precedents. Others embraced the technological advances and implement governance-supporting algorithms, better sooner than later (Kubota, 2019).

Some might argue that companies acting as intermediaries should not be held liable for content they republish or host. In the USA, this was integrated into legislation, so firms do not fear prosecution there (US Code 47 § 230, 2018). Supporters advocate this as being the sole way to protect free speech (Ammori, 2014). The freedom of expression, they argue, is the foundation that allows platforms to operate on user-generated content, enable bloggers to communicate with their readers and to sustain life of communities that discuss controversial topics (EFF, 2019). In U.S. court rooms, cases involving the editorial characteristic of search engines were generally ruled in their favor, referencing the U.S. constitution’s first Amendment and the right to free speech (Volokh & Falk, 2012).

In the meantime, the European Union has taken up a different stance. A voluntary agreement titled “code of practice on disinformation” was signed by big tech companies and the Union (Schulze, 2019). Along with these self-commitments, the EU wants to “upgrade liability and safety rules for digital platforms, services and products” (Schulze, 2019). They are willing to force regulation onto technology companies to protect citizens in their member nations (Ungku, 2019). Germany, for example, imposed significant fines of up to 50 million euros on misconduct or hosting of “criminal” content (Faiola &...
3.2. Governance

Furthermore, the EU crafted the far-reaching General Data Protection Regulation (GDPR) to theoretically grant the right be informed about data collection to users (European Parliament & EU Council, 2016). Observers notice in the press how regional legislation (here: the aforementioned European advances) have an international influence on how services are provided in other countries. Thus, a reevaluation of an algorithm that was initiated due to local regulation often disseminates. Local adjustments leads to global adoptions. This way, a public discussion about the suggestive nature of Google’s autocomplete feature had ramifications for the global application of the algorithm, for example (Dickey, 2017). The public was not informed of whether this was a matter of precaution or simply a measure to avoid multiple versions of code. This shows that it is worth to scrutinize and question algorithms, as beneficial effects are contagious.

Scholars claim, it first takes a scandal pertaining to data privacy or discrimination for public to take notice, media to report or government to act (O’Neil, 2017a). But instead of precipitant legislation, scholars demand an open discourse and common understanding of values and policy objectives. Accordingly, this should steer discussions on regulatory strategies and yield sound policies that govern in agreement with all stakeholders (Gasser, 2006). In Section 3.1 it came clear that the realm of proprietary SRAs needs some sort of governance. The paragraph above showed how legislation can attempt to regulate Internet-based companies (in the case of Germany and the EU) or how they fail to do so due to conflicts of interest (free speech and content control).

Goldman argues to let intermediaries fix the problems themselves as any regulatory interventions reduced their freedom to improve service quality and adapt to their environment (Goldman, 2006). This might pose a problem as they are profit-driven companies that are possibly more concerned with customers than consumers. Some algorithms disrupt and transform social systems and impose new rules of engagement (Kitchin, 2017). This prompts some scholars to propose that this kind of technological advancement is due to a technological determinism (Habermas, 1968; Mensch, 1980; Schelsky, 1961) that imposes its reign on a society and shapes it accordingly to fit its functional requirements (Grunwald, 2002). It infers that humans are doomed to “say certain words, click certain sequences, and move in predictable ways” (Ananny, 2016, p. 104) so an algorithm can anticipate their actions. Accordingly, advocates argue that in this sense, technological progress would strive to a single optimal solution in an almost Darwinian sense (Ropohl, 2013). Ropohl immediately rejects the idea and points to the multiplicity of stakeholders and their variety of motivations and goals when it comes to technology (Ropohl, 2013). This infers that there are diverse agents interested in shaping technological

---

9The idea of technological determinism was heavily criticized by scholars like Ropohl, who argued that technological progress can be controlled with appropriate methods. It requires a systemic approach though, as an individual cannot face the challenge alone. Furthermore, Ropohl rejects the idea of the “best solution” that technology supposedly strives to achieve. He argues that in the multiplicity of stakeholders, this is a naive simplifications (Ropohl, 1983, 2013).
In consequence, society has to appoint agents to enforce governance if it does not want to surrender to technological progress that is both uncontrollable and unstoppable (or enforced and dictated by a single actor) as it is destined in the dystopia of technological determinism (Grunwald, 2002). Grunwald adds that society has to consistently reflect on its norms and regulations once it has a learning experience regarding emerging technologies. It must question the motives and intentions of stakeholders and the basis of their decisions. These reevaluations must be premised on the new insight that entail technological progress (Grunwald, 2002). Black Box analysis are a possible tool to source these insights and fuel discussions on the subject of technology evaluation.

To sum up, herein this idea is rejected due to two reasons. First, as described in Section 2.5 and Section 2.8 a social system uses components of a technical system to facilitate its communication. It negotiates what technological advances it considers necessary to support its communication and freely decides what to include in its self-description. Thus, it has capability to shape the human-computer interaction that it integrates in its communication processes. Second, as shown in Section 3.3, the emergent behavior of algorithms can be accounted for by an agentic swarm. Its constituent actors make discrete design decisions concerning the technical system based among others on laws and norms. Moreover, as pictured in this chapter, these decisions can be subject to a variety of governance forces that have a forming impact. In conclusion, society has the power to form technology in its respective socio-technical system by leveraging the various forces that are capable to shape an object to govern.

3.2.2. Proposals of governance

Due to an increasingly complex and interconnected world, scholars developed a new perspective on governance, that is no longer state-centered and monopolized by institutional authorities. The “new” governance is concerned with the collective creation of rule through mechanisms that are not uniquely controlled by governmental agents by an autonomous network of interdependent actors (Stoker, 1995). Kooiman points out how it is more of a process than an entity. From now on, well-being, progress and security can no longer be achieved by one central agent alone. In contemporary societies, he argues, successful governance is a matter of interaction and cooperation between state, private, NGO\(^\text{10}\) and hybrid actors (Kooiman, 2008). There is no longer one single authority that dictates and decides but a networked plurality of interdisciplinary stakeholders that engage in cooperation and confrontation and collectively come to a conclusion. The boundaries between traditional institutional actors, private sector companies, citizens and bystanders blur as they are more and more interconnected (Introna, 2016). Nevertheless, Grunwald notes that governance in a democracy has to be legitimized by state actors (Grunwald, 2000). However, a government alone cannot achieve this.

\(^\text{10}\)Non-governmental organizations
In (Grunwald, 2000) he elaborates on four aspects that hamper state actors in meeting expectations as serious regulator. The factors are as follows:

**Knowledge:** In a decentralized and functional diversified society, a state actor cannot assemble all required knowledge to properly govern complex technology

**Orientation:** The state itself cannot represent its citizens’ concerns anymore. Instead of for the common good it acts on behalf of its own interests.

**Implementation** In a differentiated society and political landscape, there is no central body of planning, implementing and controlling change that could consistently carry out the transformations.

**Acceptance** Due to the first two problems, explicit and enforced measures will not be accepted by society.

The bottom line is that governmental agents cannot solve this issue satisfactorily due to the complex nature of the interconnected society and the multitude of stakeholders with contradicting interests. It needs some other sort of governance that is capable to act effectively, legitimately and extensive in both space and time in order to make claims relevant to society without the limits of national laws.

Ananny recommends a multivariate approach to algorithmic accountability. Code transparency, state regulation and user education on their own do not grasp the scope of a socio-technical system, he says (Ananny, 2016). Donzelot, who calls this emerging social tendency that arises in absence of conflict, oppression and poverty “mobilization of society”, suggests that problems must be solved by society in a bottom-up manner instead of the state implementing solutions top-down. He sees *social partners* to self-manage and resolve issues in a decentralized manner. In this approach, he expects society to accept shared responsibility and find answers in the mutual fruitful conflict that used to be extinguished by states in the past (Donzelot, 1991). The actual government takes the role of a *meta-government*, coordinating and stimulating discourse. This perspective allows us to think of the entirety of society as an active body of citizens that engages in molding its future because it is aware of its own needs. It seeks confrontation with other agents and is willing to negotiate the processes that affect them.

In (Lessig, 2006), Lawrence Lessig labels these stakeholders and draws a framework of four “regulators” shaping governance of Internet-based agents. Although they are distinct forces, they are highly interdependent. Not only can they shape the object of regulation, but they also affect how other forces behave through their interdependence.

**Law** is the state-driven regulator. It is equipped with the most immanent consequences. Misdemeanor entails prosecution and conviction might be severe (see the EU case above). Taxation and benefits incentivize decent behavior.
Norms steer behavior through community-imposed punishment. Disregarding these rules (both explicit and implicit) might get an offender expelled from a social group or a company to fall into disgrace.

Markets enact their force through supply and the nature of the services and products they provide. They steer through pricing, accessibility and marketing, for example. In doing so, they can restrict access, shape their supply and advertise their positions.

Architecture constitutes the last pillar. Technical infrastructure, protocols and code create a space for communication that is constrained by the limits of hardware and software. Behavior is limited to what is technically feasible and allowed by the programming (Lessig, 2006, 120ff).

Lessig adds that the regulators above can act indirectly and enact their power via another force. For example, Google as a market agent, investing into academia (Google Transparency Project, 2017, 2018) (HIIG, 2020) (Readie, 2020) in order to influence public discourse and thus norms or engaging with political organizations to shape law (Corporate Europe Observatory, 2016, Vogel, 2017). Google also gives incentives to agents who play by the rule and

---

11 The Alexander von Humboldt Institute for Internet and Society (HIIG) was founded in 2012 by the Humboldt University of Berlin (HU), the Berlin University of the Arts (UdK) and the WZB Berlin Social Science Center, together with the Hans Bredow Institute for Media Research (HBI) in Hamburg as a partner through an initial donation from Google in the amount of €4.5 million (until 2013). This funding was renewed again in 2014 (see below) (HIIG, 2020).

12 Readie “promotes digital policies that benefit society and drive economic growth” (Readie, 2020) and sees itself as a network of organizations within the digital economy.

13 The Google Transparency Project and Corporate Europe Observatory are two investigative transparency organizations concerned with the entanglement of Internet corporations and policy makers or political authorities. They use publicly available data like meeting records or business reports to find and analyze the interlockings.
fear demotion for “gaming” the system (Rashtchy et al., 2007; Yuan et al., 2012). This allows the platform to shape the Norms and architecture of the web advertisement ecosystem and push customers or other affiliated agents to adapt or adopt a practice (Edelman, 2011). Ultimately, platforms might also engage in politics, specifically concerning regulation of the world wide web and Internet-based services (Google, 2012). Journalists as well as scholars raise awareness of big platforms’ capability to influence offline behavior of citizens. In (Bond et al., 2012) more than 60 million Facebook users were mobilized to vote.\footnote{This urges scholars to speak against what they call “digital gerrymandering” (Zittrain, 2014, p.335). Lessig warns that this heavily undermines credibility and acceptance if done non-transparent. Analogously, if markets enact their power through opaque code and infrastructure, it creates an imbalance that is perceived as unfair (Lessig, 2006).}

Drawing from this fourfold forcefield of regulation allows us to put a label on some of the entities in the *agentic swarm* influencing the socio-technical system of web-advertisement. Law is enforced by the body of government. In legislation, politicians determine fair conduct in the online advertising business by a set of commands and threats. By this, they sketch the values of the respective community and impose punishment on those who disregard them by a centralized authority. Social norms on the other hand are enacted in a decentralized manner through entities of a social systems like professional associations, advertisers, net activists, citizens, users or cultural distinct parts of the population. They are enforced through societal sanctions following violations. The market forces are shaped by Internet-based companies and ISEs like Google and their business partners, in this case advertisers. However, most importantly, the regulation imposed by architecture (code and technical infrastructure) can be attributed to the “architects of our society” (Glaser, 2009), namely informaticians and computer scientists. They shape cyberspace with the values and norms they embed in code. Their structural perspective is molded into technical infrastructure whose performativity or emergence defines the means of communication in a socio-technical system. Therefore, they play an important part in governing Internet-based services, as explained above in Section 3.3.

Due to the interdependent nature of these forces, it is hard to assess a net impact of single measures or one regulator as a whole. Nonetheless, it is sufficient to show that computer scientist play a significant role in establishing governance. They are required to contribute their expertise, both domain-specific but also interdisciplinary, as Glaser argued in (Glaser, 2009). Only through their participation, a balance of power can be established and maintained (Lessig, 2006).

According to (Grunwald, 2000), the social partners need to determine five aspects, in order to jointly shape technology:

1. An object to shape

\footnote{The researchers found only marginal effects on increased voting willingness but conclude that the experiment only consisted of one message displayed to each user, so it might be extensible.}
Chapter 3: Related Work

2. Involved actors that are willing to design
3. Goals and intentions (non-discrimination, privacy boundaries)
4. Means to influence the formation
5. Reasonable expectation of success

All requirements can be satisfied to a certain extent with respect to Black Box testing of SRAs as it has been presented in related work and this thesis. The object to shape is either an algorithm (albeit unknown in its specifics) or the whole web-advertising ecosystem. The actors willing to do so are researchers that lay their finger on unwanted side effects of those objects, citizens that demand change and politicians who invite the collaborative efforts of all parties to craft a socially acceptable system through legislation. Herein, members of the society could be integrated as auditors, enacting governance via an auditing platform or participating in a “bug bounty” (Eslami et al., 2019). Removing discrimination, harmful bias or ensuring safe conduct on Internet platforms are the common goals of the actors. The tools and measures used to scrutinize the technical systems and justify change include software and methods like the ones mentioned at the beginning of Chapter 3 and the outcome of this thesis as presented in Chapter 4. For the last item on the list, one can only hope to make a valid and convincing case to persuade all involved actors to accept a regulatory measure. The past shows, that this is possible. Apparently, Google is generally willing to make their services safe and sane, as seen in the examples above.

Lessig’s model enables us to understand how technical systems can be regulated. It supports to find actors that engage in governance and opens new perspectives on the challenge of algorithm accountability. With this in mind, the academic body, media and citizens can scrutinize SRAs and punish misbehavior and ignorance of common norms accordingly.

3.2.3. Challenges

Scholars saw a rise in attempts to govern search engines over the years. According to Gasser (2006), future debates will have to consider a wide array of subjects. Discussions will include

- infrastructure (physical and logical characteristics of search engines),
- content (free speech and limitations on it, cultural bias),
- ownership (proprietary code, indexed content),
- security (fraud, safe conduct),
- identity and privacy (governmental access, commercial exploitation),
- participation (impact on political and cultural processes),
- ethics (tension between localized laws and morality of conduct).
Furthermore, in Gasser, 2006 Gasser highlights how the high variety of topics poses a challenge for regulators and identifies some key aspects. Social partners must prioritize issues, reconcile policy goals, find appropriate strategies and most importantly find timely solutions that are internationally and interculturally acceptable. To meet these challenges, Gasser derives three democratic key principles that are generally consistent with ethical concept like human right and agreed upon across cultural boundaries. He suggests guiding policies with informational autonomy, diversity and information quality. The first comprises free speech, freedom of choice and possibility to participate. Diversity is concerned with variety of information and source thereof. An environment with high-quality information encompasses functional and cognitive as well as aesthetic and ethical dimensions (Gasser, 2006). All of these aspects support sound decision-making, for example with health-related issues (see Section 3.1) and should guide a technology assessment like the Black Box analysis. We can benefit from the insights in this chapter to develop methods of collaborative examination later in this work.

3.3. Algorithm Accountability

“Explainability is a social agreement. We decided in the past it mattered. We’ve decided now it doesn’t matter.” (Heaven, 2013, p.35)

The purpose of Algorithm Accountability is to assess “power structures, biases, and influences that computational artifacts play in society” (Diakopoulos, 2015, p.3). In recent years the field has developed in an interdisciplinary discussion spanning the domains of law, tech, business, sociology and psychology. In 2017, the ACM US Public Policy council came up with the following seven principles to foster algorithmic accountability (USACM, 2017).

1. Awareness
2. Access
3. Accountability
4. Explanation
5. Data Provenance
6. Auditability
7. Validation and Testing (USACM, 2017)

The council aimed to encourage algorithm designers to act responsibly, knowing how their choices in algorithmic design can introduce bias and entail harm.

15Nello Cristianini in (Heaven, 2013). He is with the University of Bristol, UK and writes about the evolution of AI research.
They demand them to provide interfaces for public scrutiny, explanations of algorithmic decisions and documentation of data and procedures used in testing and training (USACM, 2017). In this context, an explanation is a “comprehensible representation of a decision model associated with a black box, acting as an interface between the model and the human” (Pedreschi et al., 2018, p. 6).

Thus, the goal is to communicate an algorithm’s functionality and purpose so that humans can understand it. The explanation needs to be interpretable by stakeholders at their respective level of domain-specific literacy. Hence, Algorithmic Accountability strives to establish transparency of algorithmic decisions for the sake of public scrutiny and responsible development that is aware of potential bias.

3.3.1. Transparency

Lessig argues that “in at least some critical contexts, the kind of code that regulates is critically important” (Lessig, 2006, p.139). By “kind of code” he distinguishes between open and closed code. Herein, he is concerned with the transparency of its functionality. Transparency, he argues, depends on the kind of architecture and code a computer scientist chooses. It creates credibility and legitimacy because users are aware of how the architecture component regulates them (Lessig, 2006). Moreover, transparency enables informed decisions (Diakopoulos, 2013a). Hence, critical scholars see the urge to reestablish transparency in domains that require consumers to exercise information literacy. This ability allows consumers to “recognize when information is needed and have the ability to locate, evaluate, and use [it]” (“Presidential Committee on Information Literacy: Final Report”, 1989). Opaque technologies, they argue, hamper this ability and thus harm the credibility and trust that organizations rely on to provide their services (Albright, 2017). Naturally, there are limits to open code, especially with respect to proprietary code of private companies. It usually constitutes a trade secret and loss thereof would diminish competitive advantage and put the company at risk (Diakopoulos, 2013a). On top of that, disclosure would open the gates to malicious actors who arbitrarily manipulate or “game” an algorithm which would degrade the quality of search or advertising (Bracha & Pasquale, 2008; L. A. Granka, 2010).

People might turn against algorithms that do not perform correctly in their eyes (Dietvorst et al., 2015). However, research suggests that users defend or challenge an opaque algorithm, even if they perceive it as biased, depending on whether they benefit from it (Eslami et al., 2019). On another platform of similar dominance (Facebook), researchers found that ad explanations can be incomplete and misleading. Moreover, they allow malicious advertisers to

---

16Interpretability is defined as the “ability to explain or to present in understandable terms to a human” (Doshi-Velez & Kim, 2017, p. 2). The perspective on interpretability from researchers in the field of Machine Learning (Explainable AI) is used here because it is equally complex with similarly far-reaching consequences for society.

17Though this was meant to apply to journalism, reporting and the dissemination of news, we can clearly see how this can be generalized to search engines and SRAs alike.
obfuscate their intention to target sensitive attributes (Andreou et al., 2018). Dietvorst also showed that if participants observed forecasting algorithms perform, they showed less confidence in its performance. This could have implications about advertising algorithms as well. Irrelevant ads after targeting could disappoint users but transparency about choice of inputs might churn trust in a SRA.

Of course, the more complex an algorithm, the more complicated an informational description gets. To bridge the gap between complexity and explainability scholars suggest a standardized label like the “Nutrition Label for privacy” (Kelley et al., 2009) that allows quick and easy understanding of an algorithm’s “ingredients”.

On this basis, some scholars demand a standardized disclosure of an algorithm’s basic aspect. Diakopoulos, for example, suggests the following in (Diakopoulos, 2013a):

1. Criteria of prioritizations, classifications, rankings and associations including their definitions, implementations, thresholds and possible alternatives.

2. Input and other relevant parameters

3. False positives and false negatives as well as the method of balancing those two

4. Training data, potential bias and the ensuing evolution

Nonetheless, there is more to an algorithm’s performativity than code. In the case of Google, company values, hiring procedures, hidden labor of quality raters and culture play an important role (Bilić, 2016).

3.3.2. Responsibility

The question of responsibility concerning SRAs in complex socio-technical systems is not trivial. Letour comes up with the notion of an actant describing an artificial actor (like an algorithm or any arbitrary technical entity) that requires a human actor to enact agency (Latour, 2005). But once they collectively act, they can only be held accountable together

Consequently, this perspective holds all entities accountable that fall in line with the algorithm’s purpose. Design decisions, emergent effects as well as interpretation of outputs and ensuing actions are all interdependent and rely on each other.

Introna points out that only through their execution, algorithms have the ability to “enact objects of knowledge and subjects of practice in more or less significant ways” (Introna, 2016, p.27). Introna uses Law’s idea of “empirical practice with ontological contours” (Law & Lien, 2013) to stress how algorithms perform in the real-world, and have the capability to create entities,

18Like a human firing a gun. In his sense, both are to be held accountable. The human for pulling the trigger, the gun for shooting the bullet.
rules, norms and social measures. What they call *performativity*\(^{19}\) stresses how the code is not an end in itself, but it exerts agency through empirical, ontological and normative artifacts that emerge from its execution. These artifacts may have a significant impact on society. This effect is concerning in a sense that the inscrutable instructions and how they produce their outputs often remain obscure Black Boxes to those who are affected (Heaven, 2013).

From the definition of algorithms in Section 2.3.1, it can be inferred that all computational steps as well as inputs and outputs are well-defined. Introna argues how algorithms express a nature of flow, inheriting from prior and imparting to subsequent actions (Introna, 2016). Thus, the specifics of all actions are significant regarding its following practices. Because the operations are interrelated, an algorithm’s outcome can never be accounted for or associated with a single act or actor alone. All involved actors partake in design, development, execution and interpretation of the algorithm. Especially in large and complex SRAs, a heterogeneous “agentic swarm” (Bennett, 2010, p.32) collaborates to creatively construct distributed, sophisticated algorithms. This collective authorship is motivated by various goals at different times (Seaver, 2014). This creates a complicated and ever-changing structure. Seaver concludes: “once these systems reach a certain level of complexity, their outputs can be difficult to predict precisely, even for those with technical know-how” (Seaver, 2014, p. 418).

As a consequence, they cannot be judged separately from their development or deployment (Geiger, 2014). However, design of code is not self-sufficient, but it is deliberately determined by programmers. Observers assume that algorithms of large software systems incorporate values and attitudes of their creators and users through criteria choices, training data, semantics, interpretation and possibly feedback (Diakopoulos, 2013a; Grimmelmann, 2017). Even the notion of relevance with respect to search results and personalized advertising is highly subjective (van Couvering, 2007). Seaver understands these properties as intrinsic parts of culture that will find their representation as technical details in an algorithm’s code (Seaver, 2017). He further points out that one should especially pay attention to the logic that guides the decisions on algorithmic workings, data structures and methods. Seaver expects them to be more persistent than the technical details. Thus, assessment of algorithms has to consider their respective “relational, contingent [and] contextual” (Kitchin, 2017, p. 18) features and the socio-technical system they perform in (Kitchin, 2017). This suggests, that no one involved can fully grasp the multitude of purposes, intentions and motivations that a piece of software was built on.

Conclusively, we need to understand algorithms in their respective context and how they are embedded in the social system. Thus, one should not assign agency to the algorithmic actor or the developer of single instructions

---

\(^{19}\)Introna describes performativity as an “ontology of becoming” (Introna, 2016). In this sense, an algorithm does not exist solely for the sake of execution of its step-wise instructions but for to be “enacted as such by a heterogeneous assemblage of actors, imparting to it the very action we assume it to be doing” (Introna, 2016, p.23)
alone, but rather to the entirety of participants in the flow of actions along its development, deployment and usage (Introna, 2016). In this sense, Datta notes that online advertising is a result of complicated mechanisms and interactions between data collection, user profiling, keyword bidding and inventory auctions. Thus they admit that it is unrealistic to assign blame for a specific ad delivery to a single actor only from external observation (Datta et al., 2015). Ananny even holds the users accountable since they contribute to the algorithms output through their interaction. Bilic also notes how their “free labor” and commodified transactions are an integral part of the STS of web search (Bilić, 2016).

In Section 3.2 different approaches of governance to shape SRA were discussed. Lessig’s proposal described four forces, one of which was concerned with architecture. This perspective is concerned with algorithms than sustain a socio-technical system. Above, this thesis argues that the collective of creators has to ensure the correct behavior of algorithms. Glaser points out how informaticians partly carry responsibility for the radical changes that transform our society today. They encode laws and norms into software and provide infrastructure for society to operate on. Thus, he concludes, they are indeed architects of tomorrow’s society and are therefore accountable for the repercussions of information technology on society (Glaser, 2009). Though in this thesis, informaticians is used equivalently with computer scientists, the latter suggests that professionals and academics in this field are merely concerned with the design and development of hard and software and the networking of computers alone. This reduces the role of informaticians, computer scientists and all IT-professionals to that of technical suppliers. Unfortunately, this resembles the public opinion, argues Glaser in (Glaser, 2009). He points out how the portrayal of computer scientists as only being occupied with technical aspects of computation deprives them of their qualification or authorization to evaluate the social or systemic ramifications of their actions due to their supposedly techo-centric world view. Glaser’s insists on repositioning the discipline as a science concerned with structure and communication of technical system. He claims that informaticians’ have the ability to identify and analyze structures and mechanisms of technical and non-technical systems (organizational and social) and transform them into computational processes. This competence can be applied interdisciplinary to evaluate and improve socio-technical systems.

In the view of this, the Chain of Responsibilities is introduced to describe pitfalls throughout the lifecycle of an algorithm from development to deployment including evaluation. The concept is drawn from (Zweig, 2016; Zweig, Fischer, et al., 2018; Zweig, Wenzelburger, et al., 2018). It is adapted to shift the focus from Automated Decision Making towards SRAs in general because both domains face similar challenges, such as a high degree of complexity, an unknown array of (confounding) variables and high significance for those

---

20He asks : “[W]ho is the maker and who is its target when algorithms dynamically adapt to the users they encounter? Should users be held partly accountable for an algorithm’s output if they knowingly provided it with data?” (Ananny, 2016, 108f.)
Chapter 3: Related Work

Figure 3.2: Chain of Responsibility on the left, possible pitfalls in the development and deployment process in the respective phases on the right, adapted from (Zweig, Fischer, et al., 2018) and altered with respect to orientation of the graphic and wording of the pitfalls.

affected by its outcomes. The metaphor of a chain underlines how an algorithm can only live up to expectations if all links hold (or can only be as reliable as its weakest link). The similarity to the waterfall model of software development is not a coincidence. Errors early in the process are propagated throughout the progress of the development, as subsequent steps are based on their predecessors. It emphasizes how every actor involved in the development and deployment process is responsible for the algorithm as a whole due its interrelated creation. On the left side of Figure 3.2, the responsibilities of the respective phases in software development and deployment of SRAs are listed. On the right hand challenges and risks are enumerated. These pitfalls need special attentions in the process of creating SRAs and releasing them into the wild. Below I elaborate on the distinct phases’ most important tasks that are introduced in (Zweig, Wenzelburger, et al., 2018), (Zweig, Fischer, et al., 2018) and (Zweig, 2016).

1. **Problem definition:** First, the problem to be solved has to be clearly defined. Here, misinterpretation of requirements or wrong assumptions can lead to misconceptions about the purpose of an algorithm. Especially in multi-causal and interdisciplinary problem spaces, this is a great challenge that requires the cooperation of domain experts from different fields.

2. **Algorithm development:**
   
   i **Algorithm selection:** Failures in problem analysis can lead to misinformed choices of methods and algorithms. Some algorithms may be more suitable to solve the problem than others. Detecting
these problems is facilitated by access to code, concise specification
with respect to purpose and function and a large user base. For
example, what existing code to reuse or which class of algorithms
might be appropriate for a certain problem?

ii Algorithm implementation: The transformation of algorithms
into machine-readable code bears the risk of wrong translation or
usage of programming language with limited or inappropriate ap-
plicability.

3. Data and method selection:

i Data collection: Availability, purpose and origin of data can have
an impact on data quality, bias and relevance. Data needs to be
accessible and usable. On top of that, the method might require a
certain sample size to work properly.

ii Data selection: Developers must determine which subset of data
they assume to be a meaningful input to the algorithm. Here, noise
or irrelevant data might hamper an algorithm. The choice has to
be made regarding the specific problems nature.

iii Operationalization: The translation of data into informational
measures (like relevance) can lead to errors due to misconceptions
about certain causations and interpretations.

iv Method selection: Developers have to come up with an idea of
how to solve the problem. Here, misconceptions about a model, its
structure and construal, can lead to errors. This includes parameter
space, fidelity criteria and intended scope of a method.

4. Design, training, testing: Intelligent software systems must be trained
on training data that can include biases. Developers ought to determine
adequate training parameters and decide whether the data sufficient in
quality and quantity to find patterns and draw conclusions. When to
end training and testing and how to define success or correctness is an-
other important decision. In this phase it is vital to explore all possible
usage scenarios.

5. Deployment: Deployment to a social context entails a learning expe-
rience for all its user. It requires them to interact with the system as
intended. This requires the system to be explainable. Naturally, some
cannot or want not to comply with these demands. Moreover, unwanted
effects can emerge from the human-computer interaction. Furthermore,
the system could be used in an improper manner or its results could be
misinterpreted.

6. Re-Evaluation: The behavior of a software systems and the quality of
its output are compared with the expectations it has to satisfy. This
feedback can be used to improve the system or detect issues. Feedback
loops that reinforce negative effects due to asymmetric feedback (O’Neil,
Chapter 3: Related Work

2017b) are a threat to this endeavor. Here, finding an appropriate quality measure is a challenge. Methods to evaluate and analyze software systems are described below, in Section 3.4.

Zweig et al. recommend several measures to solve the aforementioned issues in Zweig, Fischer, et al., 2018. They suggest institutionalizing a watchdog authority for algorithms to guide and assess their development and demand professional ethics for data scientists21. Furthermore, input monitoring and Black Box experiments should ensure unbiased foundations and correct performance of an algorithmic system.

3.4. Black Box Analysis

One method to establish Algorithmic Accountability is to conduct a Black Box analysis. Black Box analysis is a form of reverse engineering22, where an opaque system is scrutinized by analyzing observable in- and outputs, deducing the inner mechanics that transform the former into the latter and approximating the inner workings with models. This can be achieved by manipulation and observation of the box (Ashby, 1957). The insights are usually juxtaposed to expectations with respect to certain statistics, norms or standards of stakeholders about how the system is intended to work (Diakopoulos, 2013a). This kind of analysis tries to produce a model (computational or mathematical) of an algorithm.

To analyze SRAs, scholars have made up different approaches. In Mikians et al., 2012, for example, crowdsourced user requests were rerouted over the researcher’s proxy and captured in a man-in-the-middle fashion to examine price and search discrimination. Other work has spawned various software solutions to run Black Box experiments on web search and targeted advertising. Below, some programs to scrutinize the workings of ISE are listed without intention to be exhaustive.

XRay leverages differential correlation to examine targeted advertising and educate users how their input (email, web search, shopping behavior) translates into certain outputs (personalized ads, prices, product recommendations) (Lécuyer et al., 2014).

AdScape examined user interest based personalization on 175k display ads from 180 websites (Barford et al., 2014).

AdReveal analyzes targeting mechanisms for ad delivery (B. Liu et al., 2013).

21Data Scientists extract knowledge from data. They “[require] an integrated skill set spanning mathematics, machine learning, artificial intelligence, statistics, databases, and optimization, along with a deep understanding of the craft of problem formulation to engineer effective solutions” (Dhar, 2013, p. 1).

22Diakopoulus denotes Reverse Engineering as “the process of articulating the specifications of a system through a rigorous examination drawing on domain knowledge, observation, and deduction to unearth a model of how that system works” (Diakopoulos, 2013a, p. 16)
3.4. Black Box Analysis

AdFisher examines the relationship between behavioral tracking and Google Ads and the impact of Google’s Ad Settings (Datta et al., 2015).

AdAnalyst reviews Facebook’s ad explanations and collects data on ads and explanations to give users an understanding of the advertising algorithms and data sources (Andreou et al., 2018). It also examines the advertisers behind promotions and “measures” the ad ecosystem (Andreou et al., 2019).

Datenspende Project crowdsourced data collection for an analysis of SERP personalization during the last German election (Bundestagswahl) with a Browser extension (Krafft et al., 2017).

Most models in this field can be classified in either reverse engineering (Black Box explanation) or design (transparent box design) approaches. While the first is concerned with the general logic of mechanics within the Black Box and an explanation thereof and how outputs correlate with inputs, the latter tries to re-create the outputs of an algorithm with a given set of training data (Diakopoulos, 2013a).

This work elaborates on the Black Box explanation problem, specifically outcome explanation (Guidotti et al., 2018) (Pedreschi et al., 2015). It attempts to reconstruct an explanation of an algorithm from only the output. In our case, just a fraction of the input was available. We could only collect the information that participants submitted via the surveys they filled out when they downloaded the plugin. Contrary to this, a fully observable In-Out-Relationship would require an API that serves as single source of input (Diakopoulos, 2013a). But even then, an opaque system may use more than that input. Thus, in our study, the variety of input variables that the algorithms takes into account remain mostly unknown and uncontrollable.

It has be noted that reverse engineering SRA is a highly complex endeavor, as there is constant feedback from the social system and the workings of the technical system usually are in an ever-changing state. Thus, Seaver argues that in analyzing them, the Black Box algorithm is more of a social construction created by outsiders that differs for each observer as it is influenced by cultural background (Seaver, 2014 pp. 413 & 419). Herein, Seaver’s notion is adopted as he accepts a variety of interpretations to exist. The attempts to analyze the technical system in this thesis are part of the social system’s communication processes and thus can yield different descriptions of the same algorithm depending on which communication processes the Black Box analysis observes. The detailed specifics of an algorithm cannot be determined by observers outside of the Black Box. Eventually, they do not need to be known in their completeness to infer about an algorithm’s workings and effects in practice (Diakopoulos, 2013a). It is sufficient to “develop a critical understanding of the mechanisms and operational logic” (Bucher, 2016 p. 86). Rather, the examination should be conducted with focus on

---

23Theoretically, the best we could do is create an isomorph representation of the algorithm (Ashby, 1957).
relevant aspects only and consider those conditions that are required to un-
derstand a phenomenon (Grunwald, 2002). Hence, the Black Box analysis
of the web-advertisement algorithms of Google conducted in Chapter 4 can
be restricted to the question of whether there still are questionable advertise-
ments delivered via Google Ads after the announced policy changed that are
harmful to patients. In this sense, it is irrelevant to examine the technical
systems of Google’s ad exchange and search engine as an integrated Internet-
service. Rather, the implications for the distinct social system of patients of
Parkinson’s Disease, Multiple Sclerosis and Diabetes are of interest.

Nevertheless, the results and interpretations of the analysis can have conse-
quences for the socio-technical system. Ideally, it facilitates understanding of
the technical system. It might influence the use and perception thereof among
the entities of the social system. This can spark new motivations and com-
munication and a changed behavior of interactions with the algorithm. For
a responsible society, methods of algorithm accountability like the Black Box
analysis are integrated in their respective self-description, thus into the STS.
Hence, this thesis claims that the Black Box analysis itself is an SRA.

In this thesis, we strive for empirical quantifiable evidence of the phe-
omenon and do not try to create an accurate representation of the algorithm.

3.4.1. Methodology

Ashby (Ashby, 1957) points to the three central questions below that re-
searchers have to consider in a Black Box analysis.

1. What is the analysis process?
2. Which properties can be uncovered, which remain disclosed?
3. What methods should be used?

In the paragraphs below, these questions will be discussed in more detail.

Analysis process

As argued at the beginning of Section 3.4, a Black Box analysis can be denoted
a socially relevant algorithm as it has repercussions on both the technical and
social system. It furthermore facilitates the discourse about the adequacy of
algorithmic decisions. Thus, the Chain of Responsibility from Section 3.3.2
can be used to design the analysis process along its axis. Again, Figure 3.3
illustrates how each phase of the development process should receive attention
according to its specific concern. To the right of each phase, the Black Box-
specific pitfalls are listed. Below, a list of exemplary questions was compiled
that can support the execution of a Black Box analysis. They guide the design,
development and deployment of a Black Box analysis study and assist in the
post-analysis process as well. They are mostly based on lessons learned in the
process of conducting the EuroStemCell Data Donation.

1. • What phenomena emerge from the SRA’s deployment?
3.4. **Black Box Analysis**

| Problem Definition & Study design | Wrong understanding of the impact of SRA on society, misconceptions about stakeholders, research question, approach, and scope |
|---|---|
| Algorithm Development Selection & Implementation | Wrong implementation, inadequate software, hardware, ignorance towards existing solutions |
| Data collection, Data selection, Method selection | Errors in data collection and selection, false selection of participants, inappropriate methods, statistical models and measures |
| Testing | Moving target system |
| Deployment & Embedding in Social System | Slow adoption in time and space, countermeasures, repercussions, side effects and explainability of the approach |
| Interpretation/Decision, (Re-) Evaluation, Presentation | Wrong interpretation, presentation and actions inferred from the results |

**Figure 3.3:** *Translation of the Chain of Responsibilities to the Black Box analysis process, own illustration, adapted and altered from (Zweig, Fischer, et al., 2018)*

- How are they interrelated and what dependencies exist?
- How can the scope of interest be determined and limited?
- In this scenario, what is the real impact of the SRA in question?
- How can this translate into a testable hypothesis?
- Who are the stakeholders that need to be considered?
- How should the study be sized in time and space?
- How are they affected by the SRA, the Black Box analysis and its outcome?
- What are their motives and attitudes towards the analysis?
- How can they contribute?
- Which resources can be used (crowdsourced labor and hardware)?
- How to design the study to analyze the Black Box?
- What is the ideal scientific approach in terms of efficacy, effectiveness, efficiency and validity?

2. How can the phenomenon be analyzed?
- Are there reliable (software-) solutions available?
- Are there accessible APIs?
- Which hardware is required to conduct the analysis?
- What programming approach is adequate in functionality and sustainability?
3. • Which variables are of interest?
   • Which inputs to the Black Box are observable?
   • What are the limitations of data collection?
   • How to clean the data and remove noise?
   • Which methods are most suitable to approach the problem with respect to data collection and analysis?
   • How are participants recruited?

4. • Can the application be tested in a realistic environment?

5. • How can the change of the target system be controlled for?
   • Could there be countermeasures by the target system?
   • Does the study need to be adapted?
   • How to evaluate the quality of the results?
   • What repercussions and side effects can the analysis produce?
   • Is the approach explainable and reliable?
   • How can the analytic process be guaranteed to be consistent across time and space?

6. • How to interpret the results?
   • What implication do they have?
   • How can the results be presented in a comprehensive and unbiased way?
   • Are the results actionable?

To scrutinize the crucial steps of an analysis, Krafft introduces a conceptual pipeline of generic Black Box analyses in (Krafft et al., 2020, forthcoming). He emphasizes the crucial steps in the process and points out possible sources of errors and misconceptions. His ideas will be used to assess the EDD along the pipeline (seen in Figure 3.4) in Section 4.3.2.

![Conceptualized process of a black box analysis. The numbers represent the different steps in which errors can occur, from (Krafft et al., 2020, forthcoming)](image)

According to this, errors can be introduced in probing the system (1) with either a Scraping Audit (1A), a Sock Puppet Audit (1B) or a Crowdsourced Audit (1C). Then, central data collection (2) can fail and data cleaning (3) can degrade quality. The choice of data analysis methods (4) is crucial as well. Eventually, the presentation of the results also needs careful attention (5) (Krafft et al., 2020, forthcoming).
3.4. Black Box Analysis

Properties
The nature of the discoverable properties is mainly dependent on the applied method and how the challenges reviewed in Section 3.4.2 can be met. Most times when dealing with proprietary systems, researchers can just assume the inputs and manipulate only a fraction of these variables. Consequently, inferences from the output are mainly based on informed statistics and subject to noise and methodological limits.

Methods
Kitchin proposes six different methods of algorithm examination in (Kitchin, 2017). They are reviewed below to show alternative approaches and why they were not applied. Below they are assessed with respect to their applicability in the EDD.

- Examining pseudo-code / source code
- Reflexively producing code from task formulation and design ideas
- Interviewing designers or conducting an ethnography of a coding team
- Unpacking the full socio-technical assemblage of algorithms
- Examining how algorithms do work in the world
- Reverse Engineering

Approach (1) fails at the Access challenge as well as the second method (2), which is also impracticable due to the networked nature of the algorithm. Interviewing designer could possibly yield interesting insight in design decisions, constraints and implementation details, but again it breaks down due to access. Reviewing the entire social impact poses a complex problem due to the algorithm being “performative” (see above) having emergent effects. (Diakopoulos, 2013a). As we have not had immediate contact with Google’s algorithm designers and unpacking the full socio-technical system of web advertising would exceed the scope of this work, we dropped the first four alternatives. Nevertheless, the real-world effects of algorithms (5) were examined in Section 3.1 possible implementations (1,2 and partly 3) were derived from academic literature and patents in Appendix C and conducted a small-scale study (6) in Chapter 4. To expand the approaches to reverse engineering, five different Algorithmic Audits of opaque Internet-platforms are proposed in (Sandvig et al., 2014). All come with distinct advantages and drawbacks.

Code Audit  Code review of proprietary code by expert third parties (Pasquale, 2010)

Noninvasive User Audit  Self-reported measures of users’ normal interactions

\[^{24}\text{He notes, however, that “[e]ach approach has its strengths and drawbacks and their use is not mutually exclusive” (Kitchin, 2017 p. 22).}\]
Chapter 3: Related Work

Scraping Audit  Observing the results of repeated scripted queries to a platform or requests to an API

Sock Puppet Audit  Programatically impersonate specific user behavior or traffic

Crowdsourced or Collaborative Audit  Recruit real users to collect data

From the approaches above, we merged Scraping Audit with Crowdsourced Audit. This way, we were not forced to find affected individuals in person to observe for a noninvasive user audit or construct reliable and authentic but artificial user profiles. As Google does not provide an API or discloses code or data for this cause, we had to discard these approaches, too. The benefits of the methods we applied are natural interaction with the web service by participants with real profiles and the opportunity to get a broad selection of input configurations through a variety of users. The disadvantages of procedurally collecting data from a platform are the risk of detection (and subsequently blocking requests or adapting outputs to them), the possibility of violation of the service’s terms of service\footnote{Sandvig presumed that under the US Computer Fraud and Abuse Act (CFAA) (US Code 18 §1030, 2008), any unauthorized access to any computer is prohibited. He argues, that this unnecessarily broad definition would penalize any access to a website unwanted by the provider.\cite{Sandvig2014}} and the lack of fully controlled real-user data as regular Internet user would produce it\footnote{For privacy reasons, we only collected self-reported demographic and statistical data at registration and the eventual submissions}. It was the most cost- and time-efficient approach that allowed us to quickly distribute our software and gather data via data donations.

Data donations are an emerging topic in the scientific community and spark interdisciplinary discussions. Scholars make a case for donations as an act of sovereignty that can “generate social bonds, convey recognition and open up new options in social space” (Hummel et al., \citeyear{Hummel2019}, p. 48). This way, patients can be involved in scientific progress and be invited to take an active stand enacting their autonomy on behalf of solidarity (Prainsack, \citeyear{Prainsack2019}). We also faced the challenges of data donations with respect to trust, future use, invasiveness, affected people and voluntariness pointed out in (Hummel et al., \citeyear{Hummel2019}). To do so, we collaborated with a trustworthy institution (EuroStemCell), declared the possibility of future accessibility of the data (Couturier, \citeyear{Couturier2019}). We further minimized invasiveness through reduced data collection and a non-obtrusive software implementation. As to voluntariness, the study was proposed to affected and non-affected individuals alike. In contrast to donations in the purely medical field, the participants were not subject to moral pressure or an alluring expectation of direct reciprocity. After all, this study was not concerned with researching curative therapies but misconduct in online advertising. Concerning the affected people, we did not check whether only the people who decided to contribute donated but also other users of the respective browser. As consent was given at installation, anyone using the browser took part in the study.
3.4. Black Box Analysis

The author further admits and accepts the dissonance between the notion of transparency and trust that we established through publication of the collected data and the possibility of uncertain and possibly problematic future use.

3.4.2. Challenges

There are numerous challenges to the Black Box analysis of an algorithm. They range from the most trivial pitfalls to sophisticated technical restrictions and from adversarial efforts to systematic complications.

As scholars have noted in Section 3.3.2, the algorithm cannot be divorced from the conditions it was developed under or the contexts it is applied in. Thus, a wholesome analysis of an algorithm and the effects thereof require an interdisciplinary team of examiners (Zweig, Fischer, et al., 2018). They need to understand not only the technical aspects, the mathematical models or methods but also the domain-specific preconditions and ramifications. Furthermore, interviews with designers and programmers of an algorithm can be helpful, as Sandvig suggested. After all, their motivations, beliefs, ideas, visions and corporate culture may be weaved into the code.

The inability to analyze clear code is due to the following challenges described in (Kitchin, 2017). They were enriched with examples and related problems below:

Access Proprietary algorithms of large Internet-based companies are simply not meant to be analyzed from the outside (Obermeyer et al., 2019). It often is a trade secret and disclosure would allow gaming the algorithm (Diakopoulos, 2013a). “[The algorithms] are designed to work without human intervention, they are deliberately obfuscated, and they work with information on a scale that is hard to comprehend” (Gillespie, 2014, p. 26), concludes Gillespie. Eventually, there might be inputs that the algorithm considers but that are not observable, thus not measurable (Pedreschi et al., 2018). This relates to the problem of correlation vs. causation, because statistical significance cannot guarantee a causal relation or design intention (Diakopoulos, 2013a). The origin of an output can remain undetected and an effect might be misattributed to a non-causal source.

Heterogeneous and embedded The algorithms of complex software systems are highly interdependent networked algorithmic systems. They are embedded in socio-technical assemblages of various types of entities that all may feedback into the system. Their constituent parts are the work of collective authorship, created “with different goals at different times” (Seaver, 2014, p. 418). A plethora of distinguished configurations of an Internet-based service can be A/B-tested and the variety of actors engaging in networked systems make it hard to determine the reason

27 In fact, what we might refer to as an algorithm is often not one algorithm but many” (Gillespie, 2014, 12f.), says Gillespie. This reflects the capability of an algorithm to be flexible and adapt to context due to its nature as intelligent agent (see Section 2.3.1)
behind marginally different outputs\textsuperscript{28} (Diakopoulos, 2013a). Furthermore, Internet-based services are delivered over a network of multiple middle-men. Routing and load-balancing of traffic make the route of requests and the actual source of an answer opaque (Guha et al., 2010). Thus, it is hard to establish a truly identical experimental setup for two experiments.

**Ontogenetic, performative and contingent** Algorithms of large-scale software systems are constantly changing, either being updated or adapting to context. They are fluid in their manifestations in code and need to be assessed with respect to their “contextual, contingent unfolding across situation, time and space” (Kitchin, 2017, p. 21). Moreover, they are highly adaptive to the user as they are personalizing their outputs (Bucher, 2016). It was early acknowledged that in a Black Box experiment, the examiner and the subject of interest form a system with feedback. Thus, the process of examination may affect the Black Box and thus alter its inner workings, making it harder to reproduce experiments (Ashby, 1957). Gillespie concludes that the entanglement of algorithms with its audience creates a moving target meaning the relationships are constantly changing (Gillespie, 2014). On top of that, the emergent effects of an algorithm can only be assessed with respect to the context it performs in (Introna, 2016). Drawing from the fact that inputs are unknown, countless and arbitrary and outputs are fluid, contextual and subject to personalization, the real challenge is to find a stable representation of a system and its environment to analyze\textsuperscript{29}.

After all, it seems like it is impossible to fully “unbox” complex Black Box systems. Nevertheless, scholars like Hilgers argue that even with the epistemological limits of the method and the sheer impossibility to deduce all specifics, the analysis still yields insights and allows knowledge acquisition. Even if all we learn is that we need new methods and practices to analyze Black Boxes (von Hilgers, 2011).

\textsuperscript{28} A/B-Testing is widely applied in web development to assess the efficacy of design changes in either processes or presentation on the feedback of uninformed users by providing slightly different versions of a service (Christian, 2012). (Journalistic source, but gives a concise and comprehensible description of the technique).

\textsuperscript{29} Bucher puts it in a nutshell: “If the Black Box by definition is a device of which only the inputs and outputs are known, what remains of the metaphor when we can no longer even be certain about the inputs or outputs?” (Bucher, 2016, p. 94)
4. EuroStemCell Data Donation 2019 / 2020 (EDD)

As introduced before, EuroStemCell is concerned with educating the public and patients especially about stem cells. They work closely with patient groups, educators, policy makers and regulators to develop material that caters to their respective needs (Eurostemcell, 2019). They produce material on forms of treatments, specific therapies, scientific works and commercial aspects. One of their major concerns is to inform the public about questionable applications of stem cells pertaining to Parkinson’s disease, Multiple Sclerosis and Diabetes and the respective clinics or providers. Anna Couturier, Digital Manager at EuroStemCell and PhD candidate in Science, Technology and Innovation Studies at the University of Edinburgh found, along with many other scholars that these agents make use of online advertising, possibly in a targeted manner (behavioral advertising) to market directly to affected individuals. She contacted us with the intention to scrutinize these practices with respect to the underlying algorithms.

She initiated the EuroStemCell Data Donation project (EDD) to examine online advertising pertaining to unapproved stem cell treatments. As a part of that project this thesis intends to answer whether;

1. There is no more evidence of questionable advertising on Google’s search engine result page concerning unproven stem cell treatments of Parkinson’s Disease, Multiple Sclerosis or Diabetes (I and II), e.g..

2. Users affected by any of the diseases (Parkinson’s disease, Multiple Sclerosis, Diabetes) receive more critical advertisement than members of a control group.

The cooperation between Couturier and the AALAB started in summer 2019. In a two-day workshop, the project’s keystones were discussed. Following these agreements, a plugin\(^1\) for both Firefox\(^2\) and Chrome browser\(^3\) was developed along with a Django server that received and stored data. While the server and backend were constructed by a fellow student on AALAB’s payroll, the plugin was part of this thesis.

The server counterpart was developed by a fellow student (Roman Krafft\(^4\)) and is not part of this thesis. The data collection and study design were adminis-

---

\(^1\)Herein, the terms plugin, extension and addon are used interchangeably.
\(^2\)https://addons.mozilla.org/en-US/firefox/addon/EuroStemCell-data-collection
\(^3\)https://chrome.google.com/webstore/detail/EuroStemCell-data-collect/mdlalcnkekgohgbhblkbgbphaic
\(^4\)r_krafft14@cs.uni-kl.de
Chapter 4: EuroStemCell Data Donation 2019 / 2020 (EDD)

tered by researchers of EuroStemCell, Anna Couturier and AALAB, Tobias Krafft.

After development, just before go-live, Google announced in a new health-care and medicines policy to “prohibit advertising for unproven or experimental medical techniques such as most stem cell therapy” (Biddings, 2019a) in a blog post which lets assume that the company was aware of the issue (Biddings, 2019a). We expected this change to degrade the quality and quantity of the collected material with respect to our research question (see below). However, data collection ran for about 3 months. Despite the high attention the subject received and the wide reach of EuroStemCell’s partnership network, installation numbers stagnated at a low two-digit range. As a result, this thesis’ focus was shifted from a quantitative to a qualitative analysis.

4.1. The Donation Plugin

Because of the small scale of the development project, the manageable amount of expected requirements, the time constraint imposed by Google’s policy change and the proof-of-concept nature of the plugin, we omitted an extensive documentation of requirements and project planning and in turn used a SCRUM-like approach to development. Below, explanations of the plugins workings are enhanced with screenshots and UML diagrams.

4.1.1. Requirements

Couturier acted as product owner, the initial product backlog was compiled during aforementioned workshop (see Appendix A.3). The software should regularly search Google for keywords, collect content from the SERP and send this to a server dedicated to storing the results. Its goal was to imitate a user who repeatedly queries Google for specific search terms (see Appendix A.2 for the User Story of a typical user). User should experience easy installation and on-boarding and only little disruption in their browsing experience. Upon registration, a survey should provide statistical background information about participants. The infrastructure should be scalable and maintainable with respect to updates.

4.1.2. Conceptual Design

To allow a crowdsourced audit (see Section 3.4.1), we decided to collect data via a browser plugin. This way, the study gets easily scalable on the client side. Moreover we could capitalize on the realistic nature of participant’s requests as they would engage with Google using their natural browsing profile and behavior.

---

1. Anna.Couturier@ed.ac.uk
2. krafft@cs.uni-kl.de
3. The Unified Modelling Language is a popular language to model software systems. Among others, it comprises graphic notations to express structure, activity and flow of software.
The Donation Plugin

The Plugin was designed to operate on the current versions of Mozilla Firefox and Google Chrome. They were picked because they cover a majority of users as they are among the most popular web browsers (statcounter, 2019a). By using two major platforms, we could benefit from their infrastructure that allowed easy distribution, download and install, uncomplicated updates and possibly gave us an air of legitimacy as being hosted from the official store site. The usage process was derived from the requirements compiled in the product backlog (see Appendix A.3). It is illustrated in Figure 4.1.

As most participants / donors were assumed to be patients of the aforementioned diseases, thus elderly people with limited technological literacy and willingness to cope with complicated software, we needed to provide an unsophisticated piece of software. It required a seamless onboarding process and automatic execution with minimal user involvement. Hence, we minimized the number of steps in the registration process and provided FAQs. Additionally, it should not interfere with everyday browsing and operate in an unobtrusive manner. That is why the collection runs in non-active tabs in the current browser window. Nevertheless we provided transparency through a utility that showed the recent submissions to give users an idea of how their contribution looked like.

Upon downloading, participants should be walked through a gapless onboarding process. First, they were to accept a privacy statement \(^8\), then they should be redirected to a survey. Here, we wanted to request information about participants for statistical reasons and to assign them to a study group. We furthermore planned to gather information to control for frequency of use, domain-specific results (in the case of academic researchers) Groups should be allocated server-side in a country-by-disease manner plus an additional control group each. Users impacted by a disease were to be allotted to the respective group, unaffected people were to be used as control. Controls should successively fill the control groups. This would ensure that the users were not scattered among the groups and we could guarantee to provide at least one comparative study. Their donations should be assigned to a participant and group identifier.

From then on, the plugin should automatically crawl the SERP of Google at browser startup and every 4 hours (starting at midnight). Upon completion, it submitted the collection to the server along with participant- and plugin-related administrative and statistical data (IDs, version, time, language). The plugin queried the Google search engine with terms according to the study group a participant was associated with. We denote the results of the individual queries (searches for keywords) donations. The wrapped up collections that were sent to the server were called submissions. Every four hours, the terms were subsequently sent to Google in a randomized order. The plugin requested the website \(https://www.google.[top level]/search?q=[term]\).

---

8Herein, the notions of participants and donors are distinct. Participants describe users that only downloaded, installed the plugin and registered, whereas donors are active contributors who submitted their respective collected data.

9see https://www.Eurostemcell.org/datadonation#paragraph-1576
where [top level] corresponds to the respective top level domain of a participant group’s region and [term] relates to the search terms or query. The queries were composed of either a [disease] prefix (“parkinson’s”, “multiple sclerosis”, “diabetes”) followed by clinical terms or “stem cells” in a more general wording (see Appendix A.5.1 for details).

4.1.3. Development

Sprints lasted about two weeks and were loaded with about three work packages each. The software then evolved in a planned manner, as prioritized by the product owner. Each sprint concluded with a working prototype of the plugin that was critically reviewed by the product owner. Versioning was ensured on an university-based github repository\footnote{https://git.cs.uni-kl.de/m_reber16/EuroStemCell}.

Development was guided by Mozilla’s online documentation of browser extensions (MDN contributors, 2019). According to Mozilla’s documentation, a browser extension consists of a manifest file, a background page, content scripts, an options page, browser actions and others.

Additionally, to ensure browser interoperability, the \textit{webextension-polyfill} library was included in my code\footnote{https://github.com/mozilla/webextension-polyfill}. This allowed me to development the Firefox version only. If ported, the library checks the environment it runs in and adapts the code to use callbacks on Chrome and \textit{promise}-based APIs on Firefox. This pertains to all functions of the \textit{chrome} and \textit{browser} namespaces, respectively.

Furthermore, the uploaded package included HTML files for on-boarding,
4.1. The Donation Plugin

off-boarding and overview over submitted results, a privacy statement, a configurations file, their respective CSS and JavaScript files as well as icons for the addon’s button.

On- and off-boarding sites comprised informational content whereas the options page contained the mandatory survey. They were plain HTML pages styled with CSS. We used a design similar to the EuroStemCell corporate design to create a feeling of familiarity and leverage the legitimacy of said organization. After all, trust is deemed an important success factor in data donations (Prainsack, 2019).

The manifest file declared version number, extension name and other specifics that are required for upload to the browser addon stores in a JSON file format. Moreover, the file details the scripts to run and the required permissions. We minimized the amount of permissions to increase the acceptance rate for privacy-sensitive users through explicitly stating the domains we intended to crawl.

The background page incorporated the main script, the background script, that runs once the browser starts if the addon is active. It administers registration, manages communication with the server, keeps track of the study schedule and initiates the crawls. In addition, it checks for updates and loads the configuration file that comprises all parameters for data extraction and server communication. Eventually it contains handlers to process browser-actions that are triggered after a click on the addon’s button on the browser interface.

First, the page-crawl.js script was developed. It extracts information from HTML elements on the Google SERP according to the respective parameters (see Appendix A.5.2 for detailed descriptions). It receives them upon invocation through the parameters passed by the background script. Finally, it returns the donation to the background-script.

Then the registration process was implemented as illustrated in Figure 4.2. At installation users were prompted to read, understand and accept a privacy statement, see (Figure A.1a). Users were directed to an options page, where they filled out a survey, see Figure A.1b. They were interrogated with respect to health condition, demographics and stem cell-related experiences (see Appendix A.4 for details). The client submits this information to the server and registers as a new user there. The server answers with a participant ID, a study identifier and a list of keywords associated with the study (for a detailed list of query compositions, see Appendix A.5.1).

After registration, scheduling was initiated by the background-script. The scheduler is also started at each browser startup. First, it executes a crawl, then it uses the browser.alarms API to fire every 4 hours (or more specifically at 0, 4, 8, 12, 16 and 20 o’clock).

Here, we included a question concerned with the participants being contacted by direct-to-marketing practitioners of stem cell therapies. We hoped that this would encourage contribution, underline the high topicality of the issue and give patients the feeling that they are seen and their problems are acknowledged. Research suggests that this can assist reconciliation from harm (Prainsack, 2019).
To start a crawl, the background page opens a new tab for each search term in the background and injected the *page-crawl* script. After each keyword-crawl, the respective tab was closed, the results were collected and returned. Then, the next result page was requested according to the randomized keyword list. We decided to run the collection in the background to provide a less intrusive experience. The crawl code was injected directly into the newly opened tabs to circumvent the implementation of *content scripts* which would have applied to all requests to Google. That could have been seen as privacy invasion by participants, thus we reduced the scope of the crawl to only those tabs that the extension itself opened.

The *page-crawl* script returned the results as listed in Appendix A.5.2 to the background script, which added context information like user and study identifiers, packaged them and submitted them to the server. As we intended to deliver the plugin to different time zones, we decided to include a time zone offset identifier with the submissions. For a sketch of the collection process, see Figure 4.3.

The browser action button was added to increase both engagement of users and transparency of the addon. While users where not actively participating, the button was styled with an attention-grabbing exclamation mark. Upon click or after the first automated crawl (about 30 seconds after browser startup), the button would resolve to a clean EuroStemCell symbol, if a user was ready to participate. If not, the registration procedure was imitated. If a user was signed up and actively donating, the click on the browser button revealed a page showing recent donations. This was implemented for transparency reasons and to consider the *relationality* of the donated data. This way, we could honor the participants’ work through a display of their contributions (Prainsack, 2019).
4.1. The Donation Plugin

Figure 4.3.: UML activity diagram of the data collection process, by author

4.1.4. Deployment

The first release candidate was uploaded to the addon / extension stores of the respective browsers after testing. The upload consisted of packaged code, privacy statements, explanatory screenshots and a Readme file. The raw code was also published and updated on a public repository under GNU GPL v3 for the sake of transparency and reproducibility\textsuperscript{14}. Following feedback from stakeholders and to resolve issues that came up during production, the plugin was continuously improved in terms of usability, recognizability and stability. Subsequent updates versions were distributed via the stores update mechanisms.

Then, 13 Virtual Private Servers (VPS) were used to provide region-specific baseline data. Three servers were set up in each of the regions in scope\textsuperscript{15}. The machines operated on a clean-slate Ubuntu 18.04 LTS and ran Firefox and Google Chrome browsers which would only access Google search websites of various domains (.com, .ca, .co.uk, respectively). The VPS providers were each based in and offered services from one of the respective countries, so we could accommodate for regional effects. The machines were regularly monitored and updated to assure duly operations. A server-side logging process was established to give a rough overview of VPS performance. IP logging of only virtual clients was rejected by project partners due to privacy concerns. Though running on the same specifications, some servers suffered from unexplainable loss of performance while others operated flawlessly. Hence, operation of the Firefox browsers was switched to headless mode to decrease the

\textsuperscript{14}Repository: https://github.com/AALAB-TUKL/EuroStemCell-data-donation

\textsuperscript{15}Australia, Canada, United Kingdom, United States of America. In the course of the study, one VPS was added in Florida as our partners noted a large density of firms practicing stem cell therapy there.
processing load. As the reiteration of the plugin process strained the working memory of the servers which caused the browsers to crash, cron-jobs were installed to schedule reboots for the machines and restarts for the browsers. The automatized behavior of our plugin allowed us to initiate the donations computationally.

The overall study period lasted from September, 30th 2019 until March 2020. After that, an offboarding prompt was delivered via an update of the respective plugins informing the participants of the end of the study and inviting them to fill out an offboarding survey. Finally, they were asked to uninstall the plugin.

4.2. Findings

The donation data\footnote{Data is among the work’s uploaded files for the reader’s examination.} was downloaded at the beginning of February. Thus, the study period in scope ranges from September, 30th 2019 until February, 11th 2020. The data was compiled to a CSV file\footnote{A Comma-separated value (CSV) is a textfile containing data that is delimited by a distinct separator} and analyzed with Python after a first evaluation in Microsoft Excel. The illustrations were created using Jupyter Notebook in combination with pandas for data cleaning and formatting and matplotlib as well as bokeh for visualization.

4.2.1. Data Analysis

In summary, 162 participants registered their plugins on the server. 102 of them were actively contributing. They are denoted donors. Of those, 24 were VPS servers automatically submitting data as described above (the VPS represented 23.5.% of contributing participants). The VPS accounts are addressed by VPS or VPS donor and the supposedly human donors as “real” donors. Figures B.1 to B.3 in Appendix B.1 show the download statistics of both versions of the extension\footnote{The figures are drawn from the addon stores’ statistics dashboard.}. The store statistics in Appendix B.1 showed that download figures plateaued after the mid of November (a third of the study period).

Participants

![Figure 4.4.](image)

\textit{Figure 4.4.:} Cardinality of all study groups, grouped by region, color-coded by condition
The scope of this thesis was limited to the Parkinson’s Disease (PD) study groups because the numbers were too low in the groups concerned with the Diabetes and Multiple Sclerosis conditions, as seen in Figure 4.4. The chart visualizes the respective group sizes and shows that there are as low as zero participants in some groups. The study groups were encoded by numbers. Groups 3, 6, 9, 12 and 15 thus accommodated the users affected by PD from Canada, the UK, Australia, the US and the global control respectively. Users who indicated the absence of a relevant medical condition in the survey were assigned to the control. In the following, this thesis will refer to them as control or control group. These participants were assigned in a fashion that ensured a certain control group size that would allow comparability. The control “buckets” for each condition were subsequently filled. First, all unaffected participants were assigned to the PD control bucket. After this reached a size of 50 participants, another condition’s bucket was going to be filled. We chose to firstly fill the PD bucket as it was Couturier’s primary concern to investigate the situation in the realm SCT with respect to PD.

Figure 4.5 illustrates the cardinality of the PD study groups. It shows how many real participants were assigned to the respective groups. From this analysis we could have inferred the efficacy of our communications strategy. Because we partnered with medical institutions to promote our cause in the different regions, the numbers would possibly reflect the success of the respective communication strategy. Nonetheless, their numbers were too low to draw statistically significant conclusions.

**Figure 4.5:** Numbers of “real” participants (donors) in the Parkinson’s studies (without VPS participants)

**Donations**

In the study period, 177,756 donations\(^{19}\) were submitted to the collection server. The contributing participants averaged at 21,747 submissions with a median of 105. This measure and the 80th percentile of 3270 donations show how the distribution of donations among donors fits a long tail distribution,

\(^{19}\)The terms “donations”, “submissions”, “entries” are used interchangeably to refer to the data from an individual crawl that was submitted by actively contributing participants. A crawl denotes one request-scrape-collect cycle of the plugin with one of the study’s respective keywords.
Figure 4.6.: Total donations of real and VPS donors per day (encoded with blue and orange bars, respectively), from September, 30th 2019 until February 2nd, 2020

Thus is heavily skewed. Figure 4.6 shows that the collection server received regular daily donations on a stable level from mid-November on. Although the VPS' submission frequencies may vary slightly as we see in Figure 4.6, they were a reliable source of donations as they continuously submitted data as planned.

Figure 4.7.: Distribution of donations over hours of a day

The VPS donors worked as expected, submitting in a recurring manner, as depicted by the regular four-hour pattern of the orange bars in Figure 4.7. The contributions in Figure 4.7 between the scheduled donations show the submissions at browser startup (by real participants, encoded with blue bars) or reboot / restart (by VPS donors, indicated by orange bars). As most “real” donations were submitted between the four hour spikes (the blue bars in Figure 4.7), triggering the initial donation at startup was a vital function for our data collection. This allowed us to capture data even when users were just briefly browsing the web.

Many real donors collected only little data, but there are some users that consistently submitted, as seen in Figure 4.8. The figure shows the individual submissions of each real donor. Each donors contributions are depicted by data points along the x-axis which measures time. The donors are sorted top down by contribution rank. The lower part of the illustration shows that
4.2. Findings

Figure 4.8.: Submission events of real donors over the course of the study. The blue markers indicate the top-20 donators.

There were about 140 users that only occasionally donated (red data points). The illustration reflects the rise in donation numbers in mid-November, as visualized in Figure 4.6. Also, we can derive usage patterns from this data that would allow us to validate the self-declaration of users concerning computer/internet usage. Figure 4.8 further visualizes that there are about 20 donors who account for about 75% of the donations.

Figure 4.9.: Donations by individual participant and cumulative submissions

Figure 4.9 supports the lead from above concerning the 20 most active donors. On top of that it visualized the large contribution of VPS donors which amounted to 63.8% of all entries. However, if we would narrow the research down to the top 20 donors, we would lose many of the real donors.
As shown in Figure 4.10, the majority of real donors only submitted low quantities, most of them for a very short period of time (as low as a single day, see in Figure 4.8.

![Figure 4.10.: Histogram of donor’s donation distributions](image)

**Advertisements**

Among the 177,756 donations stored at the server, only 5.7% contained ads. This number is derived by selecting only those entries that contain values in the `ads` field. As some submissions included more than one advertisement per page, they were extracted, which lead to 21,188 single advertisements. According to the domain of the landing pages, about 285 hosts accounted for the paid slots on the SERPs. Figure 4.11 shows that the advertisements on the SERP originate from many small-time advertisers and only few large companies. This is reflected by an average ad-count per host of 74 and a median of only 7. 80% of advertisers appeared less than 50 times in the data. This leads to the conclusion that there are many minor players in the field who compete with very strong actors that have significant impact as their ads are regularly delivered and thus dominate the field of advertisements on the SERPs of SCT-related searches.

![Figure 4.11.: Histogram of advertisement host distribution by ad count](image)

Because the intricate nature of the stem cell therapy ecosystem and my

---

20 A click on the advertisement directs a user to a landing page. This can happen immediately or via a proxy which enables an ad exchange platform to monitor click-through rates. In the latter case we could seldom capture the destination of a link due to obfuscation (see Section 4.3)
limited knowledge thereof, I consulted with Anna Couturier, PhD candidate in Science, Technology and Innovation Studies of the University of Edinburgh to assess the background and validity of the ads and their respective promotional messages. Due to her proficiency and experience in the field of science communication and stem cell-related research, she undertook the task of labeling the hosts\textsuperscript{21}. This being said, it has to be noted that the categorization and labeling as well as the distinction of problematic ads do not reflect my educated decision. The labels were selected by Couturier to reflect the background of advertisers as it could be inferred from the contents on their website (the advertisement’s landing page)\textsuperscript{22}.

Commercial clinics were deemed to be the \textit{Most Problematic} actors, aggressively advertising questionable SCT as it was described in Section 3.1. The \textit{Quite Problematic} category contains mostly commercial actors that capitalize on patients’ conditions through complementary services or are interested in involving them in clinical trials. As described in Section 3.1, private and commercialized clinical trials are that charge for participation are a threat for affected people as they might exploit their dire need for a cure. \textit{Potentially Problematic} institutions need to be evaluated in a more detailed way. Their influence do not have immediate impact on patients, but pharmaceutical companies and lobbying groups might have an interest in branding keywords or “framing” (Kahnemann & Tversky, 1984) the search domain around stem cell research and treatments (as described in Section 2.7.3). This can be interpreted as the Market-Force of Lessig’s regulation framework presented in Section 3.2. The entities in the \textit{Neutral} category were deemed unbiased by Couturier in a sense that they would not actively engage in advertising questionable therapies.

Figure 4.12 shows that the top-20 of advertisers by number of ads in the data sample comprise many different categories. A multitude of advertisers with varying motives compete for users’ attention on the SERP. This is especially interesting in the field of emerging technologies like SCT where persuasion by commercial actors and lobby interests clash with educational efforts by NGOs and legitimate medical authorities. Among the top-20 there are 6 foundations

\textsuperscript{21}“This masters thesis is contributing to on-going work at the University of Edinburgh through the PhD work of Anna Couturier, PhD candidate in Science, Technology and Innovation Studies. As such, the qualitative analysis of the sources of advertisements is still on-going and will include a detailed coding of the advertising sources according to a number of factors, including relationship to stem cell tourism, potential risk to patients, scientific credibility, and financial impact. The coding included here is a rough “first pass” finding for the purpose of this master’s thesis and has been designed to mark potentially problematic advertising sources. These sources have been marked as problematic according to a number of factors derived from an overview of the landing pages. These factors include explicit referencing of scientifically unproven treatments, vague claims about medical outcomes, promotion of stem cell tourism, and targeting of vulnerable patient communities with financial impact.” (Anna Couturier)

\textsuperscript{22}The complete list of hosts with their respective labels and risk score can be reviewed in \texttt{Ads\_Data\_Labeled\_by\_Couturier.csv} and \texttt{problematic\_mapping\_by\_Couturier.csv}. The files are among the uploaded files. Both documents were filled out by Anna Couturier.
| Most Problematic                          | commercial clinic                        |
|                                         | clinical trials - private                |
|                                         | clinical trials - commercial            |
|                                         | complementary treatment - commercial    |
|                                         | blood banking - commercial              |
|                                         | health news - commercial                |
| Quite Problematic                       | political lobby organization            |
|                                         | pharmaceutical company                  |
| Potentially Problematic                 | commercial non-health specific          |
|                                         | conference - commercial                 |
|                                         | biopharma supplies                      |
| Neutral                                 | health news - public                    |
|                                         | research institute                      |
|                                         | blood banking - public                  |
|                                         | clinical trials - public                |
|                                         | conference - public                     |
|                                         | governmental                            |
|                                         | healthcare provider - institution       |
|                                         | non-profit health organization          |
|                                         | patient groups                          |
|                                         | social                                 |
|                                         | crowdfunding                           |
|                                         | other                                  |
|                                         | news                                   |
| Not to determine                        | unknown                                |
| Possibly drugs                          | Needs review                           |

Table 4.1.: Advertisement host labels and categorization proposed by Anna Conturier
4.2. Findings

Figure 4.12.: Top 20 advertising domains with respective ad count and labeling by Couturier.
dedicated with educating about PD and fostering scientific research. The second largest source of advertisements titled *Prescription Treatment Website* accounts for promotion of PD drugs related to Carbidopa / Levodopa that are direct-marketed to both patients and practitioners. This shows that not only affected people are addressed but also health-care professionals. Nine providers of drugs were identified in the obfuscated links that direct users to their respective landing pages via an ad network. Furthermore, there are four clinical trials being advertised among the top-20, three of which are deemed problematic. Apparently, there is also recruitment for clinical trials via online advertising, which may be a hint to the marketing strategies of providers of unproven SCT to acquire customers through ostensible research.

This categorization was further boiled down to a binary classification of critical / noncritical hosts. Although the majority of critical actors were in fact commercial clinics, there were also entities labeled as commercial clinics that were not deemed critical, as seen in Figure 4.13. Additionally, some providers of health news, private clinical trials and complementary treatments qualified to be critical. False claims with respect to treatment efficacy, open promotion of stem cell tourism and claims of applicability of SCT for sports injuries, hair transplants and cosmetic treatments accounted for the categorization as a problematic actor.

To investigate the differences between the three groups (affected, control and VPS) with respect to entries, advertisements and critical ads, the donors'
entries were grouped by study ID for further analysis. Figure 4.14b showed that users from the affected study groups (study groups 3, 6, 9, 12) received more advertisements in proportion to the number of requests than participants assigned to control or VPS groups. The fraction of critical ads was surprisingly low in the affected groups, as seen in Figure 4.14c. Figure 4.14b raises the suspicion that there is some sort of fitting of the ad delivery algorithm to repeated probing through research, as described in (Guha et al., 2010). This can be inferred from our VPS servers in Figure 4.14b as they see a particularly high number of ads.

Figure 4.15 contrasts the proportion of ads between VPS and real donors. Again, there is no clear sign of targeted advertising between groups or due to real / VPS distinction. This is probably due to the small number of participants and the skewed distribution of contributions. Interestingly, the VPS servers that operated from the UK received the ads and the smallest share of critical ads.

A further analysis could confirm this, as seen in Figure 4.16. Study group 3 from Canada can be excluded from this examination as there were not enough donors. There was no significant difference between the proportion of critical ads.
Figure 4.15: Proportion of critical ads delivered to real donors, grouped by study.
4.2. Findings

Figure 4.16: Proportion of critical ads received among all ads, by study group

Figure 4.17: keywords

ads among the study groups as Figure 4.16 shows and a Kruskal-Wallis Test confirmed.

Figure 4.17 shows that keywords associated with PD were not necessarily more targeted as other. Critical advertisers seemed to concentrate on advertising stem cell treatments, therapies and cures in general.

Detailed inspection of exemplary SCT advertisers

The host named swissmedica.startstemcells.com was selected by Couturier to be a typical source of problematic advertisements. Figure 1.2 proved an insightful example of its ads. It was consistently placing ads in the course of the study and was the third-largest source of advertisements in this study.

Typical example for problematic ads were the ones hosted by swissmedica.startstemcells.com were composed of a certain number of keywords in alternating arrangements. The terms included but were not limited to

27It might be of interest that their ads were the only ones in our collection whose URL features smileys and emoticons. Admittedly, this is eye-catching.
Cure with the new technology. Proven results. Higher success rate. The latest treatment. Save & effective. No side effects. In details! Revitalization. Diagnostic. Post treatment. Stem cells treatment. Accommodation. Treatment for 60 diseases. Higher success rate.
– swissmedica ad content on September 30th, 2019

The latest treatment. Proven results. No side effects. Cure with the new technology. High success rate. In details! Post treatment. High success rate. Dementia. Diabetes 2. Diagnostic. Arthritis. Autism. Multiple sclerosis. Innovative treatment. Treatment for 60 diseases. – swissmedica ad content on February 8th, 2020

Figure 4.18.: Typical examples for swissmedica advertisement creatives

- Proven results
- Cure with the new technology
- Higher success rate
- No side effects
- Treatment for 60 diseases
- Higher success rate
- Save & effective
- Destinations: Switzerland, Slovenia, Serbia, Russia, Austria

These keywords relate to the narratives of the stem cell tourism industry. They usually advertise their treatments as safe, successful, advanced and approved. They furthermore offer international travel and claim applicability for a wide array of conditions.

4.2.2. Limitations

As further discussed below, we could not determine the mechanics behind the targeted advertising of questionable SCT. This is due to the limited number of actively contributing participants and the nature of the data collection. Our approach refrained from large-scale data collection for the benefit of privacy and data security. We did not want to stimulate privacy concerns among potential participants or endanger them through uncertain future use of the published data. Furthermore, we cannot guarantee, that our research had not repercussions on the target system because our intent was discovered.

Since selection processes are at the heart of an ad exchange, the entirety of advertisements in the online advertising ecosystem are subject to rigorous selection. From the plethora of available ads, only few make it to the bidding process due to quality or policy reasons. Then, they are subject to an intricate
4.3. Lessons learned

In the course of the EuroStemCell Data Donation, the remarks of Section 3.4.1 were implemented if feasible. Nevertheless, there are some learning experiences that are described in the following paragraphs. They originate from the review of literature, discussions with peers, the deployment of the plugin, data collection and analysis, and the interpretation thereof. Some were of conceptual nature, while others just took time to review and fix. They are presented so future research can build on top of them. First, learnings concerning the study design are listed. Then, the individual learnings pertaining to technical aspects are assigned to the crucial phases of Krafft et al.’s Black Box Analysis Process (Krafft et al., forthcoming). He describes the critical steps of a Black Box analysis and illustrates how practitioners can fail to conduct a sound analysis. However, his model is only concerned with the actual execution and evaluation of an analysis. Thus, the study design aspects are not included in these assignments.

4.3.1. Study Design

The following thoughts were compiled after the data collection, when some shortcoming of the approach became evident. Herein, the learnings with respect to study design are described in chronological order pertaining to the analysis process depicted in Section 3.4. They describe the two initial steps and opaque auction. In the end, only those ads that have optimal value with respect to user personalization, bidding price, quality, inventory slot and competing content are delivered to a searcher. As a consequence, we can never grasp the entirety of ads related with a subject. We can only assess a subset thereof, in a specific environmental configuration regarding user profile, time and space of a request. In conclusions, there might be ads out there that are highly significant to a research question but there is no way to guarantee that they are eventually being delivered to participants.

The VPS services were locally sourced from Australia, Canada, the United Kingdom and the United States of America. Even though the providers were located there, we could not guarantee that the virtual servers really operated in the respective ZIP codes. We found that some location declarations from the provider deviated from our contractual agreements or details retrieved from a third party localization service. Nevertheless, we cannot expect server farms to be located in an average neighborhood, so the IP location probably reveals the artificial nature of a web request, anyway.

Due to privacy concerns we were not tracking Google login status, cookies or fingerprints. To better understand targeting, the insights with respect to user tracking would have enabled an analysis through Google’s lenses and control for tracking protection measures possibly employed by users. Also, we could have examined whether users receive different ads and results depending on whether they are logged in on Google.
in the development process as depicted in Figure 3.3 and precede the actual analysis, that will be covered in 4.3.2.

**Pre-Study:** A pre-study on existing solutions in the field of Black Box analysis could have facilitated the development of the plugin. Section 3.4 gives a brief overview of developments made so far. Most of the Black Box software solutions are open source, though some of them operate on outdated browser versions. They provide insights with respect to technologies of browser automation (like Selenium) or other libraries concerned with web crawling. However, as the EDD project was forced to quickly deliver a working plugin after the surprising announcement of the policy change, those alternatives could not be reviewed in-depth.

**Target audience:** In the projects introductory workshop, the plugin, the usage scenario (including the search terms) and the typical users were modeled. Usage scenarios, search term formulation and search strategies were discussed among young and tech-savvy academics. However, research suggests that these properties vary by demographic and motivation (Lorigo et al., 2006; Weber & Jaimes, 2011). Investigating real usage scenarios, personal backgrounds of potential users and Internet and technology literacy distributions among them could have supported a more refined understanding of the plugin’s target audience. Supposedly, it would have been advisable to consult with representatives of the target user audience which were assumed to be elderly due to the nature of the diseases we covered. The opportunity to connect with them through patient groups associated with Eurostemcell was left untouched due to the constrained time and the geographical distance. To learn more about popular

![Get keyword ideas](https://i.imgur.com/3JG5.jpg)

**Figure 4.19.:** Keyword suggestions in the Google Ads campaign setup process, screenshot of the Google web interface of Google, by author

search terms in a certain field, Google’s suggestions can be examined (see 4.19)
4.3. Lessons learned

They are presented in the process of setting up a new advertising campaign via Google Ads. Researchers could infer popular keyword combinations or search queries from these suggestions, as they are probably compiled for advertisers (who aim to maximize reach or efficacy of their ads). In conclusion, these approaches could strongly facilitate a more customized development.

**Organization:** VPS services were ordered and managed abroad from a German location and payed with Scottish credentials, it was a common view to see services suspended due to measures of automatic fraud detection. It probably streamlines organizational processes with respect to payment and management if resources and agency were allocated more closely.

**Reach:** Distribution and promotion of the plugin and EDD’s mission were only conducted via EuroStemCell’s network of affiliated researchers and patient groups. We did not try to advertise our cause to other groups that may have been enthusiastic to join. After all, #DataDonation is a thing on social media, and a broadly discussed topic in medicine, sociology, law and, of course, business. There are various NGOs, interests groups and individuals that are engaged with medical data donations and its personal and societal implications. For example, the Hasso Plattner institute recently introduced a Data Donation Pass (Hasso-Plattner-Institut, 2020; Schapranow et al., 2017). It might give research endeavors like this an uplift to connect with like-minded projects and leverage their respective networks or advances in the field of societal data donations. Additionally, this gives the chance to take a participatory role in the development of data donation concepts and infrastructures.

**Crowdsourcing Recruitment:** Since a crowdsourced audit approach was selected, this was the most critical step for the EDD project. Recruiting real-world participants leverages the opportunity to probe a Black Box with real-world user profiles. However, the target audience we meant to address is hard to mobilize, apparently. Though there are reportedly strong ties between EuroStemCell and patient groups, we failed to get affected people onboard. “A number of patient recruitment events were held including three events with Parkinson’s UK, two events with the Anne Rowling Clinic and a number of internal recruitment drives (using mailing lists and direct mailings) with the Australian Stem Cell Network, the University of Texas in Austin, Yale-New Haven Hospital, and the Edinburgh Parkinson’s Research Interest Group. However, these events produced more one-to-one structured interview opportunities rather than translation to study recruitment. This may have been due to the demographic targeted as well as the difficulty in translating in-person engagement into digital engagement” (Anna Couturier).

**Education:** Presumably, the target audience consisted mostly out of senior citizens. This can be deduced from the fact that the project is directed at people suffering from Parkinson’s disease, Multiple Sclerosis and Diabetes. It also reflected Couturier’s experience in this field. She further assumed that these users have low technology-literacy. Thus, educational material or onboarding guides regarding the plugin and the EDD might have supported the cause. Hands-on trainings or explanatory videos could have boosted adoption.

28https://twitter.com/search?q=datadonation
However, these measures must be specifically designed to address the target group and convincingly engage them to join. Unfortunately, this was not in the scope of this thesis as it requires comprehensive analysis of demands, expectations and motivations of the target group as well as an investigation of available methods and their respective efficacy.

**Survey:** The survey was composed for statistical purposes. In fact, the correctness of the submitted data was never controlled. We trusted users to truthfully fill out the survey and not falsify information. Also, this kind of information gathering is a balancing act between invading the privacy of sensitive groups and detailing a user’s characteristics which facilitates analysis. On another note, the survey could have been expanded by questions like “How did you learn about the study?”

This would enable researchers us to evaluate the success of your recruitment efforts between regions and among partner institutions and communication channels. In consequences, this would have allowed us to strengthen some bonds and emphasize our efforts to push the EDD to some regions.

**Time period:** It remained unclear whether the time period allocated for the study had any impact on the results. We see that some academics allotted as little time as a week to their study (Guha et al., 2010; Yan et al., 2009), while others processed data from longer intervals. As described in Section 2.7, some web services update on a daily basis, which infers highly volatile algorithms. However, the changes might be so marginal that for narrowed-down research questions it may be unlikely to see an impact. Nevertheless, the longer the study interval, the greater the effect of aggregated changes. This being said, for a snapshot-like investigation of a specific question (like in this case) it could suffice to reduce time and broaden the search effort in this time in exchange (e.g. expand queries, create sophisticated profiles, create more variety among participants). If there is no major advancement in the field of stem-cell related research or a major shift in the web advertising ecosystem, the structure of results supposedly remains stable. Nonetheless, these are interesting effects that should definitely be accounted for.

### 4.3.2. Technical

![Diagram](image)

**Figure 4.20:** Conceptualized process of a black box analysis. The numbers represent the different steps in which errors can occur, from (Krafft et al., 2020, forthcoming)

The lessons learned with respect to technical aspects are structured along Krafft’s concept of Black Box analyses (Krafft et al. 2020, forthcoming). Figure 4.20 schematically displays the analysis process in the last four steps of the Chain of Responsibility described in Section 3.4 and Figure 3.3, especially.
4.3. Lessons learned

(1) **“Fluid” Internet:** As seen in Appendix C, ISEs like Google and other modern Internet-based platforms are in a constant flow. They dynamically adapt their websites to follow trends, update their algorithms daily and improve their services through A/B-Testing. This makes web crawling strenuous, as website structure can change any time. Thus, it is hard to identify different instances of the same ad. Incomplete information due to real-time auction among several other advertisements, load balancing and network routing may affect delivery (Guha et al., 2010). Thus, if relying on HTML tags, one has to closely monitor the online documents to register changes and appropriately tweak the respective software. A slight change in website (DOM-) structure or naming conventions (element IDs) would have rendered our crawl useless, as no data would have been extracted. This can be countered with storing the whole website.

(1 A/B) **Infrastructural Limitations:** By using VPS hosts that accommodate numerous virtual systems, there is the risk that an IP range will be blocked by Internet services. This happened at our US-based VPS server location in Dallas, where requests to Google’s web search were consistently blocked. Some other locations required us to solve captchas to prove the truthful intentions and non-robotic nature of the user. As the servers were meant to automatically deliver baseline results, this turned out to be impracticable as it required constant manual interaction.

(1 A/B) **VPS Security** Although the VPS’ operating systems were regularly updated to the latest version, we received alerts of increased Disk I/O requests during the study on one of the Australian VPS (see Figure 4.21a). As we did not perform recurring high-load operations on these machines, they possibly received malicious attention from the outside. The server logs showed the patterns of a distributed brute-force authentication attack over SSH on almost all of the servers (see Figure 4.21b for an example log). The server becoming a target of coordinated attacks disqualifies it as reliable control for the study. However, due to the structure of the attacks I assumed that we were dealing with an arbitrary non-targeted online attack with either leaked or widely used “standard” credentials. As our servers were protected with strong passphrases, they were not shut down. As a countermeasure, we could have used a SSH port different from the standard Port 22, blocked all access from IPs other than the ones on a whitelist, entirely prohibit SSH remote logins or only allowed SSH login via public/private RSA keys. These approaches were rejected, because the problem occurred at the end of the machines’ lifecycle. For future studies that use a similar setup, it would be advisable to use a whitelisted VPN server to connect to the VPS, so all stakeholders have access through a protected tunnel. Other than that, enabling authentication via fingerprint is also effective but requires the stakeholders to collect their respective keys first and add them to every server.

(1 A/B) **Human-Computer Differences:** As discussed in (Diakopoulos, 2013a), a SRA might behave differently if queried by an automatic agent. Diakopoulos therein experienced this phenomenon as results of human-computer interaction did not line up with bare API requests. He argues that in order to
Hello Anna Couturier,

Your Cloud Server ‘north-cheese.bnr.la’ has triggered its Disk I/O Requests alert by averaging 1409 requests/second over the last four hours. This alert is currently generated at 500 requests/second.

This alert is provided to help ensure your Cloud Server is performing optimally and inform you if there is an unexpected change in your Cloud Server resource usage pattern. It is not an official warning nor are you required to act on its contents.

If you do not wish to receive alerts of 500 requests/second is not a suitable threshold for your Cloud Server, please visit https://www.bnr.la/panel/alerts/north-cheese.bnr.la to modify or disable the Disk I/O Requests alert.

Kind Regards,
The [Redacted]

(a) VPS provider alert after a spike of 1409 request per second, screenshot by author

(b) auth.log of the attacked server, screenshot by author

Figure 4.21: Brute-force attack on one of the VPS in the Australia control group on 15.02.2020
4.3. Lessons learned

To conduct a truly reliable study, one has to closely imitate users and simulate the usage scenario as close as possible. This has to be adapted to the respective target audience of a Crowdsourced Audit as well since demographics might have an effect on Internet and media literacy.

(1 B/C) Research detection: Internet-based service providers of Google’s scale might have the capability to detect automatized audits. There is no such evidence but some of our VPS were blocked because of increased traffic from the respective Internet node. This proves that there are at least some mechanisms to deal with suspicious traffic. Scholars already noted the possibility of this to happen in [Datta et al., 2015].

This being said, organized computational approaches like Sock Puppet or Crowdsourced Audits that operate in very predictable patterns are easy to be identified and might see countermeasures such as captchas, traffic thresholds, IP-range blocking and adapted responses. They were all hosted by a single provider, thus it seemed like other virtual machines on the respective server already produced too much traffic. This being said, relying on third-party hardware, especially virtual machines can impede a research endeavor. Actions by other clients of the respective virtual machine can arouse suspicion. This might entail punitive measures by the researched Black Box system against the whole IP range allocated to the virtual machines of a server.

(1 B/C) Bot-Control: A scraping audit like the one used in this thesis must be easily manageable. This requires centralized roll-out, administration and controlling of VPS as well as real-time information about every machine’s performance. It took an unnecessarily long time to set up the VPS due to the multitude of providers, procedures, requirements. Although the rented VPS had equal specifications, the runtime behavior of the machines differed greatly from optimal to unstable to unusable. Some would perform flawlessly, others crashed at low loads. It would have saved a lot of time and effort to order VPS services from only one provider that operates globally and serves with scalability both in size and reach. This could have greatly reduced setup times, administrative overhead and configuration efforts. Also, it would have greatly simplified logging of VPS performance.

(1 C) Timing Intervals: Data analysis showed that the majority of submissions by real users occurred in between the 4-hour intervals. Thus, including the data donation in the startup process of the browsers was vital for the collection. Of course, the subject of interest (stem cell treatments) may show some topical advancement over time, but it is not as time-sensitive as for example news-related political data shortly before a major election (as in [Krafft et al., 2017]).

(2) Collected Data: “Raw” data is superior. By pre-selecting the attributes to store, the chance to re-analyze the results is missed. Thus, an evaluation from a different perspective or with an alternative research question at a later point of time is basically impossible. Also, the snapshot of the real result page is lost. On top of that, future research is hampered by this limitation. After all, we decided to publish the collected data after the study

29meaning unfiltered
concludes.

(3) **Timeliness and obfuscation of ads:** Many ads were delivered over ad networks like Google’s *doubleclick* or *googleadservices*. To enable performance tracking and billing, these referrer links contain uniquely identifying sequences and are often obfuscated with respect to their actual destination. Moreover, those links are only valid for a limited time. Therefore, the destinations of the links collected during the study period were not accessible for further examination at the time of the analysis.

The source of an advertisement was inferred only from the data that was available on the SERP, namely the respective *name* of each ad as it was denoted in the crawled HTML element. In the process of creating ads though, one is not hindered to put any arbitrary URL as a redirect destination. Theoretically, an entity other than the promoted one may have created the ad. Consequently, neither their origin, nor their destination could be retrieved.

Further research should consider capturing the eventual landing pages (possibly after a user interaction like a click) as well to allow a reliable association of ads and websites. Nevertheless, some links included clear text destination URLs that could be extracted and scrutinized.

(3) **Data Format:** The data was made available as a csv-file download. The collected data was very heterogenous with respect to symbols (some even included smileys) and special characters like commas were not escaped in the first place. Thus, the delimiter (we used a semi-colon, “;”) has to be carefully picked to correctly structure the downloaded data. Moreover, the server download function initially changed all double-quotes to single-quotes making parsing the string data to JSON impracticable.
5. Conclusion

“I think our findings suggest that there are parts of the ad ecosystem where kinds of discrimination are beginning to emerge and there is a lack of transparency, this is concerning from a societal standpoint.” (Simonite, 2015, Anupam Datta, one of the developers of AdFisher)

In this thesis, I examined the socio-technical system of web-advertising using the example of Google’s integrated search engine. I developed a browser plugin to crowdsource data that was used to conduct a Black Box analysis of said system. I wanted to scrutinize whether a change in Google’s advertising policy had any effect on problematic health-related ads.

The data from our collection shows that Google’s policy change did not eradicate questionable stem cell advertisements on its online platform. Thus, patients of severe diseases are still being targeted by providers of unproven stem cell treatments and other questionably actors. This poses a societal risk because a vulnerable user group is being discriminated. The second research question cannot be fully answered. Although there were no significant effects, this might be due to our small and possibly biased sample.

Besides, we learned that there are several competing actors that advertise in the realm of stem cell treatments. Those actors have distinct motivations with respect to either commercial or educational intentions. There is a constant struggle for attention between cautionary medical associations and questionable actors. The narrative of stem cell tourism as described in Section 2.6 could be confirmed as there were multiple agents that openly advertised unapproved treatments.

Discrimination can occur through an advertiser’s questionable motivation, the targeting process or the targeted audience (the eventual outcome) (Speicher et al., 2018). Due to the high complexity and interdependency of the platform, we cannot determine which of the three causes ultimately lead to this condition. In order to sustain the web search ecosystem, it is vital to guarantee users safe interaction with advertisers’ content (K. O’Donnell & Cramer, 2015). Society and especially advertisers and intermediaries in the online advertising ecosystem need to consider users’ perception of ads, including potential confusion as well as concerns regarding personalization and abuse.

To summarize, it should be possible to scrutinize socially relevant algorithms as they have significant impacts on society. Because society decides which parts of a technical system to adopt, all involved parties have to assess technical components collaboratively to establish fair and safe communication processes. Either providers of SRE should enable examination or society should strive to analyze, evaluate and correct these systems.
6. Future Work

On a last note, we found that socially relevant algorithms like the ones deployed in Google’s ISE are impossible to scrutinize from the outside. Any conventional small-scale study fails because of unobservable variables, timeliness of algorithms, interdependence of actors, Personalization and A/B-Testing of online services make it make it hard to retrieve a comparable snapshot of a system. Due to the opaque nature of these SRE, researchers are compelled to use Black Box analysis and demand “infrastructure and tools to study these systems at much larger scale” (Simonite, 2015, Roxana Geambasu). This would allow for a “widely applicable, systematic approach with a real impact” (Pederechi et al., 2018, p. 5). This being said, academics concerned with the field propose two main approaches. Along with an (possibly selectively) accessible API to test SRAs (possibly by a watchdog authority (Zweig, Fischer, et al., 2018)) it would be helpful to establish methods and infrastructures that allow for crowdsourced and publicly available data donations.

The first approach intends to probe SRAs or socio-technical systems via an interface that enables researchers to gather receive output for a specified. In our case, outputs are usually heavily personalized, so this would require computing input configurations based on the variables that the algorithm uses. As these remain undisclosed, this option falls short. Further research may come up with software to facilitate crowdsourced data collection and standardized Black Box frameworks to scrutinize online platforms. Regulatory efforts should encourage developers of algorithms to comply with principles of algorithm accountability and foster public scrutiny (USACM, 2017).

However, SRAs must be evaluated in the respective contexts or environments they are applied in to account for emergent effects. Thus, involving the affected social system is crucial for a sound analysis. Thus, it has been suggested to establish trustworthy and honest Donation Brokers (Vaught & Lockhart, 2012). These could act as an intermediary between data donors and researchers. They could enable donors to determine the terms of usage with respect to time, research subject or involved parties. In turn, the broker would ensure proper use and conduct as well as fair licensing (Hummel et al., 2019). Crowdsourcing data collection in a privacy preserving manner would enable society to take part in the process of algorithm accountability and support the scrutinizing of algorithmic systems that affect them. Herein,

\footnote{However, this would undermine the notion of a donations as gifts in the sense of “conscious, deliberate, uncoerced acts of giving, informed by beliefs about a need that is being addressed through the donation” (Hummel et al., 2019). Nonetheless, it has to be made clear to users that digital data donations are subject to an uncertain future use and an unknown degree of comprehensibility through emerging methods of gathering and analysis.}
future research could develop frameworks of transparent and reliable donation platforms were society can contribute to public scrutiny of private technical systems.

In addition, comprehensible information pertaining to data sources and algorithmic decisions can be a field of future research. Similar to the “Nutrition Label for privacy” (Kelley et al., 2009; Kelley et al., 2010), this may improve users’ understanding of underlying mechanics and risks and improve technological literacy. This might increase user acceptance and reduce perceived discrimination, questionable advertisements and data privacy scandals.

Finally, interdisciplinary research might yield interesting insights in how systems can be governed. Kooiman draws a framework that helps to characterize interactions and mutual influences of interdependent systems. His model of governance could in the future be applied to STS to understand the governability of the systems and their respective interactions (Kooiman, 2008; Kooiman & Bavinck, 2013).

With respect to the EDD, there is still a lot to uncover. This thesis only provided a glimpse at the workings of the web-based SCT industry. The multivariate data that was collected, provides new perspectives on the web advertising ecosystem that evolves around stem cell treatments. Including questions like:

- Who is your go-to information source pertaining to stem cell treatments?
- Do you search for health-related information online?
- What are your concerns with respect to stem cell treatments?
- What are the first 3 terms that come to your mind when you think of stem cell treatments?
- Are you willing to try experimental therapies?

on future surveys might shed a light on the motivations of patients to search for health related information online and who they trust. It would also be interesting to learn whether some advertisers succeeded in “branding” a search term. If donors are willing to submit more data about themselves, researchers are able to deduce targeting mechanisms. They could investigate the relation between types of advertisement and medical condition or sensitive attributes like religious beliefs, risk affinity and Internet literacy. Because the evaluation of online offers of SCT is probably highly dependent on familiarity with the Internet and the health sector in general, correlations between those factors could be subject of future research.

The majority of creatives was composed from a collection of terms that are used in alternating order and combinations. It would be interesting to analyze these compositions in the future to search for patterns with respect to personalization.

Another interesting field is the to be found at the second largest host of ads in our study. The subset of data concerned with drugs can be analyzed with respect to the targeting behavior of advertisers. The peek into some
of the advertisements revealed that they are equally addressing patients and practitioners. Future research could be concerned with the degree to which this targeting occurs.

As Couturier proposed above, the classification of advertisement hosts is ongoing work and needs some more scrutiny by medical professionals and people who are familiar with the field of SCT. The comparison of advertisement creatives and landing page content could reveal whether misleading lures are used to capture users’ attention.

To further explore the international targeting of providers of SCT, it would be interesting to collect more detailed user information with respect to their residence and examine the regional scope of the various advertiser categories.
Bibliography

Adam Gale. (2015). Management Today: Are Google’s algorithms sexist? Retrieved February 6, 2017, from http://www.managementtoday.co.uk/googles-algorithms-sexist/article/1354946

Akhtar, A. (2019). New York is investigating UnitedHealth’s use of a medical algorithm that steered black patients away from getting higher-quality care. Retrieved December 16, 2019, from https://www.businessinsider.de/international/an-algorithm-treatment-to-white-patients-over-sicker-black-ones-2019-10/

Albright, J. (2017). Welcome to the Era of Fake News. Media and Communication, 5(2), 87–89. https://www.doi.org/10.17645/mac.v5i2.977

Algorithm Watch. (2017). Watching the watchers: Epstein and Robertson’s „Search Engine Manipulation Effect“. Retrieved January 29, 2020, from https://algorithmwatch.org/en/watching-the-watchers-epstein-and-robertsons-search-engine-manipulation-effect/

Amariglio, N., Hirshberg, A., Scheithauer, B. W., Cohen, Y., Loewenthal, R., Trakhtenbrot, L., Paz, N., Koren-Michowitz, M., Waldman, D., Leider-Trejo, L., et al. (2009). Donor-derived brain tumor following neural stem cell transplantation in an ataxia telangiectasia patient. Public Library of Science, 6(2).

Ammori, M. (2014). The “New” New York Times: Free Speech Lawyering in the Age of Google and Twitter: The First Amendment moves beyond the courts. Harvard Law Review, 127, 2259–2296. https://harvardlawreview.org/2014/06/the-new-new-york-times-free-speech-lawyering-in-the-age-of-google-and-twitter/

Ananny, M. (2016). Toward an Ethics of Algorithms. Science, Technology, & Human Values, 41(1), 93–117. https://doi.org/10.1177/0162243915606523

Andreou, A., Venkatadi, G., Goga, O., Gummadi, K., Loiseau, P., & Mislove, A. (2018). Investigating Ad Transparency Mechanisms in Social Media: A Case Study of Facebook’s Explanations. NDSS 2018 - Network and Distributed System Security Symposium. https://doi.org/10.14722/ndss.2018.23204.hal-01955309

Andreou, A., Silva, M., Benevenuto, F., Goga, O., Loiseau, P., & Mislove, A. Measuring the Facebook Advertising Ecosystem (A. Oprea & D. Xu, Eds.). In: In Proceedings 2019 Network and Distributed System Security Symposium (A. Oprea & D. Xu, Eds.). Ed. by Oprea, A., & Xu, D. Reston, VA: Internet Society, 2019, 1–15. ISBN: 1-891562-55-X. https://doi.org/10.14722/ndss.2019.23280.
Angwin, J., & Parris Jr., T. (2016). Facebook Lets Advertisers Exclude Users by Race. Retrieved February 6, 2017, from https://www.propublica.org/article/facebook-lets-advertisers-exclude-users-by-race

Angwin, J., Varner, M., & Tobin, A. (2017). Facebook Enabled Advertisers to Reach ‘Jew Haters’. Retrieved January 15, 2020, from https://www.propublica.org/article/facebook-enabled-advertisers-to-reach-jew-haters

Arbeitsgruppe Soziologie. (1978). Denkweisen und Grundbegriffe der Soziologie: Eine Einführung (Vol. 543). Campus.

Ashby, W. R. (1957). An Introduction to Cybernetics. Chapman & Hall.

Ashkan, A., Clarke, C. L. A., Agichtein, E., & Guo, Q. Classifying and Characterizing Query Intent (M. Bouhanem, C. Berrut, J. Mothe, & C. Soule-Dupuy, Eds.). In: Advances in Information Retrieval (M. Bouhanem, C. Berrut, J. Mothe, & C. Soule-Dupuy, Eds.). Ed. by Bouhanem, M. Berlin, Heidelberg: Springer Berlin Heidelberg, 2009, 578–586. ISBN: 978-3-642-00958-7.

Backstrom, L., & Kleinberg, J. Romantic partnerships and the dispersion of social ties: a network analysis of relationship status on facebook. In: Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing. 2014, 831–841. Retrieved January 9, 2020, from https://dl.acm.org/ft_gateway.cfm?id=2531642

Baker, P., & Potts, A. (2013). ‘Why do white people have thin lips?’ Google and the perpetuation of stereotypes via auto-complete search forms. Critical Discourse Studies, 10(2), 187–204. https://doi.org/10.1080/17405904.2012.744320

Ballatore, A. (2015). Google chemtrails: A methodology to analyze topic representation in search engine results. first monday, 20(7). https://doi.org/10.5210/fm.v20i7.5597

Balog, K., & Kenter, T. Personal Knowledge Graphs (Y. Fang, Y. Zhang, J. Allan, K. Balog, B. Carterette, & J. Guo, Eds.). In: Proceedings of the 2019 ACM SIGIR International Conference on Theory of Information Retrieval - ICTIR ’19 (Y. Fang, Y. Zhang, J. Allan, K. Balog, B. Carterette, & J. Guo, Eds.). Ed. by Fang, Y. New York, New York, USA: ACM Press, 2019, 217–220. ISBN: 9781450368810. https://doi.org/10.1145/3341981.3344241

Barford, P., Canadi, I., Krushevskaja, D., Ma, Q., & Muthukrishnan, S. (2014). Adscape: Harvesting and Analyzing Online Display Ads. Retrieved January 3, 2020, from http://arxiv.org/pdf/1407.0788v2

Battelle, J. (2005). The Search: How Google and Its Rivals Rewrote the Rules of Business and Transformed Our Culture. Nicholas Brealey.

Baum, W. M. (2013). What counts as behavior? The molar multiscale view. The Behavior Analyst, 36(2), 283–293. https://doi.org/10.1007/bf03392315

Belkin, N. J. (1978). Information concepts for information science. Journal of documentation, 34(1), 55–85.
Bennett, J. (2010). *Vibrant matter: A political ecology of things*. Duke University Press.

Bi, B., Shokouhi, M., Kosinski, M., & Graepel, T. Inferring the demographics of search users: Social data meets search queries. In: *Proceedings of the 22nd international conference on World Wide Web*. 2013, 131–140. Retrieved January 9, 2020, from https://www.microsoft.com/en-us/research/wp-content/uploads/2013/01/www2013.pdf

Biddings, A. (2019a). A new policy on advertising for speculative and experimental medical treatments. Retrieved December 2, 2019, from https://support.google.com/google-ads/answer/9475042

Biddings, A. (2019b). Google Ads Help: A new policy on advertising for speculative and experimental medical treatments. Retrieved December 25, 2019, from https://support.google.com/google-ads/answer/9475042?hl=en

Bilić, P. (2016). Search algorithms, hidden labour and information control. *Big Data & Society, 3*(1), 205395171665215. https://doi.org/10.1177/2053951716652159

BIS Research. (2019). PR Newswire: Global Stem Cell Therapy Market to Reach $11 Billion by 2029: BIS Research. Retrieved January 4, 2020, from https://www.prnewswire.com/news-releases/global-stem-cell-therapy-market-to-reach-11-billion-by-2029-bis-research-300911365.html

Bond, R. M., Fariss, C. J., Jones, J. J., Kramer, A. D. I., Marlow, C., Settle, J. E., & Fowler, J. H. (2012). A 61-million-person experiment in social influence and political mobilization. *Nature, 489*(7415), 295–298. https://doi.org/10.1038/nature11421

Bracha, O., & Pasquale, F. (2008). Federal Search Commission - Access, Fairness, and Accountability in the Law of Search. *Cornell Law Review, 93*(6), 1149–1210.

Brin, S., & Page, L. (1999). The Anatomy of a Large-Scale Hypertextual Web Search Engine. Retrieved December 29, 2019, from http://infolab.stanford.edu/~backrub/google.html

Broder, A. (2002). A Taxonomy of Web Search. *SIGIR Forum, 36*(2), 3–10. https://doi.org/10.1145/792550.792552

Brukman, M. Y., Horling, B. C., & Zamir, O. E. (2013). *Systems and methods for promoting search results based on personal information* (No. 8,620,915). Retrieved January 1, 2020, from https://patentimages.storage.googleapis.com/fd/5e/c8/8e9f3bf69ac9fb/US8620915.pdf

Brunton, F., & Nissenbaum, H. (2011). Vernacular resistance to data collection and analysis: A political theory of obfuscation. *First Monday, 16*(5). Retrieved January 29, 2020, from https://firstmonday.org/ojs/index.php/fm/article/view/3493

Bucher, T. (2016). Neither Black Nor Box: Ways of Knowing Algorithms. In S. Kubitschko & A. Kaun (Eds.), *Innovative Methods in Media and Communication Research* (pp. 81–98). Springer International Publishing. https://doi.org/10.1007/978-3-319-40700-5_15
Cambridge Dictionary. (2019). Dictionary: relevance. Retrieved December 28, 2019, from https://dictionary.cambridge.org/us/dictionary/english/relevant

Chambers, C. (2014). Facebook fiasco: was Cornell’s study of ‘emotional contagion’ an ethics breach? Retrieved January 31, 2020, from https://www.theguardian.com/science/head-quarters/2014/jul/01/facebook-cornell-study-emotional-contagion-ethics-breach

Chandler, J. A. (2007). A right to reach an audience: An approach to intermediary bias on the Internet. Hofstra Law Review, 35(3), 1095–1136. http://scholarlycommons.law.hofstra.edu/hlr/vol35/iss3/6

Chen, S. (2017). China to build giant facial recognition database to identify any citizen within seconds. Retrieved January 7, 2020, from https://www.scmp.com/news/china/society/article/2115094/china-build-giant-facial-recognition-database-identify-any

Christian, B. (2012). The A/B Test: Inside the Technology That’s Changing the Rules of Business. Retrieved February 22, 2020, from http://www.wired.com/business/2012/04/ff_abtesting/.

Citron, D. K., & Pasquale, F. (2014). The Scored Society: Due Process for Automated Predictions. Washington Law Review Washington Law Review, (89). https://digitalcommons.law.uw.edu/wlr/vol89/iss1/2

Clark, H. H., & Brennan, S. E. (1991). Grounding in Communication. Perspectives on Socially Shared Cognition, 13, 127–149. Retrieved January 6, 2020, from http://www.cs.cmu.edu/~hillah/CLASSDOCS/Clark91.pdf

Clark, J. (2015). Google Turning Its Lucrative Web Search Over to AI Machines. Retrieved December 30, 2019, from https://www.bloomberg.com/news/articles/2015-10-26/google-turning-its-lucrative-web-search-over-to-ai-machines

comscore. (2019). Latest Rankings. Retrieved December 30, 2019, from https://www.comscore.com/Insights/Rankings

Connolly, R., O’Brien, T., & Flaherty, G. (2014). Stem cell tourism—a web-based analysis of clinical services available to international travellers. Travel medicine and infectious disease, 12(6 Pt B), 695–701. https://doi.org/10.1016/j.tmaid.2014.09.008

Corporate Europe Observatory. (2016). Thinking allowed? How think tanks facilitate corporate lobbying. Retrieved February 4, 2020, from https://corporateeurope.org/en/power-lobbies/2016/07/thinking-allowed

Couturier, A. (2019). Stem Cells and Google Search. https://www.eurostemcell.org/datadonation

Coy, W. (2013). Was ist Informatik? Was ist Informatik? Zur Entstehung des Faches an den deutschen Universitäten. In H. D. Hellige (Ed.), Geschichten der Informatik: Visionen, Paradigmen, Leitmotive (pp. 473–497). Springer.

Dai, H. K., Zhao, L., Nie, Z., Wen, J.-R., Wang, L., & Li, Y. Detecting online commercial intention (OCI). In: Proceedings of the 15th international conference on World Wide Web. 2006, 829–837. Retrieved January 13, 2020, from https://dl.acm.org/doi/10.1145/1135777.1135902
Bibliography

Datta, A., Tschantz, M. C., & Datta, A. (2015). Automated Experiments on Ad Privacy Settings. *Proceedings on Privacy Enhancing Technologies, 2015*(1), 92–112. https://doi.org/10.1515/poptets-2015-0007

Davies, D. (2017a). Patent 1 of 2: How Google learns to influence and control users. Retrieved December 30, 2019, from https://searchengineland.com/patent-1-2-google-learns-influence-control-users-272358

Davies, D. (2017b). Patent 2 of 2: How Google learns to guide purchasing decisions. Retrieved December 30, 2019, from https://searchengineland.com/patent-2-2-google-learns-guide-purchasing-decisions-273055

Dhar, V. (2013). Data science and prediction. *Communications of the ACM, 56*(12), 64–73. https://doi.org/10.1145/2500499

Diakopoulos, N. (2013a). Algorithmic Accountability Reporting: On the Investigation of Black Boxes. https://doi.org/10.7916/D8ZK5TW2

Diakopoulos, N. (2013b). Sex, Violence, and Autocomplete Algorithms: What words do Bing and Google censor from their suggestions. Retrieved December 24, 2019, from https://slate.com/technology/2013/08/words-banned-from-bing-and-googles-autocomplete-algorithms.html

Diakopoulos, N. (2015). Algorithmic Accountability. Journalistic investigation of computational power structures. *Digital Journalism, (3)*, 398–415. https://doi.org/10.1080/21670811.2014.976411

Dickey, M. R. (2017). Algorithmic Accountability. Retrieved December 16, 2019, from https://techcrunch.com/2017/04/30/algorithmic-accountability/

Dietvorst, B. J., Simmons, J. P., & Massey, C. (2015). Algorithm aversion: people erroneously avoid algorithms after seeing them err. *Journal of experimental psychology. General, 144*(1), 114–126. https://doi.org/10.1037/xge0000033

Dodd, H. (2017). Exclusive Q&A with Google’s Gary Illyes at BrightonSEO 2017.

Donzelot, J. (1991). The mobility of society. In M. Foucault, G. Burchell, C. Gordon, & P. Miller (Eds.), *The Foucault effect* (pp. 169–179). University of Chicago Press.

Doshi-Velez, F., & Kim, B. (2017). Towards A Rigorous Science of Interpretable Machine Learning. http://arxiv.org/pdf/1702.08608v2

Duden. (2020). Definition googeln. Retrieved February 21, 2020, from https://www.duden.de/rechtschreibung/googeln

Dyer, G. (1982). *Advertising as communication*. Routledge.

Ebeling, M. F. (2019). Patient disempowerment through the commercial access to digital health records. *Health (London, England : 1997), 23*(4), 385–400. https://doi.org/10.1177/1363459319848038

Eckersley, P. How Unique Is Your Web Browser? (M. J. Atallah & N. J. Hopper, Eds.). In: In *Privacy Enhancing Technologies* (M. J. Atallah & N. J. Hopper, Eds.). Ed. by Atallah, M. J., & Hopper, N. J. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010, 1–18. ISBN: 978-3-642-14527-8. Retrieved January 13, 2020, from https://panopticlick.eff.org/static/browser-uniqueness.pdf
Edelman, B. (2011). Bias in Search Results?: Diagnosis and Response. The Indian Journal of Law and Technology, 7, 16–32.

Edelman, B., Ostrovsky, M., & Schwarz, M. (2007). Internet advertising and the generalized second-price auction: Selling billions of dollars worth of keywords. 97(1), 242–259. Retrieved January 25, 2020, from http://www.cs.columbia.edu/coms6998-3/gsp.pdf

Editorial. (2010). The Google Algorithm. The New York Times, A30. Retrieved December 30, 2019, from https://www.nytimes.com/2010/07/15/opinion/15thu3.html

EFF. (2019). CDA 230: The most important law protecting internet speech: Section 230 of the Communications Decency Act. Retrieved December 16, 2019, from https://www.eff.org/issues/cda230

Ehrling, L., & Wöß, W. Towards a Definition of Knowledge Graphs Conference on Semantic Systems - SEMANTiCS2016 and the 1st International Workshop on Semantic Change & Evolving Semantics (SuCESS’16) co-located with the 12th International Conference on Semantic Systems (SEMANTiCS 2016), Leipzig, Germany, September 12-15, 2016 (M. Martin, M. Cuquet, & E. Folmer, Eds.). In: In Joint Proceedings of the Posters and Demos Track of the 12th International Conference on Semantic Systems - SEMANTiCS2016 and the 1st International Workshop on Semantic Change & Evolving Semantics (SuCESS’16) co-located with the 12th International Conference on Semantic Systems (SEMANTiCS 2016), Leipzig, Germany, September 12-15, 2016 (M. Martin, M. Cuquet, & E. Folmer, Eds.). Ed. by Martin, M. CEUR Workshop Proceedings. CEUR-WS.org, 2016. http://ceur-ws.org/Vol-1695/paper4.pdf

Enserink, M. (2006). Biomedicine. Selling the stem cell dream. Science (New York, N.Y.), 313(5784), 160–163. https://doi.org/10.1126/science.313.5784.160

Epstein, R., & Robertson, R. E. Democracy at risk: Manipulating search rankings can shift voters’ preferences substantially without their awareness. In: 25th annual meeting of the Association for Psychological Science. 2013.

Epstein, R., & Robertson, R. E. (2015). The search engine manipulation effect (SEME) and its possible impact on the outcomes of elections. Proceedings of the National Academy of Sciences of the United States of America, 112(33), E4512–21. https://doi.org/10.1073/pnas.1419828112

Eslami, M., Vaccaro, K., Lee, M. K., Elazari Bar On, A., Gilbert, E., & Karahalios, K. User Attitudes towards Algorithmic Opacity and Transparency in Online Reviewing Platforms (S. Brewster, G. Fitzpatrick, A. Cox, & V. Kostakos, Eds.). In: In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19 (S. Brewster, G. Fitzpatrick, A. Cox, & V. Kostakos, Eds.). Ed. by Brewster, S. New York, New York, USA: ACM Press, 2019, 1–14. isbn: 9781450359702. https://doi.org/10.1145/3290605.3300724.
Evans, D. S. (2009). The online advertising industry: Economics, evolution, and privacy. *Journal of economic perspectives*, 23(3), 37–60.

Faiola, A., & Kirchner, S. (2017). How do you stop fake news? In Germany, with a law. Retrieved December 16, 2015, from https://www.washingtonpost.com/world/europe/how-do-you-stop-fake-news-in-germany-with-a-law/2017/04/05/e6834ad6-1a08-11e7-bcc2-7d1a0973e7b2_story.html

Farber, D. (2013). Google Search scratches its brain 500 million times a day. Retrieved December 30, 2019, from https://www.cnet.com/news/google-search-scratches-its-brain-500-million-times-a-day/

Farr, C. (2019). Amazon acquires start-up Health Navigator, its first health-related purchase since PillPack. Retrieved December 11, 2019, from https://www.cnbc.com/2019/10/23/amazon-acquires-digital-health-start-up-health-navigator.html

Federal Trade Commission. (2014). Data Brokers: A Call For Transparency and Accountability. Retrieved December 12, 2019, from https://www.ftc.gov/system/files/documents/reports/data-brokers-call-transparency-accountability-report-federal-trade-commission-may-2014/140527databrokerreport.pdf

Foerster, J. N., & Brewin, F. P. (2017). *Detecting and correcting potential errors in User Behavior: G06N7/00* (US 20170083821 A1). Retrieved December 30, 2019, from http://www.freepatentsonline.com/y2017/0083821.html

Food and Drug Administration. (2019). FDA Warns About Stem Cell Therapies. Retrieved February 22, 2020, from https://www.fda.gov/consumers/consumer-updates/fda-warns-about-stem-cell-therapies

Gabriel, R. (2016). Enzyklopädie der Wirtschaftsinformatik - Online Lexikon: Informationssystem. Retrieved December 25, 2019, from https://www.enzyklopaedie-der-wirtschaftsinformatik.de/wi-encyklopaedie/lexikon/uebergreifendes/kontext-und-grundlagen/informationssystem/index.html

Gangadharan, S. P. (2017). The downside of digital inclusion: Expectations and experiences of privacy and surveillance among marginal Internet
users. *New Media & Society*, 19(4), 597–615. https://doi.org/10.1177/1461444815614053

Gasser, U. (2006). Regulating search engines: Taking stock and looking ahead. *Yale Journal of Law and Technology*, 8(1), 201. Retrieved December 27, 2019, from https://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1028&context=yjolt

Gauzente, C. (2010). The intention to click on sponsored ads—A study of the role of prior knowledge and of consumer profile. *Journal of Retailing and Consumer Services*, 17(6), 457–463. https://doi.org/10.1016/j.jretconser.2010.06.002

Geiger, R. S. (2014). Bots, bespoke, code and the materiality of software platforms. *Information, Communication & Society*, 17(3), 342–356. https://doi.org/10.1080/1369118X.2013.873069

Gelles, D., Tabuchi, H., & Dolan, M. (2015). Complex Car Software Becomes the Weak Spot Under the Hood. Retrieved January 21, 2020, from https://www.nytimes.com/2015/09/27/business/complex-car-software-becomes-the-weak-spot-under-the-hood.html

Gilbert, R. (2018). Understanding Stem Cell Therapy in Parkinson’s Disease Treatment. Retrieved January 4, 2020, from https://www.apdaparkinson.org/article/understanding-stem-cell-therapy-in-parkinsons-disease-treatment/

Gillespie, T. (2014). The Relevance of Algorithms. *Media technologies: Essays on communication, materiality, and society*, 167.

Glaser, T. (2009). Die Rolle der Informatik im gesellschaftlichen Diskurs: Eine Neupositionierung der Informatik. *Informatik-Spektrum*, 32(3), 223–227. https://doi.org/10.1007/s00287-009-0324-y

Goel, S., Hofman, J. M., & Sirer, M. I. (2012). Who Does What on the Web: A Large-Scale Study of Browsing Behavior. *Sixth International AAAI Conference on Weblogs and Social Media.*

Goldacre, B. (2014). When data gets creepy: the secrets we don’t realise we’re giving away. https://www.theguardian.com/technology/2014/dec/05/when-data-gets-creepy-secrets-were-giving-away

Goldman, E. (2006). Search engine bias and the demise of search engine utopianism. *Yale Journal of Law and Technology*, 8(1), 188–200. Retrieved December 29, 2019, from https://digitalcommons.law.yale.edu/yjolt/vol8/iss1/6

Google. (2007). Google to Acquire DoubleClick. Retrieved January 13, 2020, from https://googlepress.blogspot.com/2007/04/google-to-acquire-doubleclick-13.html

Google. (2010). Corporate Information. Retrieved January 15, 2020, from https://web.archive.org/web/20100222194842/http://www.google.com/80/corporate/tech.html

Google. (2012). Don’t censor the web. Retrieved February 23, 2020, from https://googleblog.blogspot.com/2012/01/dont-censor-web.html

Google. (2019a). About - Google. Retrieved December 16, 2019, from https://about.google/intl/en/
Google. (2019b). About ad position and Ad Rank. Retrieved January 27, 2020, from https://support.google.com/google-ads/answer/1722122
Google. (2019c). About automation with Google Ads. Retrieved December 30, 2019, from https://support.google.com/google-ads/answer/9297584?hl=en&ref_topic=6294205
Google. (2019d). About Customer Match. Retrieved February 3, 2020, from https://support.google.com/google-ads/answer/6379332
Google. (2019e). Ad Rank thresholds: Definition. Retrieved January 27, 2020, from https://support.google.com/google-ads/answer/7634668
Google. (2019f). Be just a Google search away. Retrieved February 3, 2020, from https://ads.google.com/home/campaigns/search-ads/
Google. (2019g). Determine a bid strategy based on your goals. Retrieved January 27, 2020, from https://support.google.com/google-ads/answer/2472725
Google. (2019h). General Guidelines to Search Quality Rating. Retrieved February 4, 2020, from https://static.googleusercontent.com/media/guidelines.raterhub.com/en//searchqualityevaluatorguidelines.pdf
Google. (2019i). How Ad Exchange works with Google Ads. Retrieved February 3, 2020, from https://support.google.com/google-ads/answer/2472739?hl=en&ref_topic=3121944
Google. (2019j). How Google Search Works: Learn how Google discovers, crawls, and serves web pages. Retrieved December 28, 2019, from https://support.google.com/webmasters/answer/70897?hl=en
Google. (2019k). How our Quality Raters make Search results better. Retrieved December 30, 2019, from https://support.google.com/websearch/answer/9281931?hl=en
Google. (2019l). How Search algorithms work. Retrieved December 28, 2019, from https://www.google.com/search/howsearchworks/algorithms/
Google. (2019m). How Search organizes information. Retrieved December 28, 2019, from https://www.google.com/search/howsearchworks/crawling-indexing/
Google. (2019n). List of Ad policies: Healthcare and medicines. Retrieved December 29, 2019, from https://support.google.com/adspolicy/answer/1760831
Google. (2019o). Misrepresentation. Retrieved December 27, 2019, from https://support.google.com/adspolicy/answer/6020955
Google. (2019p). Personalized advertising. Retrieved February 3, 2020, from https://support.google.com/adspolicy/answer/143465
Google. (2019q). Personalized Search Graduates from Google Labs. Retrieved December 16, 2019, from http://googlepress.blogspot.com/2005/11/personalized-search-graduates-from_10.html
Google. (2019r). Search Engine Optimization (SEO) Starter Guide. Retrieved December 28, 2019, from https://support.google.com/webmasters/answer/7451184
Google. (2019s). The Display Network tab. Retrieved February 3, 2020, from https://support.google.com/google-ads/answer/2456531?hl=en&ref_topic=3121769

Google. (2019t). Where your ads will appear on Google. Retrieved January 27, 2020, from https://support.google.com/google-ads/answer/6335981

Google. (2020a). About Gmail ads. Retrieved January 27, 2020, from https://support.google.com/google-ads/answer/7019460?hl=en

Google. (2020b). Search Engine Optimization (SEO) Starter Guide. Retrieved February 4, 2020, from https://support.google.com/webmasters/answer/7451184

Google. (2020c). Targeting your Ads. Retrieved January 27, 2020, from https://support.google.com/google-ads/answer/1704368?hl=en

Google. (2020d). Why you’re seeing an ad. https://support.google.com/accounts/answer/1634057

Google Transparency Project. (2017). Google Academics Inc. Retrieved February 4, 2020, from https://googletransparencyproject.org/sites/default/files/Google-Academics-Inc.pdf

Google Transparency Project. (2018). Google’s Academic Influences in Europe. Retrieved February 4, 2020, from https://www.googletransparencyproject.org/articles/googles-academic-influence-in-europe

Graham, M. (2019). Amazon is eating into Google’s most important business: Search advertising. Retrieved January 13, 2020, from https://www.cnbc.com/2019/10/15/amazon-is-eating-into-googles-dominance-in-search-ads.html

Granka, L. A. (2010). The Politics of Search: A Decade Retrospective. The Information Society, 26(5), 364–374. https://doi.org/10.1080/01972243.2010.511560

Granka, L., Joachims, T., & Gay, G. (2004). Eye-Tracking Analysis of User Behaviour in WWW Search. Proceedings of the 27th annual international ACM SIGIR conference on Research and development in information retrieval, 478–479. https://www.researchgate.net/profile/Geri-Gay/publication/2917730_Eye-Tracking_Analysis_of_User_Behavior_in_WWW_Search/links/0a85e5370029d39912000000/Eye-Tracking-Analysis-of-User-Behavior-in-WWW-Search.pdf

Grimmelmann, J. (2008). The google dilemma. NYL Sch. L. Rev., 53, 939.

Grimmelmann, J. (2010). Some Skepticism About Search Neutrality. The next digital decade: Essays on the future of the Internet, 435–459. Retrieved December 27, 2019, from https://digitalcommons.law.umd.edu/cgi/viewcontent.cgi?article=2421&context=fac_pubs

Grimmelmann, J. (2013). What to do about Google? Communications of the ACM, 56(9), 28–30. https://doi.org/10.1145/2500129

Grimmelmann, J. (2014). Speech engines. Minnesota Law Review, 98, 868. https://scholarship.law.umn.edu/mlr/299

Grimmelmann, J. (2017). The Structure of Search Engine Law. Iowa Law Review, 93, 3–63. Retrieved January 1, 2020, from https://digital
Grimmelmann, J. (2018). The Platform is the Message. Georgetown Law Technology Review, (Forthcoming), 18–30. Retrieved January 1, 2020, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3132758

Grohol, J. M. (2018). Emotional Contagion on Facebook? More Like Bad Research Methods. Retrieved January 31, 2020, from https://psychcentral.com/blog/emotional-contagion-on-facebook-more-like-bad-research-methods/

Grunwald, A. (2000). Technik für die Gesellschaft von morgen: Möglichkeiten und Grenzen gesellschaftlicher Technikgestaltung. Campus.

Grunwald, A. (2002). Technikfolgenabschatzung - Eine Einführung. edition sigma.

Gubin, M., Sung, S., Bharat, K., & Dauber, K. W. (2016). Entity identification model training (No. 9,251,141). Retrieved December 30, 2019, from http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=2&f=G&l=50&co1=AND&d=PTXT&s1=9,251,141&OS=9,251,141&RS=9,251,141

Guha, S., Cheng, B., & Francis, P. Challenges in measuring online advertising systems. In: Proceedings of the 10th ACM SIGCOMM conference on Internet measurement. 2010, 81–87.

Guidotti, R., Monreale, A., Ruggieri, S., Turini, F., Giannotti, F., & Pedreschi, D. (2018). A Survey of Methods for Explaining Black Box Models. ACM Comput. Surv., 51(5). https://doi.org/10.1145/3236009

Gupta, R., Sun, S., Blitzer, J., Lin, D., & Gabrilovich, E. (2014). Question answering to populate knowledge base (No. 10,108,700). Retrieved December 30, 2019, from http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2& Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PTXT&s1=10,108,700&OS=10,108,700&RS=10,108,700

Habermas, J. (1968). Technik und Wissenschaft als”Ideologie”? Man adn World, 1, 483–523.

Halevy, A. Y., Wu, F., Whang, S. E., & Gupta, R. (2018). Identifying entity attributes (No. 9,864,795). Retrieved December 30, 2019, from http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1& Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.htm&r=1&f=G&l=50&co1=AND&d=PTXT&s1=9,864,795.PN.&OS=PN/9,864,795&RS=PN/9,864,795

Hannak, A., Sapiezynski, P., Molavi Kakhki, A., Krishnamurthy, B., Lazer, D., Mislove, A., & Wilson, C. Measuring personalization of web search. In: Proceedings of the 22nd international conference on World Wide Web. 2013, 527–538.

Hannak, A., Soeller, G., Lazer, D., Mislove, A., & Wilson, C. Measuring Price Discrimination and Steering on E-commerce Web Sites (C. Williamson, A. Akella, & N. Taft, Eds.). In: In Proceedings of the 2014 Conference
Jansen, B. J., Booth, D. L., & Spink, A. (2008). Determining the informational, navigational, and transactional intent of Web queries. *Information Processing & Management, 44*(3), 1251–1266. https://doi.org/10.1016/j.ipm.2007.07.015

Joachims, T., Granka, L., Pan, B., Hembrooke, H., Radliski, F., & Gay, G. (2007). Evaluating the Accuracy of Implicit Feedback from Clicks and Query Reformulations in Web Search. *ACM Transactions on Information Systems (TOIS)*, **25**(2).

Jouhki, J., Lauk, E., Penttinen, M., Sormanen, N., & Uskali, T. (2016). Facebook’s Emotional Contagion Experiment as a Challenge to Research Ethics. *Media and Communication, 4*(4), 75. https://doi.org/10.17645/mac.v4i4.579

Kahnemann, D., & Tversky, A. (1984). Choices, Values, and Frames. *American Psychologist, 39*(4), 341–350.

Kang, R., Dabbish, L., Fruchter, N., & Kiesler, S. “My Data Just Goes Everywhere:” User Mental Models of the Internet and Implications for Privacy and Security. In: *Eleventh Symposium On Usable Privacy and Security (SOUPS 2015)*. 2015, 39–52.

Kay, M., Matuszek, C., & Munson, S. A. Unequal representation and gender stereotypes in image search results for occupations. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. 2015, 3819–3828.

Keller, M. (2013). The Apple ‘Kill List’: What Your iPhone Doesn’t Want You to Type. Retrieved January 29, 2020, from https://www.thedailybeast.com/the-apple-kill-list-what-your-iphone-doesnt-want-you-to-type

Kelley, P. G., Bresee, J., Cranor, L. F., & Reeder, R. W. A nutrition label for privacy. In: *Proceedings of the 5th Symposium on Usable Privacy and Security*. 2009, 4.

Kelley, P. G., Cesca, L., Bresee, J., & Cranor, L. F. (2010). Standardizing Privacy Notices: An Online Study of the Nutrition Label Approach. *Proceedings of the SIGCHI Conference on Human factors in Computing Systems* (pp. 1573–1582).

Kienle, A. (2003). *Integration von Wissensmanagement und kollaborativem Lernen durch technisch unterstützte Kommunikationsprozesse* (Dissertation). Universität Dortmund. Dortmund. Retrieved January 6, 2020, from https://www.fh-dortmund.de/de/fb/4/personen/lehr/kienle/veroel/10302010000158885.media/168985/10302010000168885.pdf

Kienle, A., & Kunau, G. (2014). *Informatik und Gesellschaft: Eine soziotechnische Perspektive*. De Gruyter / Oldenburg.
kim tami, t., Barasz, K., & John, L. K. (2019). Why am I seeing this ad? The effect of ad transparency on ad effectiveness. *Journal of Consumer Research, 45*(5), 906–932. https://doi.org/10.1093/jcr/ucy039

Kitchin, R. (2017). Thinking critically about and researching algorithms. *Information, Communication & Society, 20*(1), 14–29. https://doi.org/10.1080/1369118X.2016.1154087

Klymenko, I. (2012). Autopoiesis. In Ö. Jahraus, A. Nassehi, M. Grizelj, I. Saake, C. Kirchmeier, & J. Müller (Eds.), *Luhmann-Handbuch* (pp. 69–71). J.B. Metzler.

Kneer, G., & Nassehi, A. (1993). *Niklas Luhmanns Theorie sozialer Systeme: Eine Einführung* (Vol. 1751). W. Fink.

Knuth, D. E. (1968). *The art of computer programming* (1968): Volume 1 / Fundamental Algorithms. Addison-Wesley.

Kooiman, J. (2008). Exploring the Concept of Governability. *Journal of Comparative Policy Analysis: Research and Practice, 10*(2), 171–190. https://doi.org/10.1080/13876980802028107

Kooiman, J., & Bavinck, M. (2013). Theorizing Governability – The Interactive Governance Perspective. In M. Bavinck, R. Chuenpagdee, S. Jentoft, & J. Kooiman (Eds.), *Governability of Fisheries and Aquaculture: Theory and Applications* (pp. 9–30). Springer Netherlands. https://doi.org/10.1007/978-94-007-6107-0_2

Koscher, K., Czeskis, A., Roesner, F., Patel, S., Kohno, T., Checkoway, S., McCoy, D., Kantor, B., Anderson, D., Shacham, H., et al. Experimental security analysis of a modern automobile. In: 2010 IEEE Symposium on Security and Privacy. 2010, 447–462.

Kowalski, R. (1979). Algorithm = logic + control. *Communications of the ACM, 22*(7), 424–436. https://doi.org/10.1145/359131.359136

Krafft, T. D., Gamer, M., & Zweig, K. A. (2017). What did you see? Personalization, regionalization and the question of the filter bubble in Google’s search engine. *Proceedings of ACM Conference, Washington, DC, USA, July 2017*. http://arxiv.org/pdf/1812.10943v1

Krafft, T. D., Hauer, M. P., & Zweig, K. A. (2020). Why do we need bots? What prevents society from detecting biases in recommendation systems.

Kramer, A. D. I., Guillory, J. E., & Hancock, J. T. (2014). Experimental evidence of massive-scale emotional contagion through social networks. *Proceedings of the National Academy of Sciences of the United States of America, 111*(24), 8788–8790. https://doi.org/10.1073/pnas.132004011

Krishnamurthy, B., & Wills, C. E. (2006). Generating a Privacy Footprint on the Internet. *Proceedings of the 6th ACM SIGCOMM conference on Internet measurement* (pp. 65–70). ACM. Retrieved January 8, 2020, from http://www.cs.wpi.edu/~cew/papers/imc06.pdf

Krishnamurthy, B., & Wills, C. E. (2009a). On the Leakage of Personally Identifiable Information Via Online Social Networks. *Proceedings of the 2nd ACM workshop on Online social networks* (pp. 7–12). ACM.
Krishnamurthy, B., & Wills, C. E. (2009b). Privacy Diffusion on the Web: A Longitudinal Perspective. *Proceedings of the 18th international conference on World Wide Web* (pp. 541–550). ACM. Retrieved January 8, 2020, from [http://www2009.eprints.org/55/1/p541.pdf](http://www2009.eprints.org/55/1/p541.pdf)

Krishnamurthy, B., Malandrino, D., & Wills, C. E. Measuring Privacy Loss and the Impact of Privacy Protection in Web Browsing. In: *Proceedings of the 3rd Symposium on Usable Privacy and Security*. SOUPS ’07. New York, NY, USA: ACM, 2007, 52–63. ISBN: 978-1-59593-801-5. [https://doi.org/10.1145/1280680.1280688](https://doi.org/10.1145/1280680.1280688)

Kubota, Y. (2019). China’s New Internet-Censorship Rules Highlight Role of Algorithms. Retrieved January 3, 2020, from [https://www.wsj.com/articles/chinas-new-internet-censorship-rules-highlight-role-of-algorithms-11576845817](https://www.wsj.com/articles/chinas-new-internet-censorship-rules-highlight-role-of-algorithms-11576845817)

Kühnreich, K. (2017). Gamified Control? China’s Social Credit Systems. Retrieved January 7, 2020, from [https://media.ccc.de/v/34c3-8874-gamified_control](https://media.ccc.de/v/34c3-8874-gamified_control)

Kunau, G. (2006). *Facilitating Computer Supported Cooperative Work with Socio-Technical Self-Descriptions*.

Lambiotte, R., & Kosinski, M. (2014). Tracking the Digital Footprints of Personality. *Proceedings of the IEEE, 102*(12), 1934–1939. [https://doi.org/10.1109/JPROC.2014.2359054](https://doi.org/10.1109/JPROC.2014.2359054)

Lane, N. D., Xu, Y., Lu, H., Hu, S., Choudhury, T., Campbell, A. T., & Zhao, F. Enabling large-scale human activity inference on smartphones using community similarity networks (csn). In: *Proceedings of the 13th international conference on Ubiquitous computing*. 2011, 355–364.

Laperdrix, P., Bielova, N., Baudry, B., & Avoine, G. (2019). Browser Fingerprinting: A survey. [http://arxiv.org/pdf/1905.01051v2](http://arxiv.org/pdf/1905.01051v2)

Larson, J., & Shaw, A. (2012). Message Machine: Reverse Engineering the 2012 Campaign. Retrieved January 29, 2020, from [https://projects.propublica.org/emails/](https://projects.propublica.org/emails/)

Larson, J., Mattu, S., Kirchner, L., & Angwin, J. (2016). How we analyzed the COMPAS recidivism algorithm. *ProPublica*. Retrieved January 2, 2020, from [https://www.propublica.org/article/how-we-analyzed-the-compas-recidivism-algorithm](https://www.propublica.org/article/how-we-analyzed-the-compas-recidivism-algorithm)

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford University Press.

Law, J., & Lien, M. E. (2013). Slippery: Field notes in empirical ontology. *Social Studies of Science, 43*(3), 363–378. [https://doi.org/10.1177/030631271245947](https://doi.org/10.1177/030631271245947)

Lawrence, S. R. (2010). *Personalization of web search results using term, category and link-based user profiles* (No. 2010/0228715).
Lazer, D., Kennedy, R., King, G., & Vespignani, A. (2014). The parable of Google Flu: traps in big data analysis. *Science (New York, N.Y.)*, 343(6176), 1203–1205.

Lécuyer, M., Ducoffe, G., Lan, F., Papancea, A., Petsios, T., Spahn, R., Chaintréau, A., & Geambasu, R. Xray: Enhancing the web’s transparency with differential correlation. In: *23rd 5USENIX6 Security Symposium (5USENIX6 Security 14)*. 2014, 49–64.

Lessig, L. (2006). *Code* (2.0). Basic Books.

Levy, S. (2010). Exclusive: How Google’s Algorithm Rules the Web. Retrieved December 30, 2019, from https://www.wired.com/2010/02/ff_google_algorithm/

Li, J., Theng, Y.-L., & Foo, S. (2016). Predictors of online health information seeking behavior: Changes between 2002 and 2012. *Health informatics journal*, 22(4), 804–814. https://doi.org/10.1177/1460458215595851

Liu, B., Sheth, A., Weinsberg, U., Chandrashekar, J., & Govindan, R. (2013). AdReveal: Improving Transparency Into Online Targeted Advertising. *Liu, Bin, et al. ”AdReveal: improving transparency into online targeted advertising.” Proceedings of the Twelfth ACM Workshop on Hot Topics in Networks.*

Liu, V., Musen, M. A., & Chou, T. (2015). Data breaches of protected health information in the United States. *Jama*, 313(14), 1471–1473.

Lorigo, L., Pan,Bing,Hembrooke,Helene, Joachims, & Thorsten, Granka, Laura, Gay, Geri. (2006). The influence of Task and Gender on Search and Evaluation Behavior using Google. *Information Processing and Management, 42*(4), 1123–1131. Retrieved January 1, 2020, from https://www.researchgate.net/profile/Bing_Pan/publication/222664630/The-influence-of-task-and-gender-on-search-and-evaluation-behavior-using-Google/links/5a3176740f7e9b2a2859920c/The-influence-of-task-and-gender-on-search-and-evaluation-behavior-using-Google.pdf

Lu, H., Frauendorfer, D., Rabbi, M., Mast, M. S., Chittaranjan, G. T., Campbell, A. T., Gatica-Perez, D., & Choudhury, T. Stresssense: Detecting stress in unconstrained acoustic environments using smartphones. In: *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*. 2012, 351–360.

Lu, W. L., Savenkov, D., Subramanya, A., Dalton, J.,Gabrilovich, E., & Agichtein, E. (2019). *Information extraction from question and answer websites: G06F 17/2705* (No. 10,452,694). Retrieved December 30, 2019, from http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&p=1&u=%2Fhtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&d=PTL&os=PN/10,452,694&rs=PN/10,452,694

Luhmann, N. (1984). *Soziale Systeme: Grundriß einer allgemeinen Theorie* (Vol. 666). Suhrkamp.

Luhmann, N. (1998). *Die Gesellschaft der Gesellschaft 1* (Vol. 1360). Suhrkamp.

Luhmann, N. (2000). *Organisation und Entscheidung*. Westdeutscher Verlag.
Lupton, D. (2012). M-health and health promotion: The digital cyborg and surveillance society. *Social Theory & Health, 10*(3), 229–244. [https://doi.org/10.1057/sth.2012.6](https://doi.org/10.1057/sth.2012.6)

Lysaght, T., Lipworth, W., Hendl, T., Kerridge, I., Lee, T.-L., Munsie, M., Waldby, C., & Stewart, C. (2017). The deadly business of an unregulated global stem cell industry. *Journal of Medical Ethics, 43*(11), 744–746. [https://doi.org/10.1136/medethics-2016-104046](https://doi.org/10.1136/medethics-2016-104046)

Lysaght, T., Munsie, M., Hendl, T., Tan, L., Kerridge, I., & Stewart, C. (2018). Selling stem cells with tokens of legitimacy: An analysis of websites in Japan and Australia. *Cytotherapy, 20*(5), S77–S78. [https://doi.org/10.1016/j.jcyt.2018.02.218](https://doi.org/10.1016/j.jcyt.2018.02.218)

Mackey, T. K., Cuomo, R. E., & Liang, B. A. (2015). The rise of digital direct-to-consumer advertising?: Comparison of direct-to-consumer advertising expenditure trends from publicly available data sources and global policy implications. *BMC Health Services Research, 15*(1), 236. [https://doi.org/10.1186/s12913-015-0885-1](https://doi.org/10.1186/s12913-015-0885-1)

Madden, A. D. (2000). A definition of information. *Aslib Proceedings, 52*(9), 343–350.

Mager, A. (2012). Algorithmic Ideology. *Information, Communication & Society, 15*(5), 769–787. [https://doi.org/10.1080/1369118X.2012.676056](https://doi.org/10.1080/1369118X.2012.676056)

Maheshvari, S. (2017). On YouTube Kids, Startling Videos Slip Past Filters. Retrieved January 15, 2020, from [https://www.nytimes.com/2017/11/04/business/media/youtube-kids-paw-patrol.html](https://www.nytimes.com/2017/11/04/business/media/youtube-kids-paw-patrol.html)

Marwick, A. E. (2014). How Your Data Are Being Deeply Mined. Retrieved December 12, 2019, from [http://www.tiara.org/wp-content/uploads/2018/05/Marwick-How-Your-Data-Are-Being-Deeply-Mined.pdf](http://www.tiara.org/wp-content/uploads/2018/05/Marwick-How-Your-Data-Are-Being-Deeply-Mined.pdf)

Master, Z., Robertson, K., Frederick, D., Rachul, C., & Caulfield, T. (2014). Stem cell tourism and public education: the missing elements. *Cell Stem Cell, 15*(3), 267–270. [https://doi.org/10.1016/j.stem.2014.08.009](https://doi.org/10.1016/j.stem.2014.08.009)

Matz, S. C., Kosinski, M., Nave, G., & Stillwell, D. J. (2017). Psychological targeting as an effective approach to digital mass persuasion. *Proceedings of the National Academy of Sciences of the United States of America, 114*(48), 12714–12719. [https://doi.org/10.1073/pnas.1710966114](https://doi.org/10.1073/pnas.1710966114)

Max Fisher, & Amanda Taub. (2019a). How YouTube Radicalized Brazil (The New York Times, Ed.). Retrieved February 22, 2020, from [https://www.nytimes.com/2019/08/11/world/americas/youtube-brazil.html](https://www.nytimes.com/2019/08/11/world/americas/youtube-brazil.html)

Max Fisher, & Amanda Taub. (2019b). On YouTube’s Digital Playground, an Open Gate for Pedophiles (The New York Times, Ed.). Retrieved February 22, 2020, from [https://www.nytimes.com/2019/06/03/world/americas/youtube-pedophiles.html](https://www.nytimes.com/2019/06/03/world/americas/youtube-pedophiles.html)

Mayer, J. R., & Mitchell, J. C. Third-Party Web Tracking: Policy and Technology. In: *2012 IEEE Symposium on Security and Privacy*. IEEE, 2012, 413–427. ISBN: 978-1-4673-1244-8. [https://doi.org/10.1109/SP.2012.47](https://doi.org/10.1109/SP.2012.47)
Bibliography

Mayr, K. (2012). Geschlossenheit / Offenheit. In O. Jahraus, A. Nasseri, M. Grzelj, I. Saake, C. Kirchmeier, & J. Müller (Eds.), Luhmann-Handbuch (pp. 84–86). J.B. Metzler.

McCoy, T. H., & Perlis, R. H. (2018). Temporal trends and characteristics of reportable health data breaches, 2010-2017. JAMA, 320(12), 1282–1284.

McCreadi, M., & Rice, R. E. (1999). Trends in analyzing access to information. Part I: cross-disciplinary conceptualizations of access. Information Processing and Management, 35(1), 45–76. https://doi.org/10.1016/S0306-4573(98)00037-5

MDN contributors. (2019). Anatomy of an extension. Retrieved February 4, 2020, from https://developer.mozilla.org/en-US/docs/Mozilla/Add-ons/WebExtensions/Anatomy

Meadow, C. T., & Yuan, W. (1997). Measuring the impact of information: Defining the concepts. Information Processing & Management, 33(6), 697–714. https://doi.org/10.1016/S0306-4573(97)00042-3

Mensch, G. (1980). Ist die technische Entwicklung ganz oder teilweise vorprogrammiert? Wissenschaftszentrum Berlin.

Menzel, J. (2010). Deeper understanding with Metaweb. Retrieved December 30, 2019, from https://googleblog.blogspot.com/2010/07/deeper-understanding-with-metaweb.html

Merriam Webster. (2020). Definition "to google". Retrieved February 21, 2020, from https://www.merriam-webster.com/dictionary/google

Merriam-Webster. (2019). Dictionary: relevance. https://www.merriam-webster.com/dictionary/relevance

Mikians, J., Gyarmati, L., Erramilli, V., & Laoutaris, N. Detecting price and search discrimination on the internet. In: Proceedings of the 11th ACM Workshop on Hot Topics in Networks. 2012, 79–84.

Miller, L. M. S., & Bell, R. A. (2012). Online health information seeking: the influence of age, information trustworthiness, and search challenges. Journal of aging and health, 24(3), 525–541. https://doi.org/10.1177/0898264311428167

Mistree, B. F. (2009). Gaydar: Facebook friendships expose sexual orientation. first monday, 14(10). Retrieved January 9, 2020, from http://firstmonday.org/ojs/index.php/fm/rt/printerFriendly/%202611/2302

Moz Resources. (2019). Google Algorithm Update History. Retrieved December 30, 2019, from https://moz.com/google-algorithm-change

Mukherjee, A., eds. What Yelp Fake Review Filter Might Be Doing? Chicago, IL, 2013.

Munsie, M., Lysaght, T., Hendel, T., Tan, H.-Y. L., Kerridge, I., & Stewart, C. (2017). Open for business: a comparative study of websites selling autologous stem cells in Australia and Japan. Regenerative medicine. https://doi.org/10.2217/rme-2017-0070

Muthukrishnan, S. Ad Exchanges: Research Issues. In: Proceedings of the 5th International Workshop on Internet and Network Economics. WINE
Muthukrishnan, S. (2010a). Advertisement Slot Configuration: 70.5/14.71 (No. 2010/0198694). Retrieved January 25, 2020, from https://patentimages.storage.googleapis.com/f1/20/ee/05f34af637acd3/US20100198694A1.pdf

Nagy, A., & Quaggin, S. E. (2010). Stem cell therapy for the kidney: a cautionary tale. *Journal of the American Society of Nephrology: JASN*, 21(7), 1070–1072. https://doi.org/10.1681/ASN.2010050559

Narayanan, A., & Shmatikov, V. (2008). Robust de-anonymization of large datasets (how to break anonymity of the Netflix prize dataset). *University of Texas at Austin.*

Nguyen, G. (2019). The 2019 search engine patents you need to know about. Retrieved December 30, 2019, from https://searchengineland.com/the-2019-search-engine-patents-you-need-to-know-about-326964

Novas, C. (2006). The Political Economy of Hope: Patients’ Organizations, Science and Biovalue. *BioSocieties*, 1(3), 289–305. https://doi.org/10.1017/S1745855206003024

Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S. (2019). Dissecting racial bias in an algorithm used to manage the health of populations. *Science*, 366(6464), 447–453.

O’Donnell, K., & Cramer, H. People’s Perceptions of Personalized Ads (A. Gangemi, S. Leonardi, & A. Panconesi, Eds.). In: In Proceedings of the 24th International Conference on World Wide Web - WWW ’15 Companion (A. Gangemi, S. Leonardi, & A. Panconesi, Eds.). Ed. by Gangemi, A. New York, New York, USA: ACM Press, 2015, 1293–1298. ISBN: 9781450334730. https://doi.org/10.1145/2740908.2742003

O’Donnell, L., Turner, L., & Levine, A. D. (2016). Part 6: The role of communication in better understanding unproven cellular therapies. *Cytotherapy*, 18(1), 143–148. https://doi.org/10.1016/j.jcyt.2015.11.002

Olejnik, L., Minh-Dung, T., & Castelluccia, C. (2013). Selling Off Privacy at Auction. Retrieved January 3, 2020, from https://hal.inria.fr/hal-00915249

O’Neill, C. (2017a). Opinion — The Ivory Tower Can’t Keep Ignoring Tech. https://www.nytimes.com/2017/11/14/opinion/academia-tech-algorithms.html

O’Neill, C. (2017b). *Weapons of math destruction: How big data increases inequality and threatens democracy* (First paperback edition). B/D/W/Y Broadway Books.

Otterbacher, J., Bates, J., & Clough, P. Competent Men and Warm Women (G. Mark, S. Fussell, C. Lampe, m. schraefel m.c, J. P. Hourcade, C. Appert, & D. Wigdor, Eds.). In: In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI ’17 (G. Mark,
Bibliography

S. Fussell, C. Lampe, m. schraefel m.c, J. P. Hourcade, C. Appert, & D. Wigdor, Eds.). Ed. by Mark, G. New York, New York, USA: ACM Press, 2017, 6620–6631. ISBN: 9781450346559. https://doi.org/10.1145/3025453.3025727.

Pan, B., Hembrooke, H., Joachims, T., Lorigo, L., Gay, G., & Granka, L. (2007). In Google We Trust: Users’ Decisions on Rank, Position, and Relevance. Journal of Computer-Mediated Communication, 12(3), 801–823. https://doi.org/10.1111/j.1083-6101.2007.00351.x

Pariser, E. (2011). TED2011: Beware online filter bubbles. http://www.ted.com/talks/eli_pariser_beware_online_filter_bubbles/transcript

Parra-Arnau, J., Achara, J. P., & Castelluccia, C. (2017). MyAdChoices: Bringing Transparency and Control to Online Advertising. ACM Transactions on the Web (TWEB), 11(1), 1–47. https://doi.org/10.1145/2996466

Pasca, A. M., & van Durme, B. (2014). Inferring attributes from search queries (No. 8,812,509). Retrieved December 30, 2019, from https://patentimages.storage.googleapis.com/49/d2/99/98e0d54a1e7b45/US8812509.pdf

Pasca, M., & van Durme, B. (2013). Extracting semantic classes and instances from text: G06F 7/00;G06F 17/30 (No. 8,510,308). Retrieved December 30, 2019, from http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2& Sect2=HTOFF&p=1&u=%2Fnetahml%2FPPTO%2Fsearchool.html&r=5&f=G&l=50&co1=AND&d=PTXT&s1=8,510,308&OS=8,510,308&RS=8,510,308

Pasquale, F. (2008). Internet Nondiscrimination Principles: Commercial Ethics for Carriers and Search Engines. University of Chicago Legal Forum, 2008(1). Retrieved December 29, 2019, from http://chicagounbound.uchicago.edu/uclf/vol2008/iss1/6?utm_source=chicagounbound.uchicago.edu%2Fuclf%2Fvol2008%2Fiss1%2F6&utm_medium=PDF&utm_campaign=PDFCoverPages

Pasquale, F. (2010). Beyond Innovation and Competition: The Need for Qualified Transparency in Internet Intermediaries. Northwestern university Law Review, 104(1). https://digitalcommons.law.umaryland.edu/cgi/viewcontent.cgi?article=2348&context=fac_pubs

Peddinti, R. V. M. K., & Dabbiru, L. K. (2017). Guided Purchasing via Smartphone (US 2017/0076357 A1).

Pedreschi, D., Giannotti, F., Guidotti, R., Monreale, A., Pappalardo, L., Ruggieri, S., & Turini, F. (2018). Open the Black Box Data-Driven Explanation of Black Box Decision Systems. http://arxiv.org/pdf/1806.09936v1

Peterandl, S. (2017). Predictive Policing: Dem Verbrechen der Zukunft auf der Spur. Retrieved January 2, 2020, from https://www.bpb.de/dialog/netzdebate/238995/predictive-policing-dem-verbren-der-zukunfts-der-spur

Petersen, A., Schermuly, A. C., & Anderson, A. (2019). The shifting politics of patient activism: From bio-sociality to bio-digital citizenship. Health
Petersen, A., Tanner, C., & Munsie, M. (2019). Citizens’ use of digital media to connect with health care: Socio-ethical and regulatory implications. *Health (London, England : 1997)*, 23(4), 367–384. https://doi.org/10.1177/1363459318815944

Petersen, A., Secar, K., & Munsie, M. (2013). Therapeutic journeys: the hopeful travails of stem cell tourists. *Sociology of health & illness*, 36(5), 670–685. https://doi.org/10.1111/1467-9566.12092

Petersen, A., Munsie, M., Tanner, C., MacGregor, C., & Brophy, J. (2017). *Stem Cell Tourism and the Political Economy of Hope*. Palgrave Macmillan UK. https://doi.org/10.1057/978-1-137-47043-0

Peterson, H. (2020). Amazon engineer calls for Ring to be ‘shut down immediately’ over privacy concerns. Retrieved January 31, 2020, from https://www.businessinsider.de/international/amazon-engineer-says-ring-should-be-shut-down-immediately-2020-1?r=US&IR=T

Poole, D. L., & Mackworth, A. K. (2010). *Artificial intelligence: foundations of computational agents*. Cambridge University Press.

Poole, D., Mackworth, A., & Goebel, R. (1998). *Computational Intelligence: A Logical Approach*. Oxford University Press.

Prainsack, B. (2019). Data Donation: How to Resist the iLeviathan. In J. Krutzinna & L. Floridi (Eds.), *The Ethics of Medical Data Donation* (pp. 9–22).

Presidential Committee on Information Literacy: Final Report. (1989). http://www.ala.org/acrl/publications/whitepapers/presidential

Pulliam, S., & Barry, R. (2012). Executives’ Good Luck in Trading Own Stock. Retrieved January 29, 2020, from https://www.wsj.com/articles/SB1000087239639044444146371344178

Rashtchy, S., Kessler, A. M., Bieber, P. J., & Schindler, Nathaniel H., Tzeng, Judith C. (2007). The User Revolution: The New Advertising Ecosystem And The Rise Of The Internet As A Mass Medium. Retrieved December 28, 2019, from http://people.ischool.berkeley.edu/~hal/Courses/StratTech09/Lectures/Google/Articles/user-revolution.pdf

Ratcliff, C. (2019). What are the top 10 most popular search engines? https://www.searchenginewatch.com/2016/08/08/what-are-the-top-10-most-popular-search-engines/

Readie. (2020). About us. Retrieved February 4, 2020, from https://readie.eu/about-us/

Reidenberg, J. R., Breaux, T., Carnor, L. F., & French, B. (2015). Disagreeable Privacy Policies: Mismatches Between Meaning and User’s Understanding. *Berkeley Technology Law Journal*, 30(1), 41–68.

Reuters. (2018). Amazon ditched AI recruiting tool that favored men for technical jobs. Retrieved January 9, 2020, from https://www.theguardian.com/technology/2018/oct/10/amazon-hiring-ai-gender-bias-recruiting-engine
Bibliography

Ropohl, G. (1983). A critique of technological determinism. In P. T. Durbin (Ed.), Philosophy and Technology (pp. 83–96). Springer Netherlands.

Ropohl, G. (2013). SCHELSKY Helmut. Der Mensch in der wissenschaftlichen Zivilisation, 1961. In C. Hubig, A. Huning, & G. Ropohl (Eds.), Nachdenken über Technik: Die Klassiker der Technikphilosophie und neuere Entwicklungen / 3., neu bearbeitete und erweiterte Auflage — Darmstädter Ausgabe (pp. 342–345). Nomos Verlagsgesellschaft mbH & Co. KG.

https://doi.org/10.5771/9783845269238-342

Rose, D. E., & Levinson, D. Understanding user goals in web search. In: Proceedings of the 13th international conference on World Wide Web. 2004, 13–19. https://doi.org/10.1145/988672.988675

Rosen, J. J. (2014). The Internet you can’t Google. Retrieved December 30, 2019, from https://eu.tennessean.com/story/money/tech/2014/05/02/jj-rosen-popular-search-engines-skim-surface/8636081/

Rosenberg, C. (2013). Improving Photo Search: A Step Across the Semantic Gap. Retrieved December 30, 2019, from https://ai.googleblog.com/2013/06/improving-photo-search-step-across.html

Royal Free London. (2017). New app helping to improve patient care. Retrieved December 11, 2019, from https://www.royalfree.nhs.uk/news-media/news/new-app-helping-to-improve-patient-care/

Ruckenstein, M., & Granroth, J. (2019). Algorithms, advertising and the intimacy of surveillance. Journal of Cultural Economy, 8(1), 1–13. https://doi.org/10.1080/17530350.2019.1574866

Ryan, K. A., Sanders, A. N., Wang, D. D., & Levine, A. D. (2010). Tracking the rise of stem cell tourism. Regenerative medicine, 5(1), 27–33. https://doi.org/10.2217/rme.09.70

Sandvig, C., Hamilton, K., Karahalios, K., & Langbort, C. Auditing Algorithms: Research Methods for Detecting Discrimination on Internet Platforms. In: Data and Discrimination: Converting Critical Concerns into Productive. 2014.

Sap, M., Card, D., Gabriel, S., Choi, Y., & Smith, N. A. The risk of racial bias in hate speech detection. In: Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics. 2019, 1668–1678.

Saurwein, Florian, & Natasa Just und Michael Latzer. (2017). Algorithmische Selektion im Internet: Risiken und Governance automatisierter Auswahlprozesse. 18. http://nbn-resolving.de/urn:nbn:de:0168-ssoar-51466-4

Schachinger, K. (2017). A Complete Guide to the Google RankBrain Algorithm. Retrieved December 30, 2019, from https://www.searchenginejournal.com/google-algorithm-history/rankbrain/

Schapranow, M.-P., Brauer, J., & Plattner, H. (2017). The data donation pass: Enabling sovereign control of personal healthcare data: Schapranow, Matthieu-P and Brauer, Janos and Plattner, Hasso. In H. R. Arabnia, L. Deligiannidis, & M. B. O’Hara (Eds.), HIMS 2017. CSREA Press.

Schelsky, H. (1961). Der Mensch in der wissenschaftlichen Zivilisation. In Arbeitsgemeinschaft für Forschung des Landes Nordrhein-Westfalen.
Schulze, E. (2019). EU tells Facebook, Google and Twitter to take more action on fake news. https://www.cnbc.com/2019/10/29/eu-tells-facebook-google-and-twitter-to-take-more-action-on-fake-news.html

Schumann, J. H., von Wangenheim, F., & Groene, N. (2014). Targeted Online Advertising: Using Reciprocity Appeals to Increase Acceptance among Users of Free Web Services. *Journal of Marketing*, 78(1), 59–75. https://doi.org/10.1509/jm.11.0316

Schwartz, B. (2016). Now we know: Here are Google’s top 3 search ranking factors. Retrieved December 30, 2019, from https://searchengineland.com/now-know-googles-top-three-search-ranking-factors-245882

Scott, D. (2019). Google Steps Further Into Healthcare With Fitbit Acquisition. Retrieved December 11, 2019, from https://www.forbes.com/sites/scottdavis/2019/11/06/google-steps-further-into-healthcare-with-fitbit-acquisition/

Seaver, N. (2017). Algorithms as culture: Some tactics for the ethnography of algorithmic systems. *Big Data & Society*, 4(2), 205395171773810. https://doi.org/10.1177/2053951717738104

Semturs, C., Vandevenne, L., Sinopalnikov, D., Lyashuk, A., Steiger, S., Grimm, H., Scharli, N. M., & Lecomte, D. (2015). Computerized systems and methods for extracting and storing information regarding entities: G06F 17/00 (No. 10,198,491). Retrieved December 30, 2019, from http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsbrr%2Fhtmlapp&amp;f=G&cl=50&s1=10,198,491.PN.&OS=PN/10,198,491&RS=PN/10,198,491

Shah, S. (2019). Gain more insight into your bid strategy with top signals. Retrieved December 30, 2019, from https://support.google.com/googleads/answer/9644171

Shannon, C. E. (1948). A mathematical theory of communication. *Bell system technical journal*, 27(3), 379–423.

Shaw, D. (2016). Facebook’s flawed emotion experiment: Antisocial research on social network users. *Research Ethics*, 12(1), 29–34.

Shneiderman, B., Byrd, D., & Croft, W. B. (1997). A User-Interface Framework for Text Searches. *D-Lib Magazine*, 3(1). Retrieved January 1, 2020, from http://www.dlib.org/dlib/january97/retrieval/01shneiderman.html

Siepermann, Markus, Lackes, Richard, Schew, G., & Szczutkowski, A. (2019). Ausführliche Definition Information. Retrieved January 1, 2020, from https://wirtschaftslexikon.gabler.de/definition/information-40528/version-263909
Simonite, T. (2015). Probing the Dark Side of Google’s Ad-Targeting System. Retrieved January 2, 2020, from https://www.technologyreview.com/s/539021/probing-the-dark-side-of-googles-ad-targeting-system/

Singhal, A. (2012). Introducing the Knowledge Graph: things, not strings. Retrieved December 30, 2019, from https://googleblog.blogspot.com/2012/05/introducing-knowledge-graph-things-not.html

Sipp, D., Caulfield, T., Kaye, J., Barfoot, J., Blackburn, C., Chan, S., de Luca, M., Kent, A., McCabe, C., Munsie, M., Sleeboom-Faulkner, M., Sugarman, J., van Zimmeren, E., Zarzeczny, A., & Rasko, J. E. J. (2017). Marketing of unproven stem cell-based interventions: A call to action. *Science translational medicine, 9*, 1–5. https://doi.org/10.1126/scitranslmed.aag0426

Skinner, B. F. (1938). *The Behavior Of Organisms: An Experimental Analysis*. Appleton-Century-Croft.

Slawski, B. (2018). How Search Engine Queries to Identify Entity Attributes. Retrieved December 30, 2019, from http://www.seobythesea.com/2018/03/3-ways-query-stream-ontologies-change-search/

Slawski, B. (2019). SEO by the Sea Top 10 Search Engine Patents to Know About from 2019. Retrieved December 30, 2019, from http://www.seobythesea.com/2019/12/10-search-engine-patents-from-2019/

Smarty, A. (2008). What is Google Query Expansion? Cases and Examples. Retrieved December 30, 2019, from https://www.searchenginejournal.com/what-is-google-query-expansion-cases-and-examples/7924/

Snyder, J., & Turner, L. (2018). Selling stem cell ‘treatments’ as research: prospective customer perspectives from crowdfunding campaigns. *Regenerative medicine, 13*(4), 375–384. https://doi.org/10.2217/rme-2018-0007

Snyder, J., & Turner, L. (2019). Crowdfunding for stem cell-based interventions to treat neurologic diseases and injuries. *Neurology, 93*(6), 252–258. https://doi.org/10.1212/WNL.0000000000007838

Sommerville, I. (2016). *Software Engineering* (10th ed.). Pearson.

Speicher, T., Ali, M., Venkatadri, G., Ribeiro, F., Arvanitakis, G., Benevenuto, F., Gummadi, K. P., Loiseau, P., & Mislove, A. Potential for Discrimination in Online Targeted Advertising. In: *FAT 2018 - Conference on Fairness, Accountability, and Transparency*. 81, New-York, United States, 2018, 1–15. https://hal.archives-ouvertes.fr/hal-01955343

Stanley, J. (2015). China’s Nightmarish Citizen Scores Are a Warning For Americans. Retrieved January 7, 2020, from https://www.aclu.org/blog/privacy-technology/consumer-privacy/chinas-nightmarish-citizen-scores-are-warning-americans?redirect=blog/free-future/chinas-nightmarish-citizen-scores-are-warning-americans

Starr, B. (2015). Structured Data & The SERPs: What Google’s Patents Tell Us About Ranking In Universal Search. Retrieved December 30, 2019, from https://searchengineland.com/structured-data-serps-googles-patents-tell-us-ranking-universal-search-219205
statcounter. (2019a). Browser Market Share Worldwide. Retrieved January 21, 2020, from https://gs.statcounter.com/browser-market-share

statcounter. (2019b). Search Engine Market Share Worldwide. Retrieved November 29, 2019, from https://gs.statcounter.com/search-engine-market-share/all

Steel, E., & Angwin, J. (2010). On the web’s cutting edge, anonymity in name only. *The Wall Street Journal*, 4. Retrieved January 11, 2020, from https://www.wsj.com/articles/SB100014240527487032949045755385532109190198

Steinfeld, N. (2016). “I agree to the terms and conditions”: (How) do users read privacy policies online? An eye-tracking experiment. *Computers in Human Behavior*, 55, 992–1000. https://doi.org/10.1016/j.chb.2015.09.038

Stoker, G. (1995). Governance as theory: five propositions. *International Social Science Journal*, 50(155), 17–28.

Sullivan, D. (2008). Google.com Finally Gets Google Suggest Feature. https://searchengineland.com/googlecom-finally-gets-google-suggest-feature-14626

Sullivan, D. (2013). FAQ: All About The New Google “Hummingbird” Algorithm. Retrieved December 30, 2019, from https://searchengineland.com/google-hummingbird-172816

Sullivan, D. (2016a). FAQ: All about the Google RankBrain algorithm. Retrieved December 30, 2019, from https://searchengineland.com/faq-all-about-the-new-google-rankbrain-algorithm-234440

Sullivan, D. (2016b). Google now handles at least 2 trillion searches per year. Retrieved December 30, 2019, from https://searchengineland.com/google-now-handles-2-999-trillion-searches-per-year-250247

Sweeney, L. (2013). Discrimination in Online Ad Delivery. Retrieved January 2, 2020, from http://dataprivacylab.org/projects/onlineads/1071-1.pdf

Tanner, A. (2018). *Our Bodies, Our Data: How Companies Make Billions Selling Our Medical Records*. Beacon Press.

Tanner, C., Munsie, M., Sipp, D., Turner, L., & Wheatland, C. (2019). The politics of evidence in online illness narratives: An analysis of crowdfunding for purported stem cell treatments. *Health (London, England : 1997)*, 23(4), 436–457. https://doi.org/10.1177/1363459319829194

Taylor-Weiner, H., & Graff Zivin, J. (2015). Medicine’s Wild West—Unlicensed Stem-Cell Clinics in the United States. *The New England journal of medicine*, 373(11), 985–987. https://doi.org/10.1056/NEJMIP1504560

Tindera, M. (2018). Government Data Says Millions Of Health Records Are Breached Every Year. Retrieved December 11, 2018, from https://www.forbes.com/sites/michelatindera/2018/09/25/government-data-says-millions-of-health-records-are-breached-every-year/

Toch, E., Wang, Y., & Cranor, L. F. (2012). Personalization and privacy: a survey of privacy risks and remedies in personalization-based systems.
Bibliography

Trist, E. L., & Bamforth K.W. (1954). Some Social and Psychological Consequences of the Longwall Method of Coal-Getting: An examination of the psychological situation and defences of a work group in relation to the social structure and technological content of the work system. Human Relations, 4(1), 3–38. Retrieved January 2, 2020, from https://journals.sagepub.com/doi/pdf/10.1177/001872675100400101

Tufekci, Z. (2014a). Algorithmic Harms beyond Facebook and Google: Emergent Challenges of COmputational Agency. Colorado Technology Law Journal, 203(13). Retrieved December 24, 2019, from https://heinonline.org/HOL/LandingPage?handle=hein.journals/jtelhtel13&div=18&id=&page=

Tufekci, Z. (2014b). Engineering the public: Big data, surveillance and computational politics. 19(7). https://firstmonday.org/ojs/index.php/fm/article/view/4901

Turing, A. M. (2009). Computing Machinery and Intelligence. In R. Epstein, G. Roberts, & G. Beber (Eds.), Parsing the Turing Test: Philosophical and Methodological Issues in the Quest for the Thinking Computer (pp. 23–65). Springer Netherlands. https://doi.org/10.1007/978-1-4020-6710-5\textunderscore_3

Turner, L. (2007). ‘First World Health Care at Third World Prices’: Globalization, Bioethics and Medical Tourism. BioSocieties, 2(3), 303–325. https://doi.org/10.1017/S1745855207005765

Turner, L. (2015). US stem cell clinics, patient safety, and the FDA. Trends in molecular medicine, 21(5), 271–273. https://doi.org/10.1016/j.tnmed.2015.02.008

Turner, L. (2017). ClinicalTrials.gov, stem cells and ‘pay-to-participate’ clinical studies. Regenerative medicine, 12(6), 705–719. https://doi.org/10.2217/rme-2017-0015

Turner, L. (2018). The US Direct-to-Consumer Marketplace for Autologous Stem Cell Interventions. Perspectives in biology and medicine, 61(1), 7–24. https://doi.org/10.1353/pbm.2018.0024

Turner, L., & Knoepfler, P. (2016). Selling Stem Cells in the USA: Assessing the Direct-to-Consumer Industry. Cell stem cell, 19(2), 154–157. https://doi.org/10.1016/j.stem.2016.06.007

Ungku, F. (2019). Factbox: ‘Fake News’ laws around the world. Retrieved December 16, 2019, from https://www.reuters.com/article/us-singapore-politics-fakenews-factbox/factbox-fake-news-laws-around-the-world-idUSKCN1RE0XN

Ur, B., Leon, P. G., Cranor, L. F., Shay, R., & Wang, Y. Smart, useful, scary, creepy: perceptions of online behavioral advertising. In: Proceedings of the eigth SOUPS 2012. ACM Press, 2012, 4.

US Code 18 §1030. (2008). Fraud and related activity in connection with computers: CFAA. Retrieved January 29, 2020, from https://www.law.cornell.edu/uscode/text/18/1030
US Code 47 § 230. (2018). Protection for private blocking and screening of offensive material. Retrieved December 16, 2019, from https://www.law.cornell.edu/uscode/text/47/230

USACM. (2017). Statement on Algorithmic Transparency and Accountability. Retrieved March 2, 2020, from https://www.acm.org/binaryassets/public-policy/2017_usacm_statement_algorithms.pdf

Valentino-DeVries, J., Singer-Vine, J., & SoltanimAshkan. (2012). Websites Vary Prices, Deals Based on Users’ Information. Retrieved January 29, 2020, from https://www.wsj.com/articles/SB10001424127887323777204578189391813881534

van Couvering, E. (2007). Is Relevance Relevant? Market, Science, and War: Discourses of Search Engine Quality. *Journal of Computer-Mediated Communication, 12*(3), 866–887. https://doi.org/10.1111/j.1083-6101.2007.00354.x

Vaught, J., & Lockhart, N. C. (2012). The evolution of biobanking best practices. *Clinica chimica acta; international journal of clinical chemistry, 413*(19-20), 1569–1575. https://doi.org/10.1016/j.cca.2012.04.030

Veltri, G. A., & Ivchenko, A. (2017). The impact of different forms of cognitive scarcity on online privacy disclosure. *Computers in Human Behavior, 73*, 238–246. https://doi.org/10.1016/j.chb.2017.03.018

Vinoth, G. (2017). Google Algorithm Updates Explained. https://hackernoon.com/google-algorithm-updates-explained-f4a4640154ea

Vogel, K. P. (2017). Google Critic Ousted From Think Tank Funded by the Tech Giant. Retrieved February 4, 2020, from https://www.nytimes.com/2017/08/30/us/politics/eric-schmidt-google-new-america.html

Volokh, E., & Falk, D. M. (2012). Google: First amendment protection for search engine search results. *Journal of Law, Economics & Policy, 8*, 883–889.

von Hilgers, P. (2011). The History of the Black Box: The Clash of a Thing and its Concept. *Cultural Politics: an International Journal, 7*(1), 41–58. https://doi.org/10.2752/175174311X12861940861707

Watzlawick, P., Beavin, J. H., & Jackson, D. D. (2007). *Menschliche Kommunikation* (11th ed.). Huber.

Weber, I., & Jaimes, A. Who Uses Web Search for What: And How. In: *Proceedings of the Fourth ACM International Conference on Web Search and Data Mining*. WSDM ’11. New York, NY, USA: Association for Computing Machinery, 2011, 15–24. ISBN: 9781450304931. https://doi.org/10.1145/1935826.1935839.

Weckert, S. (2020). Google Maps Hacks: Performance & Installation, 2020. Retrieved February 10, 2020, from http://www.simonweckert.com/googlemapshacks.html

Weisberg, M. (2013). *Simulation and Similarity*. Oxford University Press.

Weiss, D. J., Turner, L., Levine, A. D., & Ikonomou, L. (2018). Medical societies, patient education initiatives, public debate and marketing of unproven stem cell interventions. *Cytotherapy, 20*(2), 165–168. https://doi.org/10.1016/j.jcyt.2017.10.002
Whittaker, A., Manderson, L., & Cartwright, E. (2010). Patients without borders: understanding medical travel. *Medical anthropology, 29*(4), 336–343. https://doi.org/10.1080/01459740.2010.501318

Willis, C. E., & Tatar, C. (2012). Understanding What They Do with What They Know. https://digitalcommons.wpi.edu/computerscience-pubs/

World Wide Web Foundation. (2017). Algorithmic Accountability: Applying the concept to different country context. Retrieved December 11, 2019, from https://webfoundation.org/docs/2017/07/Algorithms_Report_WF.pdf

Wu, X., Yan, J., Liu, N., Yan, S., Chen, Y., & Chen, Z. Probabilistic Latent Semantic User Segmentation for Behavioral Targeted Advertising. In: *Proceedings of the Third International Workshop on Data Mining and Audience Intelligence for Advertising*. ADKDD ’09. New York, NY, USA: Association for Computing Machinery, 2009, 10–17. ISBN: 9781605586717. https://doi.org/10.1145/1592748.1592751.

Wu, Y., Thakur, K. M., Hylton, J., & Weissman, D. (2013). Searching Content of Prominent Users in Social Networks: G06F 7/30 (US 2016/0246789 A1). Retrieved December 30, 2019, from https://patentimages.storage.googleapis.com/d6/a5/30/a1a539a974bb93/US20160246789A1.pdf

Yan, J., Liu, N., Wang, G., Zhang, W., Jiang, Y., & Chen, Z. How much can behavioral targeting help online advertising? In: *Proceedings of the 18th international conference on World wide web*. 2009, 261–270. Retrieved January 13, 2020, from https://dl.acm.org/doi/10.1145/1526709.1526745

Yuan, S., Abidin, A. Z., Sloan, M., & Wang, J. (2012). Internet advertising: An interplay among advertisers, online publishers, ad exchanges and web users. *arXiv preprint arXiv:1206.1754*. Retrieved January 11, 2020, from https://arxiv.org/pdf/1206.1754.pdf

Zamir, O. E., Korn, J. L., Fikes, A. B., & Lawrence, S. R. (2010). Personalization of placed Content ordering in Search Engines (US 7.693,827 B2). Retrieved December 30, 2019, from https://patentimages.storage.googleapis.com/9c/ce/41/25912234856199/US7693827.pdf

Zarzeczný, A., Tanner, C., Barfoot, J., Blackburn, C., Couturier, A., & Munisie, M. (2019). Contact us for more information: an analysis of public enquiries about stem cells. *Regenerative medicine, 14*(12), 1137–1150. https://doi.org/10.2217/rme-2019-0092

Zittrain, J. (2014). Engineering an Election: Digital gerrymandering poses a threat to democracy. *Harvard Law Review, 127*(8), 335–341. Retrieved December 20, 2019, from https://harvardlawreview.org/2014/06/engineering-an-election/

Zwass, V. (2016). Information System. Retrieved December 26, 2019, from https://www.britannica.com/topic/information-system

Zweig, K. A. (2016). 2. Arbeitspapier: Überprüfbarkeit von Algorithmen. Retrieved January 31, 2020, from https://algorithmwatch.org/publication/zweites-arbeitspapier-ueberpruefbarkeit-algorithmen/
Zweig, K. A., Fischer, S., & Lischka, K. (2018). Wo Maschinen irren können: Verantwortlichkeiten und Fehlerquellen in Prozessen algorithmischer Entscheidungsfindung. https://doi.org/10.11586/2018006

Zweig, K. A., Wenzelburger, G., & Krafft, T. D. (2018). On Chances and Risks of Security Related Algorithmic Decision Making Systems. European Journal for Security Research, 3(2), 181–203. https://doi.org/10.1007/s41125-018-0031-2
A. EuroStemCell Data Donation: Development

A.1. My Code

The full code of the plugin is obtainable from https://github.com/AALAB-TUKL/EuroStemCell-data-donation.

A.2. User Story

A patient of Parkinson’s disease, Multiple Sclerosis or Diabetes perceives an information need. She wants to inform herself about the condition and the respective medical perspectives, especially in the field of stem cell-related medical applications. She decides to consult the Internet. She uses a search engine to find the most relevant website that answer her questions. Then she reviews advertisements, search results and top stories on the website to gather information and educate herself as a basis of future decisions with respect to clinical treatments and therapies.
Appendix A: EuroStemCell Data Donation: Development

A.3. Product Backlog

Below, the requirements to the plugin are listed, ordered by priority and thus, order of implementation:

1. Client-Server architecture with browser plugin dedicated to data collection and a web-server concerned with storing the data

2. Based on popular browsers (Firefox / Chrome), allow cross-browser implementation

3. Capable of crawling websites

4. Enable straightforward installation

5. Register users on the server

6. Receive a unique identifier from the server and attach this to submissions

7. Submit data to server

8. Enable uncomplicated on-boarding process

9. Display privacy statement and obtain obligatory consent

10. Include an options page to capture demographics and participant’s details

11. Request demographics (age, gender, residence, impact of Parkinson’s disease, Multiple Sclerosis and Diabetes on participant, researcher status, frequency of computer or search engine usage, experience with paid stem cell therapy, next largest city)

12. Receive a study group identifier and attach this to submission

13. Automate queries

14. Make automated queries unobtrusive to browsing

15. Enable updates of crawl specifications

16. Display recent submission and informational content
A.4. Participant survey

![Privacy Statement](image1.png)

Thank you for your decision to contribute to the EuroStemCell Data Donation Project! Please carefully fill out the survey to start your donation. Once data is submitted, you cannot change it anymore. If you made a mistake, please reinstall the plugin.

Are you or someone close to you impacted by Parkinson's Disease?

- I'm a patient.
- I'm a carer.
- No

*A carer is anyone, including children and adults who looks after a family member, partner or friend who needs help because of their illness, frailty, disability, a mental health problem or an addiction and cannot cope without their support. The care they give is unpaid. (as defined by [NHS England](https://www.england.nhs.uk))

Are you or someone close to you impacted by Multiple Sclerosis?

- I'm a patient.
- I'm a carer.
- No

Are you or someone close to you impacted by a form of Diabetes (Type I or Type II)?

- I'm a patient.
- I'm a carer.
- No

![Segment of user survey](image2.png)
A.4. Participant survey

The survey presented in the registration process comprised the following questions and informational footnotes:

1. Are you or someone close to you impacted by Parkinson’s Disease?
   - I’m a patient.
   - I’m a carer[1]
   - No

2. Are you or someone close to you impacted by Multiple Sclerosis?
   - I’m a patient.
   - I’m a carer.
   - No

3. Are you or someone close to you impacted by a form of Diabetes (Type I or Type II)?
   - I’m a patient.
   - I’m a carer.
   - No

4. Are you a stem cell researcher or medical professional?
   - Yes
   - No

5. What is your country of residence?[2]
   - Australia
   - Canada
   - United Kingdom
   - United States Of America
   - Other

6. Your age range
   - 18-29
   - 30-39
   - 40-49
   - 50-59

[1] A carer is anyone, including children and adults who looks after a family member, partner or friend who needs help because of their illness, frailty, disability, a mental health problem or an addiction and cannot cope without their support. The care they give is unpaid.” (as defined by the NHS, [https://www.england.nhs.uk/commissioning/comm-carers/carers/](https://www.england.nhs.uk/commissioning/comm-carers/carers/))

[2] Note: At this point we are only studying the impact of Google advertising in the four English speaking countries above. We will consider data from other countries to guide future research.
Appendix A: EuroStemCell Data Donation: Development

7. Your gender
   - Female
   - Male
   - Other
   - Prefer not to say

8. How often do you use your computer, laptop, tablet and/or smartphone?
   - Daily (More than 2 times a day)
   - Daily (Less than 2 times a day)
   - Weekly
   - Monthly

9. How often do you use Google Search?
   - Daily (More than 2 times a day)
   - Daily (Less than 2 times a day)
   - Weekly
   - Monthly

10. Have you ever paid for or inquired about stem cell treatments?\(^3\)
    - Yes
    - No

11. What is the next largest city near you?\(^4\)
    - City: textfield
    - Prefer not to say

A.5. Query composition and crawled HTML elements

A.5.1. Query composition

The following search terms were composed at the project’s kick-off meeting. They were meant to formulate popular queries with respect to the field we examined. Thus, we included keywords like stem cell, the names of the respective diseases (parkinsons disease, multiple sclerosis, diabetes, denoted by disease here). Also we included natural language questions as we assumed searchers to query search engines with direct questions if they are not Internet literate in a sense that they understand search engines capabilities and mechanics.

\(^3\)If Yes: We’d like to hear about your experience. Please contact us.

\(^4\)Please enter only letters. If you feel uncomfortable answering this, please choose ”Prefer not to say”.

138
• stem cells
• stem cells cost
• stem cells treatment
• stem cells cure
• stem cells therapy
• can stem cells help me?
• can stem cells cure [disease]?
• [disease] cure
• [disease] therapy
• [disease] treatment
• [disease] cells cost
• [disease] stem cells treatment
• [disease] stem cells cure
• [disease] stem cells therapy

A.5.2. Crawled HTML elements

• Ads
  – Name
  – Title
  – URL
  – Content

• Search results
  – Title
  – Content
  – URL
  – Position

• Top Stories
  – Title
  – Author
  – URL
  – Position
Figure A.2.: Detailed example of crawled elements (here: ad and organic results),
Screenshot by author
B. EuroStemCell Data Donation: Data Analysis and Visualizations

B.1. Downloads

Figure B.1.: Daily users and downloads of the Firefox addon as documented on the Mozilla Developer Hub statistics, screenshot by author
Appendix B: EuroStemCell Data Donation: Data Analysis and Visualizations

Figure B.2.: Daily Users from 2019-10-01 to 2020-02-07

Figure B.3.: Cumulative registrations via the Chrome plugin from 1.10.2019 to 7.2.2020
B.2. Participants

Figure B.4.: Donations by group

B.3. Advertisements and Advertisers

Figure B.5.: Absolute Number of advertisements per group
Figure B.6.: Fraction of Prescription Treatment Advertisements per group
C. Functionality of a Search Engine

At first, the original mechanism of Google will be portrayed by reference to (Brin & Page, 1999), the initial paper of the Google founders and the company blog at (Google, 2019r). Then, these insights will be enriched with observations of search engine researchers, tech observers and industrial professionals. Later on, patents provide a possible outlook.

Web search engine operate in a three-stepped process of crawling the WWW, indexing web pages and serving results. Additionally, they generally display advertisements along with organic search results to fund their operations. Search engines developed from merely using on-page data, link-analysis and other web-specific data (anchor text, e.g.) (Brin & Page, 1999) to leveraging manifold sources to determine a searcher’s intentions. The factors that contribute to a ranking are unknown to the public. Google only gives implicit advice on how to design websites and what they think is “high quality” that leads to an appropriate ranking with respect to a user query (Google, 2019h, 2020b). Due to this publishers might anxiously avoid anything that could possibly be a black hat SEO technique, scholars criticize (Pasquale, 2008).

While most search engine operate on well-known principles, the specific details of their algorithms remain undisclosed trade secrets, mainly to sustain search quality and remain competitive (L. A. Granka, 2010). The fundamental tasks of a search engine are as follows:

**crawling** Google uses a web crawler (or robot / spider) that operates from many computers and collects publicly available web pages on the store-server. The algorithm behind it receives a list of URLs of prior crawls from the storeserver and sitemap data. Then, crawlers collect those website, send them to the storeserver and follow links recursively. Eventually, newly created pages, changes and deletions are added to the index. It does not crawl blocked website, restricted areas and sites that are already known (Google, 2019j).

**indexing** The indexer parses the pages it receives from the storeserver’s repository and creates an index. All significant words and their position on a website, key content tags and attributes are stored. According to an

---

1For more details, see Appendix C
2Definition Crawler: “Automated software that crawls (fetches) pages from the web and indexes them.” (Google, 2019r)
3Uniform Resource Locator, or Internet address, see https://en.wikipedia.org/wiki/URL
4Websites will not be crawled if a file named robots.txt is located on the host. Through inbound hyperlinks it might still be indexed, though (Google, 2019j)
5“Pages that have already been crawled and are considered duplicates of another page, are crawled less frequently.” (Google, 2019j)
Appendix C: Functionality of a Search Engine

in-memory has table (the *lexicon*) the words are transformed into word IDs. Their occurrences on a website are recorded on a hit list that is stored in *barrels* sorted by document ID. Then, the content of the barrels is used to create an inverted index. Additionally, the indexer derives a database of linked documents from anchor files to assess meaning of linked content (web pages and media)(Brin & Page, 1999). If a page is inaccessible due to a *robots.txt* file, authorization measures or another device, it is not indexed (Google, 2019). According to Google, the index “contains hundreds of billions of webpages and is well over 100,000,000 gigabytes in size” (Google, 2019m). Observers estimate that Google only indexes a marginal part of the WWW. Grimmelmann distinguishes general from vertical search engines. While general index the whole web, vertical ones specialize in a particular category (like news, travel, shopping, e.g.). Over the years of its development, Google has added vertical search capabilities to its existing general search (Grimmelmann, 2014).

Upon a user query, words from the parsed query are converted to word IDs and searched for in the barrels. For the documents that include those words, a weighed rank is computed based on a multitude of parameters. Today, Google uses an unknown number of signals or variables to determine relevance. Linguistic cues (website content), user cues (feedback loop) and web structure (Page Rank) all contribute to a final score (L. A. Granka, 2010). The relevance is assessed using an unknown amount of signals and factors ranging from context variables (location, time, current situation) to semantic information of the search query all the way to very personalized factors (search history, profiling) (Google, 2019). In 2010, they used to amount to about 200 (Google, 2010). Google itself provides assistance to Search Engine Optimization (SEO) and qualitatively describes how publishers should design their websites in order to receive an accurate ranking without penalties. From this advice, one could infer the nature of signals contributing to the measurement like in (Google, 2019). The $k$ highest ranked results are presented to the user in descending order of relevance (Brin & Page, 1999). Today, hundreds of signals count towards the rank calculation (Sullivan, 2016a), links, content and *RankBrain* being the most significant ones (Schwartz, 2016).

Originally, Google used an algorithm called *Page Rank* to assess the importance of a website by the web’s link structure. The creators intended to compute the measure in accordance with people’s subjective idea of importance. They argued that a source which received many citations is probably credible, important or relevant. The more important those referrers are, the higher the PageRank of the respective site. Hence, they used the normalized

---

$^6$Grey literature: The estimates range from 0.004% to 4%, depending on source. What they call Deep Web consists of website without inbound links, password protected areas, databases that only respond to certain input, subscription services (Rosen, 2014).

$^7$Brin and Page state in their initial paper how “[F]iguring out the right values for these parameters is something of a black art” (Brin & Page, 1999).
Appendix C: Functionality of a Search Engine

links of other pages that direct users to a particular website to calculate the measurement iteratively. A damping factor was included to simulate a surfer that randomly jumps to a different website to avoid dead ends. Then, search results were prioritized based on their respective weight. Along with link structure, the link text was considered in assessing a page’s relevance. The authors argue that it usually describes the webpage it points to more accurately than the page it is located on. On top of that, websites without text content can thus be crawled (media, databases or other non-textual objects). (Brin & Page, 1999)

\[
PR(A) = (1 - d) + d \left( \frac{PR(T_1)}{C(T_1)} + \cdots + \frac{PR(T_n)}{C(T_n)} \right)
\] (C.1)

The PageRank algorithm above calculates the PageRank \(PR(A)\) of website \(A\) by summing up the PageRanks of websites pointed at it, normalized by the respective sites total number of outgoing links. The damping factor \(d\) is used to allow for personalization. This iterative algorithm computes a probability distribution over all websites, so \(\sigma_i = 1^n PR(A_i)\) (Brin & Page, 1999).

Disclaimer: Below, some prominent features and most recent developments are discussed by observers and Search Engine Land. Note that a patented feature is not necessarily part of the actual search algorithm. For most of the patents reviewed, there is no evidence of their clear implementation. However, it can “offer an interesting perspective on where [Google] is steering search and how it’s thinking about evolution of search.” (Nguyen, 2019) Also, the observations and argumentations below are documented by industry professionals outside of the Google universe. They stem from original interviews, research, experience and conferences and are published on their website. Thus, they do not ensure that Google uses these technologies.

The search engine enhances queries using query expansion (Smarty, 2008). This allows to broaden the search horizon and rely less on a user’s distinct input.

In 2008, Google introduced auto suggestion, a feature that showed numerical possible text completions when users started to type their query (Sullivan, 2008).

The introduction of the Knowledge Graph (Henry, 2013) indicates a paradigm shift from things to strings, as the Official Google Blog puts it (Singhal, 2012). Now, search on their platform is no longer about connecting keywords, but

---

The discussions are mostly based on the personal opinions by authors of SEO by the sea [http://www.seobythesea.com/], especially Bill Slawski

https://searchengineland.com/ especially Danny Sullivan

Gray literature: Techniques include word stemming, acronyms, synonyms, translations, spelling corrections and removal of stop words.

Critics argue that the concept of a knowledge graph (KG) is not properly defined yet. Research work dealing with KGs cite Google’s blog even though it does not explain what constitutes a KG. In (Ehrlinger & Wöß, 2016), Ehrlinger and Wöß criticize the wide variety of interpretations of the concept. They propose to define KG as follows: “A knowledge graph acquires and integrates information into an ontology and applies a reasoner to derive new knowledge.” (Ehrlinger & Wöß, 2016)

---

147
finding semantically correct results. The development was kickstarted through acquisition of Metaweb, a company maintaining “an open database of things in the world” (Menzel, 2010). Pages will not only be indexed with respect to keywords but they will also be crawled for entities their attributes, classes and relationships between them to create ontologies (Senturs et al., 2015). Google files numerous patents to bridge the “semantic gap” (Rosenberg, 2013) and further develop its KG (M. Pasca & van Durme, 2013) (Gubin et al., 2016) (Gupta et al., 2014) up the point where it grows and matures self-sufficiently from query input (Halevy et al., 2018) (A. M. Pasca & van Durme, 2014) and understands conversational queries (Sullivan, 2013) (Slawski, 2018).

The KG displays information from different sources in an infobox next to the search results to enrich the search experience through contextual and diverse information (Singhal, 2012). Google possibly adapts this method to the individual users’ background (Balog & Kenter, 2019) and enriches it with signals from their social network (Y. Wu et al., 2013). Then, it may order result based on a user profile (Zamir et al., 2010). Google expands their concept of finding “things” in (Huynh et al., 2014) where they discuss how entity metrics can be used to rank results in a way that considers semantics and context.12

In (W. L. Lu et al., 2019), for example question-answer-relationships on Q&A-websites are identified as well as how question concerning these relationships can be parsed. They filed numerous knowledge-oriented patents that tried to grasp a user’s individual context and understand semantic relationships.

In (Starr, 2015), Starr refers to (Huynh et al., 2014) and points out how different regions on a search results page may be computed by different kinds of algorithms. She implies that “different algorithms apply at different times” (Starr, 2015) and results might be of mixed origin to allow optimal presentation and information to users.

Another leap in Google’s search engine design was the introduction of a Natural Language Processor RankBrain in 2015 (Schachinger, 2017). According to (J. Clark, 2015), it is an AI-driven addition to the algorithm affecting a large fraction of searches that are ambiguous in their meaning or have never been asked before.13 If a query cannot be confidently answered, RankBrain tries to guess the searcher’s intentions. Its goal is to come up with a sufficiently good answer by inferring associations from the input and then find similarities to queries in the past (Sullivan, 2016a) (J. Clark, 2015). This guesswork is made possible by the semantic network of entities and their attributes and relationships mentioned above (Schachinger, 2017).

Recent advances include predictive computing that tries to guess user intent and guide them through search and decision processes. Davies reviews two patents ((Peddinti & Dabbiru, 2017) (Foerster & Brewin, 2017)) that support that development in (Davies, 2017a) and (Davies, 2017b). The patents

12 Examples from (Starr, 2015) include relatedness (co-occurrence of entities), notable entity type (multi-categorization of entities), contribution (content generated by an entity, like social media posts or published works) and prize (awards and prizes)

13 The latter amounting to 15% of all searches. (Farber, 2013)
describe how a search engine can include various information to infer future behavior or intent. Davies points out, that “[B]asically, the patent is built on the idea that all data from virtually any source can be used to determine expected actions a user is likely to take.” (Davies, 2017a) With this knowledge, the patented system tries to estimate future behavior and indicate to the user if an action is jeopardizing the expected outcome (Peddinti & Dabbiru, 2017). The second patent allows to inject suggestive steps into the purchasing process and enables highly targeted bidding on advertisements (Foerster & Brewin, 2017). Davies raises awareness to how these two inventions have massive impact on search behavior, advertisement bidding, purchasing processes. Consequently, this allows nudging the user in a third party’s interest which is critical in terms of the practices introduced in Section 3.1.

Google assesses search quality with feedback from third-party services and users (Google, 2019k) (Levy, 2010). Additionally they are constantly testing and reviewing algorithm prototypes through A/B testing (Levy, 2010).

---

14 According to Davies, this includes social media, motion, purchase history, weather, network account data, data from third-party applications and services all sorts of communications processed on the device. (Davies, 2017a)

15 “Every time engineers want to test a tweak, they run the new algorithm on a tiny percentage of random users, letting the rest of the site’s searchers serve as a massive control group.” (Levy, 2010)