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Managerial Challenges of Algorithmic Journalism and Journalistic Functions: An Analytical Framework

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Zusammenfassung

Die umstrittene Anwendung von Algorithmen im Journalismus bringt Herausforderungen auf verschiedenen Ebenen mit sich, auch auf Medienmanagement-Ebene. Da der Journalismus grundlegende Funktionen in Politik und Gesellschaft erfüllt, ist es essentiell, die Auswirkungen der Automatisierung auf die Funktionen des Journalismus stets neu zu reflektieren. Dieser Artikel zielt darauf ab, die Management-Herausforderungen des algorithmischen Journalismus zu identifizieren und aus einer Managementperspektive zu diskutieren, wie sie sich auf die journalistischen Funktionen auswirken könnten. Eine theoretische Analyse von Dörr & Hollnbuchner (2017) lieferte bereits einen Untersuchungsrahmen für ethische Herausforderungen des algorithmischen Journalismus. Durch eine systematische Literaturanalyse mit 39 Fachjournal-Artikeln bietet dieses Forschungsprojekt qualitative Unterstützung für diesen Untersuchungsrahmen und ergänzt ihn durch Management-Herausforderungen, die bei der Implementierung der Technologie in Medienredaktionen entstehen.

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Keywords: Algorithmischer Journalismus, Funktionen des Journalismus, analytischer Rahmen, I-T-O Model

Summary

The controversial application of algorithms in journalism arises challenges on various levels, including the media management level. Since journalism fulfils fundamental functions in politics and society, it is critical to reflect the impact of automation on the functions of journalism. This article aims to identify managerial challenges of algorithmic journalism and to discuss from a management perspective, how they could affect journalistic functions. A theoretical analysis by Dörr & Hollnbuchner (2017) already provided an analytical framework for ethical challenges of algorithmic journalism. Conducting a systematic literature review with 39 journal articles, this research provides empirical qualitative support for the analytical framework and complements it with managerial challenges that arise when implementing the technology in newsrooms.

Note: This article was already published in MedienWirtschaft, 4(2021), Special Issue "Internet-Intermediäre und virtuelle Plattformen medienökonomisch betrachtet", 18. Jahrgang, Hamburg: New Business Verlag

Keywords: Algorithmic journalism, functions of journalism, challenges, analytical framework, I-T-O model

Shifting Functions of Journalism

Nowadays, automation becomes part of many processes in the journalistic workflow. Algorithms increasingly support professionals in the journalistic content curation, production, personal adaptation or dissemination process (Bandy & Diakopoulos, 2019; Diakopoulos & Koliska, 2017). Algorithmic journalism is often platform-based. Media organisations, especially newsrooms, purchase user licences for the natural language generation (NLG) technology and corresponding data sets and adapt noteworthy parts of their content production and distribution strategy accordingly. These algorithmic journalism platforms thus serve as internet intermediaries both between news supplier and media organisation on the production level (e.g. text generation by NLG, data/text aggregation) as well as between the media organisation and the user on the distribution level (e.g. algorithm-driven dissemination, personalised articles, news aggregators, automated postings). Algorithmic journalism platforms strongly influence the media organisation's content production and distribution workflows and leads to a shift towards data-driven business strategies (Leppänen et al., 2020; Latzer et al., 2014).

With the adoption of the technology in the newsrooms, challenges on various levels arise. Since journalism also fulfils fundamental functions in politics and society, it is necessary to rethink critically the functions of journalism in the era of automation (Gunkel, 2018; Lewis et al., 2019). This article aims to identify challenges from the media management perspective and to discuss the possible impact on the functions of journalism as such. A previous theoretical study by Dörr & Hollnbuchner (2017) already analysed ethical challenges of algorithmic journalism along the three functional spheres of journalism (organisational, professional and social) (Weischenberg et al., 2006) and provided an analytical framework to identify and discuss these (ethical) challenges. Building on their preliminary work, this article provides empirical qualitative support for the analytical framework and complements it with managerial challenges arising in the adoption of the technology in the newsroom. It is therefore intended to build successively on the work by Dörr & Hollnbuchner (2017) in order to extend them. This paper addresses the following research question (RQ):

Which managerial challenges arise with the adoption of algorithmic journalism along the functional spheres of journalism (social, organisational and professional) and how can they impact these functional spheres?

This paper follows the definition by Dörr (2016, p. 3), which indicates that algorithmic journalism is 'the (semi)-automated process of natural language generation by the selection of electronic data [...] (input), the assignment of relevance of pre-selected or non-selected data characteristics, the processing and structuring of the relevant data sets to a semantic structure (throughput), and the publishing of the final text on an online or offline platform with a certain reach (output).' This definition applies in the context of this study, as it covers all stages of the journalistic value creation process at which algorithms can intervene, especially the content production and distribution. It should be added at this point, though, that the output must be a text of journalistic nature.

In literature, the terms algorithmic journalism, automated journalism and robot journalism were used similarly (Caswell, 2019; Lewis et al., 2019). However, the Leibniz Institute for Media Research (2018) concretely distinguishes algorithmic and automated journalism as follows. Automated journalism refers to the automation of journalistic content production by natural language generation (NLG), whereas algorithmic journalism also includes the selection, prioritizing and distribution of content by installation in online platforms (Loosen, 2018, p. 8). Thus, this distinction of terms goes hand in hand with the definition by Dörr (2016) used here.

Research literature deals thus far with the shift of the journalist's role (e.g. Guzman, 2019; Lewis et al., 2019) or the journalist-machine interaction while working with automation software (Lewis et al., 2019; Wu et al., 2019a, 2019b, 2019c). Scholars argue, for example, that algorithms are no longer just mediators (machine), but can increasingly take on the role of the journalist (human) (Lewis et al., 2019). Lischka (2020) evaluated news organisations in the digital age and their institutional functions (market, managerial, professional, technology). Other studies investigated single challenges of algorithmic journalism with impact on the media organisation, the profession *journalist* or the society:

Organisational impact: Managing data deluge (Kunert, 2020; Wu et al., 2019a), role changes in the

newsroom (Wu et al., 2019c) and operational handling with automated chatbots in the news industry (B. Jones & Jones, 2019).

Professional impact: Modifications in job tasks (Carlson, 2019; R. Jones & Jones, 2019) and job status (Kim & Kim, 2018), journalists' attitude towards automation software (Diakopoulos, 2020; Kim & Kim, 2018; Linden, 2017; Wu et al., 2019b).

Societal impact: Algorithmic transparency (Diakopoulos & Koliska, 2017; Shin, 2020), credibility (Wölker & Powell, 2018; Zamith & Haim, 2020), objectivity (Carlson, 2019) and accountability (Díaz-Noci, 2020; Thurman et al., 2019).

However, previous research lacks a comprehensive consensus on the challenges of algorithmic journalism from the media management perspective. The full range of managerial challenges of algorithmic journalism, especially with respect to the journalistic functions, have not yet being part of the scientific discourse. This article therefore aims to give an overview of the most present managerial challenges of algorithmic journalism in the research literature and provides an extension of the analytical framework by Dörr & Hollnbuchner (2017). This framework offers a path for assessing the application of algorithms in content creation and distribution processes. The article places a disciplinary focus on the media management perspective, but also incorporates aspects of communication science and journalism research. The framework could therefore also be relevant in other media research disciplines or for the assessment of other forms of data journalism in the future.

The article firstly gives an outline of the previous analytical framework and delivers relevant theoretical backgrounds. Secondly, it explains the methodology of the systematic literature review (SLR). It subsequently provides a detailed look on the identified challenges, systematised along the three functional spheres of journalism, and reviews their possible impact. In the end, the article presents an extended analytical framework and discusses the findings in terms of limitations and derivations for further research.

Analytical Framework

This article uses the analytical framework by Dörr & Hollnbuchner (2017), which is built on their analysis of media ethical theories, complemented with attributes derived from the technical capabilities of algorithmic

journalism. The framework is theoretically based on the institutional understanding of professional journalism and its functions by Weischenberg et al. (2006). As shown in Figure 1, the approach classifies the spheres of journalism in an organisational (media system), professional (individual/journalist) and social sphere (audience/society). Weischenberg et al. (2006) established a comprehensive definition of journalism building upon the system theory by Luhmann (2012). They aimed to differentiate the system *journalism* and its functions theoretically as precisely as possible from other systems.

Additionally Dörr & Hollnbuchner (2017) have taken into account the ethical multi-layer system of responsibility by Pürer (1992), which distinguishes ethics of the media system (organisational), ethics of the audience (social) and individual ethics (professional). Since Pürer's the multi-layer system is in this case partly comparable to the functional spheres by Weischenberg et al. (2006), it is not executed deeper at this point. Both approaches have in common that they enable to systematise challenges on three different levels: a macro-, meso- and micro-level.

Moreover, this SLR consults a general input-throughput-output (I-T-O) model (Latzer et al., 2014; Reiter & Dale, 2000) which frames the journalistic workflow. The input stage is the journalist's or algorithm's access to data. The throughput stage describes the content generation, selection and curation (Latzer et al., 2014; Wallace, 2018). The output stage contains the publication and dissemination possibilities (Dörr & Hollnbuchner, 2017; Wallace, 2018). Algorithms can find use on all three stages. On the input and throughput stage, for example, the journalist fulfils a gatekeeper function for the society (Diakopoulos, 2020). The question arises if and how far algorithms are able to perform this task as well (Diakopoulos, 2020; Wallace, 2018). On the output stage, the journalist or algorithm has a direct impact on how and on which platforms the audience consumes the content. In general, it applies that the more journalistic processes become automated, the greater the need to understand the nature of the automated output (Weber & Kosterich, 2018).

Methodology

A systematic literature review (SLR) was carried out to systematically analyse the research literature. The SLR is an efficient technique to systematise, assess and synthesise the results of existing studies (Petticrew &

Roberts, 2006; Xiao & Watson, 2019). The method enables to include only challenges in the analysis, which are perceived as relevant enough to appear in several journal articles.

As databases, *Scopus* and *EBSCOhost* were chosen since they are the two largest databases for peer-reviewed academic literature, covering all publishers (e.g. Elsevier, T&F, Sage, Springer, Emerald), disciplines (e.g. media management, journalism studies, innovation management, computational studies) and journals, which are relevant to this study. The search query enclosed the term algorithmic journalism, plus narrow terms which are used similarly in the literature (e.g. automated news or robot journalism). Terms only addressing automated language processing without reference to journalism were excluded (e.g. NLG, NLP, GPT-3, computational linguistics). To answer the research question, the selected literature also needs to relate to managerial challenges occurring during technology adoption in professional settings. The search query was therefore as follows: Title-Abstract-keywords ('algorithmic journalism' OR 'automated journalism' OR 'robot journalism' OR 'automated news') AND ('adoption' OR 'adaptation' OR 'acceptance' OR 'rejection' OR 'implementation' OR 'challenge' OR 'attitude') AND ('newsroom' OR 'journalist' OR 'professional').

Due to the current relevance of the topic and to meet a consistent research standard, the search was restricted to publications of the last five years (1/2016–12/2020) and to academic journal articles in German and English. Only since 2016, a recognisable number of journal articles on the topic of algorithmic journalism adoption in the newsroom has been recorded. Additionally, results about the challenges of a technology are outdated after a couple of years, since technological abilities grow rapidly. To make generalisable statements about challenges, it is also essential that the summarised results meet a consistent and high empirical standard (peer-reviewed journal articles). Due to these previously set search criteria (time period, journal article) and the search in the largest databases with broad search string, forward/backward reference searching was omitted. The abstracts, keywords and introductions of the articles were screened to check the sample for topic fit. Articles that addressed journalistic content production with algorithms have been included. Articles about chatbots, recommendation systems or other automated processes in human–computer interaction without reference to journalism have been excluded. Figure 2

shows the entire literature selection process. The final sample, consisting of 39 articles, is marked in the *References* with *.

The analysis of text material as part of the SLR was conducted using the qualitative content analysis approach by Mayring (2014). The entire text material was reviewed, coded and paraphrased using MAXQDA, which resulted in a list of all challenges mentioned in the text. In order to ultimately extract a more comprehensive list in the end, challenges of the same meaning and context were aggregated (generalisation) (Mayring, 2014, p. 69) and groups were formed by topic. In the end, the final list of challenges could be structured along the three functional spheres of journalism (organisational, professional, social) in order to review descriptively their possible impact on these functional spheres.

Findings - Organisational Sphere

According to Weischenberg et al. (2006), the organisational sphere is characterized by the fact that journalistic media organisations continuously produce journalistic communication and implement journalistic functions operationally. This is the sphere where journalism is traditionally produced according to institutional rules and routines.

Inter-organisational challenges, such as tensions through hierarchy or between economic aims, can complicate the performance of media organisations and affect their field of action. Accountability, transparency and legal questions arise on the organisational sphere. The literature especially points out the following relevant challenges:

Difficulty in Generating Competitive Advantage

Currently, algorithmic journalism has limited fields of use (Dierickx, 2020; Kim & Kim, 2017, 2018; Melin et al., 2018). As accurate and comprehensive data sets are required, newsrooms mostly use content automation for fact-based domains, which are easier to write (e.g. sports, weather, traffic, finance). The availability of usable, complete data is generally a big barrier for newsrooms to use automation software (Linden, 2017). For example, if a national newspaper decides to buy existing data sets or to use public data sets (quickest way), they need to be compatible with the organisational data model on the one hand (Caswell, 2019; Diakopoulos & Koliska, 2017). On the other hand, the newsroom just uses the same data as any

other competing newspaper. It is therefore easy to imitate and does not represent a competitive advantage. If the data set is self-developed, since there is more data than can be processed, algorithmic journalism can offer a strong competitive advantage for the newsroom (Diakopoulos & Koliska, 2017). The development of own data patterns is perceived as more reasonable; however, it is challenged by an organisational lack of financial and technological resources (Jamil, 2020; Kunert, 2020).

Lack of Technological Know-How

In the literature, a wide range of newsrooms report a lack of technological knowledge, especially about data management (Caswell & Dörr, 2019; Wu et al., 2019a, 2019b). Often, resistance to adoption of data journalism is due to the lack of data strategies in the newsrooms (Wu et al., 2019a) or the lack of knowledge about coding and adaption of text templates to individual preferences (Caswell & Dörr, 2018), which especially impacts data processing (throughput stage). To develop and maintain automated content solutions, highly skilled, technical staff is required in-house (Upshall, 2018), including continuous trainings for journalists in technological thinking, data managing and coding to a certain degree to enable collaborating with algorithms, managing output quality, controlling input diversity, and compliance with organisational-editorial values. Practical use cases in this context are the BBC (B. Jones & Jones, 2019; R. Jones & Jones, 2019), the Washington Post (Rojas Torrijos, 2019), L'Echo (Dierickx, 2020) and the Australian Broadcasting Corporation (ABC) (Ford & Hutchinson, 2019).

Findings - Professional Sphere

On the professional sphere, journalists aim to offer accurate news as quickly as possible (Weischenberg et al., 2006). The journalistic role conceptions also include objective reporting, giving the audience topics to talk about (Schmidt & Loosen, 2015; Weischenberg et al., 2012) and ensuring journalistic quality based on specific criteria, e.g. comprehensibility, correctness and relevance of the output (Wellbrock & Klein, 2014). If algorithms support the journalistic workflow, the complex cooperation of algorithms, coders and journalists evokes ethical challenges on the one hand, such as low transparency, controllability or accountability issues (Dörr & Holnbuchner, 2017), especially if the journalist is not able to adapt templates or to change underlying data. On the other hand,

further challenges affect the profession *journalist* and the journalistic workflow:

Fear of Replacement

One of the most present challenges in the literature is the fear of journalists of losing their jobs due to replacement by automation technology (Guzman, 2019; Jamil, 2020; Wu et al., 2019a; Zheng et al., 2018). Journalists assume that organisational restructuring will accompany the employment of robots (Kim & Kim, 2018). Software provider and media manager often spread the message that “automated technologies are not an attempt to replace human journalists but rather [...] a tool that journalists can use to improve their work processes” (Wu et al., 2019a, p. 12). However, the journalists’ sceptical attitude takes a very present role in the literature and impacts the professional sphere in terms of willingness to work with automation technology. In this context, the allocation of undesirable tasks and unwanted job assignments for journalists, such as coding templates or monitoring data processing, can fire up the already sceptical attitude of journalists against the technology (Caswell & Dörr, 2018, 2019; R. Jones & Jones, 2019; Kim & Kim, 2018; Wu et al., 2019b).

Loss of Editorial Control

The loss of editorial control poses another relevant challenge (R. Jones & Jones, 2019). Besides less influence on the output quality, journalists need to handle responsibility, transparency and accuracy issues (Carlson, 2018; Diakopoulos & Koliska, 2017; Melin et al., 2018; Montal & Reich, 2017). The algorithms act as *black boxes*, which “often lack explainability in their automated decision making” (Diakopoulos & Koliska, 2017, p. 813). A new journalistic function emerges: monitoring the automation software and its results. This shift of the journalist’s role – from the active creator to the passive controller – changes the journalist’s daily routine. It requires transparent coding and a deeper understanding of how the technology works in order to clarify the question of output responsibility.

The loss of editorial control has an immense long-term impact on the profession *journalist* as such. With various accountability and responsibility issues discussed in the research literature (e.g. B. Jones & Jones, 2019; Montal & Reich, 2017; Wellbrock, 2016), the question arises if journalists could take on a rather passive role in the production and processing of

editorial content in the future. Under the conditions of transparent coding and a deeper understanding of the software's nature, however, it might still be possible to fulfil journalistic functions.

Data Quality and Availability

The lack of compatible, accurate data sets represents another huge challenge on the input stage (Caswell & Dörr, 2018; Diakopoulos & Koliska, 2017; Linden, 2017). The used data need to be correct, up-to-date and complete in order to produce meaningful editorial content (Graefe et al., 2018; Wu et al., 2019c). In general, the challenge also arises on the organisational sphere. However, in the end, it is the journalist's task to check the accuracy and completeness of data in detail, which is why the challenge has more impact on the professional sphere. There is the discussion in the literature how often underlying data are biased or incomplete (Leppänen et al., 2020). Additionally, the code itself "may be wrong or could reflect the conscious or unconscious biases of those who developed or commissioned them" (Graefe et al., 2018, p. 599). Since journalism aims to provide orientation and fact-based, objective content, the issue of data and code objectivity and accuracy highly impacts the professional sphere on the input stage (Dörr & Hollnbuchner, 2017).

Reduced Output Readability

For algorithms, it is a challenge to write interesting, exciting or humorous texts (Dierickx, 2020; Melin et al., 2018; Wu et al., 2019c) or to express narrative structure (Graefe et al., 2018; Kunert, 2020; Wölker & Powell, 2018). The output can cause alienation of the audience (Lewis et al., 2019; Liu & Wei, 2019). Computer intelligence is "lacking in curiosity, imagination and worldliness" (Linden, 2017, p. 12) and reductive in the "use of language and creativity" (Thurman et al., 2017, p. 11). According to several studies in the literature, the poorer readability for automated articles currently still represents a major challenge for algorithmic journalism technology (Graefe et al., 2018; Jia, 2020; Leppänen et al., 2020; Liu & Wei, 2019). For example, algorithmic, journalistic texts are still perceived as either boring (Thurman et al., 2017; Zheng et al., 2018) or cold and emotionless (Wu et al., 2019c; Kunert, 2020) on the one hand. On the other hand, algorithmic journalism can be applied very well for the production of purely fact-based content.

Complicated Workflows

The data issue goes hand in hand with the challenge of data managing (Galily, 2018; Upshall, 2018). The workload for collection and maintenance of big data can be a huge challenge for media organisations that have not yet established a proven data managing system (Kunert, 2020). This workload is mainly borne by the professionals (journalists, coders) and has impact on the professional sphere (throughput).

Since the content automation software has only limited options to detect biases, journalists still have to check part of the automated content before publication (R. Jones & Jones, 2019; Lewis et al., 2019). There is still a "need for human actors to verify the information put together by the machine" (Wu et al., 2019c, p. 1451). As long as automation software is not able to produce accurate content without human intervention, there is no specific benefit for the journalist to use the technology. It might make it even more difficult for journalists to deal with the huge amount of content. Other challenges that complicate the journalistic workflow are inflexible templates/wording and complex software usability (Galily, 2018; Lewis et al., 2019; Melin et al., 2018; Thurman et al., 2017). Complicated workflows do not endanger the performance of journalistic functions per se, but they can burden professionals with additional workload, let them lose overview or lower outcome quality.

Findings - Social Sphere

On the social sphere, journalism fulfils exclusive functions for society by observing the public, providing the audience with information, controlling what information reaches the public and influencing how social reality is framed (Dörr & Hollnbuchner, 2017; Wallace, 2018; Weischenberg et al., 2006). Unlike other forms of public communication, the institutional system of journalism independently and periodically delivers content that is newsworthy, relevant and fact-based (Schmidt & Loosen, 2015; Weischenberg et al., 2012; Weischenberg et al., 2006). Journalism in the mass media needs to serve the public interest in maximizing democratic core values, such as freedom, equality and order (McQuail, 1992).

According to the ethical perspective of Dörr & Hollnbuchner (2017), the media have a responsibility to the public in terms of media education, diversity and control. Their framework outlines challenges on the social sphere, such as questions about data origin or

observation of the public. From the media management perspective, further challenges can be derived from research literature:

Limited Bias Detection

Since biases can creep in at almost any stage of the algorithmic, journalistic process (Leppänen et al., 2020), the quick dissemination of false information, immoral content or prejudices presents a certain risk (Carlson, 2018; Lewis et al., 2019; Thurman et al., 2017), especially in the age of cross-channel content strategies and social media. The same challenge emerges if the software violates moral principles, privacy or data rights (Montal & Reich, 2017). Therefore, it is visible that biases can currently occur in too many contexts and levels, while, at the same time, methods are discussed to analyse and detect biases in automated-written texts, such as machine learning methods and different user-cooperative scenarios (Leppänen et al., 2020). For the future, it is assumed that methods for detecting bias will be extensively tested and further developed.

Balancing Information Overload and Output Diversity

Automation software often applies personalisation tools to meet the needs of the customer more accurately. On the social sphere, the filter bubble effect is often discussed in research literature (Carlson, 2018; Diakopoulos, 2020; Graefe et al., 2018). Fragmented content curation, production and dissemination limits the diversity of information on the input and especially on the output stage (Thurman et al., 2019). Simultaneously, journalists and publishers are worried about overwhelming the audience with too much information (Caswell, 2019; R. Jones & Jones, 2019). Algorithms highly increase the quantity of produced texts – one of the biggest opportunities and risks at the same time (R. Jones & Jones, 2019). A huge amount of available information can improve profitability and “increase people’s burden to find news that is most relevant to them” (Graefe et al., 2018, p. 12). In providing the full range of information available, algorithms may fail to fulfil the orientation function of journalism which is supposed to help the audience to understand and categorise relevant information. With progressive content personalisation in the internet, algorithmic journalism cause filter bubble effects (Diakopoulos, 2020; Leppänen et al., 2020), which would limit output diversity and pluralism for the individual user (e.g. search engines, personalised content curation and news feeds).

Regarding this background, automation software and media organisations need normative rules to balance information quantity and output diversity. The need for public media institutions, which have a duty to educate and inform, is particularly noteworthy at this point.

Additionally, it is essential for journalism to deliver relevant context. Automation software has limited abilities in providing context, reflecting or concluding from incongruent information (Jia, 2020; Wölker & Powell, 2018; Wu et al., 2019c). These limitations of the technology evoke a lower depth and diversity of the produced content. In addition with the challenge to judge whether content has public newsworthiness (Caswell & Dörr, 2019; Diakopoulos, 2020; Kim & Kim, 2018; Wu et al., 2019c), algorithms are restricted in the journalistic function of providing diverse, informative and relevant output.

Table 1 summarises the identified managerial challenges of algorithmic journalism as extended analytical framework.

Discussion & Conclusion

With algorithms as part of journalistic processes, challenges on various levels arise, including the media management level. This article firstly showed the current relevance of the topic and the state of research. Second, it introduced the previous analytical framework by Dörr & Hollnbuchner (2017), anchored the study in theory and showed the methodology of data collection/analysis. In the main part, the article presented the found managerial challenges of algorithmic journalism along the functional spheres of journalism (RQ). Furthermore, the article discussed, which and how challenges can have an impact on these functional spheres and the journalistic functions. Out of these findings, the article offered an adapted and extended analytical framework (Table 1), which offers a path for deeper assessment of algorithmic journalism technology as an internet intermediary for the institution *journalism*.

This analysis needs to face some limitations. One limitation of the previous and extended analytical framework is the lack of separability and selectivity of the spheres. Several challenges in the professional sphere are influenced by organisational, societal and cultural structures, as well as individual principles of journalistic work (Dörr & Hollnbuchner, 2017). There can be challenges, such as data accuracy or completeness, which has impact on all functional

spheres of journalism. The same applies to the input, throughput and output stages (I-T-O). As a suitable solution, the challenge is assigned to the sphere in which it has the greatest impact on according to the literature, respectively the stage on which the challenge primarily arises. Additionally, descriptive reviews can be biased by the reviewer's experience or the overall subjectivity of the literature (Xiao & Watson, 2019). Challenges identified by the SLR are accepted as given and correct. It is possible, however, that the literature is not accurate or does not represent reality correctly, a challenge is not applicable in every case, not proven or very subjective. An attempt have been made to reduce this research bias by including only articles with highest publication standards (peer-reviewed academic journal) in the sample and by including only challenges, which were discussed in several articles.

According to these limitations, the managerial challenges studied here may differ in their diversity from those in reality. Nevertheless, the analysis delivers a relevant overview about managerial challenges of algorithmic journalism and an applicable analytical framework for a deeper assessment of journalistic functions in the era of automation. The results show, on the one hand, that algorithms are not capable of performing the same functions as a human journalist due to severe challenges (e.g. output quality, data managing, bias detection). There is a broad understanding that media organisations are apprehensive of machine error or job loss (Wu et al., 2019a). On the other hand, algorithms are highly advanced (maybe superior, if the data are accurate) in fulfilling the journalistic function of providing data-/fact-based information and offering news very quickly (Carlson, 2019; Rojas Torrijos, 2019). It is therefore not advisable that media organisations withdraw from the ongoing process of automation. If they decide not to use algorithmic data processing, digital competitors and press agencies begin to build up own data sets, which will put media content producers in a more demanding, maybe even dispensable, competitive situation in the future.

Altogether, there are currently various challenges, which hinder the technology to fulfil the same functions on the macro-, meso- and micro-level as human journalists do. Data/code accuracy, loss of editorial control and output quality are particularly noteworthy at this point. The idea of "robot journalism 3.0" (Kim & Kim, 2018), in which algorithms can cover the data research, bias detection and independent dissemination of high-quality content, is still

hypothetical. Nobody knows if algorithmic journalism will be able to cover more topics in the future (Thurman et al., 2017). With the state of technology today, algorithms are intended to reduce repetitive tasks and take care of the purely data-driven processes (= journalist in a *passive* role). Human journalists instead continue to take care of stories about people (= journalist in an *active* role). Algorithms are currently not able to replace journalists, but they provide the opportunity to take over tasks, which bore journalists and cost them time. Hence to conclude: The "fault" lies neither in the nature of the technology nor in the mind-set of the journalist. The main challenge overall is to close information gaps and to build a bridge on how journalists can work with the algorithms in a meaningful way.

For future research, it is important to reflect continuously the managerial challenges of algorithmic journalism and their impact on journalistic functions, depending on the state of technology. The fundamental functions of journalism for society and democracy require a critical, steady analysis of the algorithm's role. The analytical framework is not conclusive and needs to be adapted according to technological development. Furthermore, the framework can be tested quantitatively and qualitatively for other forms of data journalism. Eventually, it would be interesting how to adapt the framework for the assessment of other forms of AI in the media industry, such as intelligent personal assistants, content recommendation systems or video automation.

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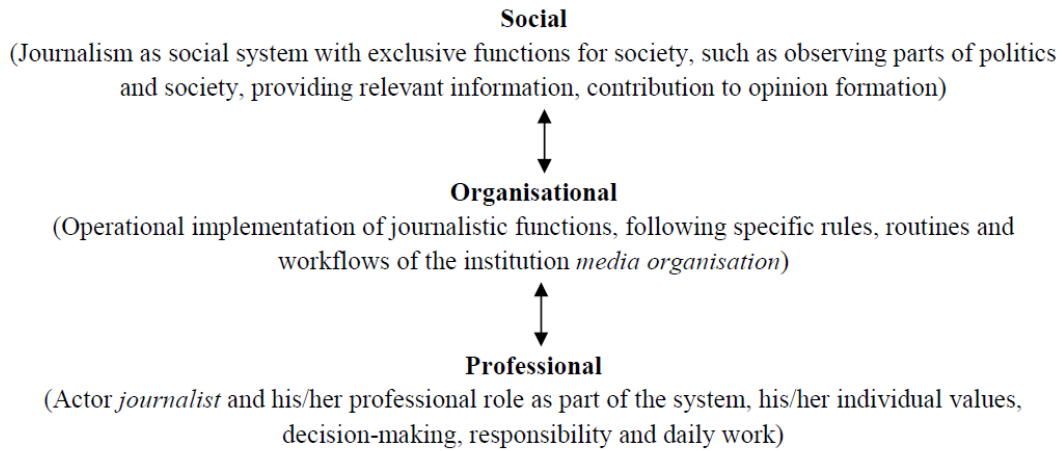
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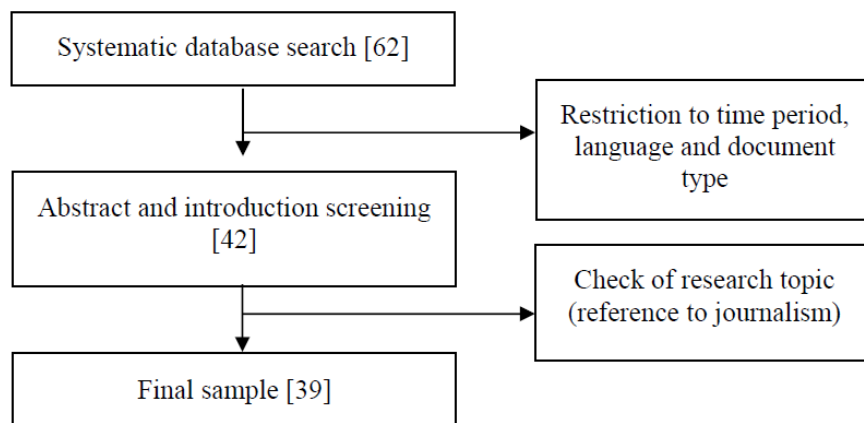
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Note: The literature of the SLR sample is marked with *.

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Figure 1: The three functional spheres of journalism

Source: Weischenberg et al. (2006), adapted by the author

Figure 2: Literature selection process

Source: Moher et al. (2009), adapted by the author

Table 1: Extended analytical framework for challenges of algorithmic journalism

	Organisational Sphere	Professional Sphere	Social Sphere
	<i>Impact on business, organisation or market</i>	<i>Impact on profession or journalistic workflows</i>	<i>Impact on ethics, education, law or public</i>
Input	Reliability / accuracy Objectivity Responsibility Appropriate methods of data collection Bias Data / code rights & authority; respect for privacy Code transparency Machine communication optimisation Economic aims Availability of usable, complete data	Code transparency Code objectivity Code responsibility Code accuracy / bias Machine communication optimisation Data availability / accuracy Data managing	Data diversity Data / privacy rights Information overload
Throughput	Production authority Lack of financial resources / technological know-how Lack of data strategies	Software / code testing Monitoring data processes Inflexible templates / wording Complex software usability	Limited bias detection
Output	Result authority Transparency / disclosure Legal accountability Difficulty in generating competitive advantage	Result monitoring Fear of replacement Loss of editorial control Reduced output readability Need to check output before publishing Output responsibility issue	Transparency / trust Control of demand Conformability Observation of society Providing verified information Output depth / diversity Public relevance

Source: Ethical challenges by Dörr & Hollnbuchner (2017), summarised by the author (grey challenges); black challenges are newly added to the framework.