Attention boost through media coverage?

Agenda setting effects from news media coverage on topic selection of scientific journals

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Abstract

The fact that media emphasis of certain topics can increase their importance for the public has already been confirmed many times in agenda setting research. However, we are not aware of any study that examines if attention by news media on certain scientific topics correlates with or even has feedback effects on topic salience in scientific journals. The aim of our analysis is to examine how a scientific topic develops in scientific journals over time, namely before and after a point of conspicuous news media attention. Our analyses reveal a relationship between the amount of attention scientific papers receive through popular media and the amount of attention the respective topics receive from scientific journals. In more than 50 percent of the cases, after a scientific paper received a noticeable amount of news media coverage, more thematically similar articles were published in scientific journals than before. In this sense, here and there journalism can be considered as an agenda setter for the choice of topics in academic journals. Our findings may be interpreted in accordance to a publicity effect, namely that popular media coverage provides a scientific attention boost for scientific studies or topics that they would not have received without news media coverage.

1 Introduction

Almost 60 years ago, the very renowned German sociologist Jürgen Habermas suspected that significant scientific findings from a specialised field of science could sometimes only become known in other fields through popular processing in mass media, thus stimulating further research (Habermas, 1969). This assumption was prompted by findings of Derek J. de Solla Price (1974) who had measured the rapid growth of scientific literature and the increasing degree of specialisation in science. Growth and specialisation, Habermas speculated, tended to lead to the drying up of communication flows across specialisation boundaries, so that sometimes great distances had to be overcome in order to transfer relevant information from one special field to another. However, scientific actors see an increasing need "to link disciplinary fields to more fully answer critical questions, or to facilitate application of knowledge in a scientific area." (Aboelela et al., 2007, p. 330) The generation and concentration of attention through mass media was seen by Habermas as a possible means of preventing the flow of communication within science from drying up.

This very positive interpretation of repercussions or feedback effects from journalistic actors' choice of topics on scientific actors' choice of topics has now given way to rather negative ones (Franzen, 2011). Positive repercussions of relatively high attention to scientific findings on the genesis of knowledge within science are linked to the prerequisite that journalism focuses attention on scientifically relevant findings, because only such findings can serve the flow of scientific communication. This is doubted. The negative interpretation of feedback effects from media coverage on science accuses journalism in grosso modo of systematically favouring spectacular new findings whose scientific content it is unable to verify.

This is a cause for concern because the importance of public attention for science has increased in the course of new political impulses to steer science in the past twenty years, for example in the form of the so-called new public management at universities. New public management is an expression of economization of the scientific system. It introduced auditing processes into the scientific system and put pressure onto the higher education system to be more effective and efficient (Weingart, 2022), e.g. with regards to scientific outcome of high impact, in the provision of state services ("Do more and better with less." (Zechlin, 2015)). As public attention has become more important for science, it is speculated, scientific authors and journals may be tempted to prioritise journalistic selection criteria such as novelty, spectacularity and usefulness when choosing topics, and/or to make use of common means of presentation in journalism such as exaggeration or even sensationalization (Franzen, 2011). Some of these assumptions have already been confirmed by studies that find a shift in the 'design' of scientific articles, like an increased usage of overstatements or exaggerations and biased interpretations. Through characterizations of research results as 'new', 'unexpected' or 'unique' scientists expect to trigger prominent news factors that are applied by journalists to select events for media coverage, like 'unexpectedness' or 'superlativeness' (e.g. Badenschier & Wormer, 2012; Dumas-Mallet & Gonon, 2020; Dumas-Mallet et al., unpublished manuscript; Fraser & Martin, 2009; Jasienski, 2006; Sumner et al., 2014; Sumner et al., 2016). This orientation of scientific actors towards journalistic selection criteria could encourage deliberate falsifications, improper exaggerations or scientifically inadequately supported 'steep' theses, whose public dissemination may become more likely. The feedback effects of this publicity on science could not be conducive to the flow of scientific communication, but on the contrary hinder or at least disrupt it.

As different as the interpretations may be, what they have in common is that the generation and bundling of attention by journalism is believed to have a feedback effect on the flow of communication within science. This is where the present study comes in.
We want to investigate whether an influence of the generation and concentration of attention by mass media on certain scientific topics on the flow of communication within science can be made plausible empirically. More specifically, we want to examine if scientific topics that

receive media attention will also receive greater attention from scientific journals. In the following sections, we first give an overview of the theoretical and empirical state of research on feedback effects of media coverage on scientific publishing. From this, we derive one hypothesis and one research question. In a further step, we describe the methodological design of our study, including data collection, processing and analysis. We then present and discuss the results of our analysis and outline avenues for future research.

2 Feedback effects of media coverage on scientific publishing

A theoretical approach that deals with feedback effects of media coverage on audiences in general is the so-called *agenda setting approach*, one of the most popular approaches in communication science (Luo et al., 2019). Agenda setting describes – in its simplest form – a relation between mass media agenda and public agenda, namely the phenomenon that if mass media select certain issues and portray them frequently as well as prominently (so called mass media agenda), this will lead people to perceive especially those issues as more important or salient than others (so called public or audience agenda). This transfer of issue awareness or the question "how media emphasis of certain issues raises their importance for the public" (Wu and Coleman 2009, S. 776) is subject of the first level agenda setting research tradition (e.g. Maurer, 2017; van Trigt et al., 1995; Scheufele, 2014). For example, if mass media increasingly report about climate change, the population will also consider climate change to be an increasingly important issue.

Agenda setting effects have been studied since the 1970s and correlations between issue salience in mass media coverage and in public have been confirmed empirically hundreds of times (pioneering studies are those by McCombs & Shaw, 1972 or Funkhouser, 1973; for an overview see e.g. Maurer, 2017 or meta-analyses by Wanta & Ghanem, 2007 or

Luo et al., 2019). The methodologies used in agenda setting studies are manifold. On the one hand, data on issue salience in mass media is required, which can be collected, for example, through content analysis. On the other hand, data on the public or audience agenda is needed, which can be collected, for example, through population surveys (usually, they ask which issues the respondents consider to be particularly important at the moment) or through the analysis of search queries on the Internet. The issues from both data sources are ranked and compared to determine any correlations. In order to (reliably) determine an effect of the media agenda on the public agenda (causal conclusion), longitudinal designs with at least two measurement points are more suitable than cross-sectional designs with only one measurement point (Gleich, 2019; Maurer, 2017; Luo et al., 2019).

As already described, first level agenda setting studies usually focus on the effect of the media agenda *in general* on the public agenda *in general* (aggregate data analyses). It is much less common to differentiate between the agendas of different media or different partial publics (e.g. political public) or individuals (individual data analyses) (Maurer, 2017). So far, we are not aware of any study that examines effects of the media agenda specifically on the scientific agenda. Our study thus contributes to close a research gap. The general idea of the agenda setting approach may be transferred to the question of our paper, namely if the attention by mass media on certain scientific topics (media agenda) correlates with or even has feedback effects on topic salience in scientific journals (as audience agenda in this special case).

We only know of one study that examines 'agenda building' effects from scientific medical journals to Dutch daily newspapers, id est analyzes exactly the opposite direction of effect (van Trigt et al., 1995). *Agenda building*, other than the classic agenda setting approach, in a broad sense deals with the question of how the media agenda itself comes about (Maurer, 2017), in other words "who sets the media's agenda?" (Vonbun et al., 2016, p. 1055). One possible explaining factor is *intermedia agenda setting*, a process of news diffusion, "where coverage of one media outlet is influenced by the agenda of other outlets" (Vonbun et al., 2016, p. 1055). Van Trigt et al. (1995) confirm „an agreement in the main groups of medicines discussed in the scientific medical literature and newspapers" (van Trigt et al., 1995, p. 893) and conclude that "medical journals are the most important sources of ideas and information for journalists writing about medicines." (van Trigt et al., 1995, p. 898) Even if the authors do not do this explicitly, one could describe this finding as an intermedia agenda setting effect, if one regards medicine journals as specialist media that influence the agenda of daily newspapers as mass media.

Feedback effects from media content on the flow of scientific communication other than influencing the issue agenda have further been made plausible at the level of individual study results by a positive correlation between mentions of study results in (mass) media and the number of their citations. Several analyses show a rather strong relationship between the amount of attention scientific studies receive through popular media and the amount of attention these studies receive from fellow scientists, measured via the number of citations in scientific literature (see e.g. Anderson et al., 2020; Dumas-Mallet et al., 2020; Fanelli, 2013; Kunze et al., 2020; Phillips et al., 1991).

Additionally, there are case studies that analyze publication time frames of scientific articles that deal with topics that are salient in public and mass media. A study by Dumas-Mallet et al. (unpublished manuscript), for example, analyzes the publication process of Zika virus research studies. It shows that after a peak in media coverage of the Zika virus in 2016, publications on the same topic in six major biomedical journals significantly increased. Further, the time delays between the Zika virus papers' submission and acceptance as well as between their acceptance and online publication were highly reduced following the peak of media attention, whereas such a reduction was not observed for studies on other topics published in the same journal issues.

3 Hypothesis and research question

In the present study, by using a time comparative analysis we want to investigate whether a feedback effect can also be made plausible for the choice of research topics by scientific authors or journals. We want to examine how a scientific topic develops in scientific journals over time, namely before and after a point of conspicuous popular media attention for a scientific paper on the topic. What we try to do is to check whether those scientific topics that received popular media attention are also in the ascendant in scientific journals and gain in salience there. If, after popular media attention for a certain scientific paper, we found significantly more attention for the corresponding topic in scientific journals than before the media coverage of the paper, this could be an indication of feedback effects of media coverage on the scientific system (in the sense of a necessary but not sufficient condition, because we are not able to show a causal connection).

Since the agenda setting approach is considered to be relatively well scientifically proven and since correlations between popular media coverage and citation rates of scientific studies have already been evidenced, we hypothesize a correlation between the attention for a scientific research topic in popular media and in scientific journals:

H1: A scientific topic that attracted media attention will attract more attention in scientific journals.

To our knowledge, to check this assumption would be the first try to link the selectivity of science journalism systematically with the selectivity of scientific journals.

Further, we want to check if there is a difference in the degree of attention correspondence (between popular media and scientific journals) regarding different types of scientific journals. Noelle-Neumann and Mathes (1987) describe that each media system has its so-called 'opinion-leader media' that set the agenda for other media (see also Vonbun et al., 2016, p. 1056). Opinion-leader media are typically media with high prestige which are used by other media as a source of information. They have a kind of trendsetting or intermedia agenda setting function, presenting topics that are picked up by other media outlets (Noelle-Neumann & Mathes, 1987). And such opinion-leader media with an intermedia agenda setting function can also be found among scientific journals. Several studies have already shown that science journalism, when researching and selecting scientific news, is particularly dependent on publications by specific scientific journals and bases its selection decisions predominantly on a very few renowned scientific journals (the relevant studies usually name between seven and ten journals as most frequently cited by journalism). Among these journals are named in agreement, for example, *Nature, Science*, *New England Journal of Medicine* (NEJM), *Proceedings of the National Academy of Sciences of the United States of America* (PNAS), *Journal of the American Medical Association* (JAMA), or the *British Medical Journal* (BMJ) (e.g. Blöbaum et al., 2004; Entwistle, 1995; Kiernan, 2016; Kohring et al., 1999; Lehmkuhl & Promies, 2020; Lehmkuhl & Promies, 2021; Moriarty et al., 2010; Pahl, 1998 Semir, 1998; van Trigt et al., 1994; Wormer, 2008). To put it another way: two handful of scientific journals serve as intermedia agenda setters for science journalism and may be therefore called opinion-leader journals. These scientific opinion-leader journals or intermedia agenda setters show a proven relation or correlation to news media coverage and thus they seem to be more strongly interwoven with the news media than less often cited scientific journals. We do not know if therefore perhaps they are also more receptive to feedback effects from popular media coverage or if their relation to the media only runs in one direction (from intermedia agenda setters to popular media). At least, it is not uncommon for agenda setting studies to show that different agendas influence each other mutually (Maurer, 2017). We therefore want to differentiate between scientific journals which we would call ‘opinion-leader journals’ and ‘non-opinion-leaders’ and formulate an open research question:

RQ: Will the degree of attention correspondence between popular media and scientific journals be higher in scientific opinion-leader journals compared to non-opinion-leader journals?

4 Method

4.1 Data collection and operationalization

To test our hypothesis and research question, we collected different types of data. To investigate the potential short time correspondence between the attention of research topics in popular media coverage and in scientific journals, we apply a systematic approach in which the single scientific article and its (popular) news media coverage are the starting point.

First, we needed to identify scientific research articles that received a noticeable amount of news media attention. Theoretically, we connect here to the so-called 'threshold model' of agenda setting research, which assumes that an agenda setting effect only occurs when a certain reporting threshold is exceeded. According to this model, a few popular media reports on a topic initially do not trigger any significant agenda setting effects. However, once the threshold for public perception of a topic has been crossed, the perception and perceived importance of the topic on the audience agenda increases (Maurer, 2017).

To identify research articles that received conspicuous news media attention, we use data from the altmetrics provider *Altmetric*, as other studies have done, e.g. Anderson et al. (2020) or Kunze et al. (2020). More precisely, we use their Mainstream-Media-Score (MSM-Score). *Almetric* is an increasingly popular online database that reports the number of news outlets, the numbers of tweets, blogs and Facebook pages citing scientific studies. The MSM-Score represents the number of online media portals that mention the respective scientific study. A previous study validated this score and showed that only a score ≥ 100 indicates that a scientific paper was taken up by several editorial offices at the same time in at least three important markets (USA, UK, and Germany) (Kohler et al., 2020). We rely on this value and thus identified all scientific papers with an MSM-Score ≥ 100 during a time period from August 2014 to July 2018 by applying an automatic search on *Altmetric* using a validated Python script (Milhahn et al., 2018). These were 1 068 scientific articles from 261 scientific journals. To be able to recognize potential adaptation processes of scientific journals, it is necessary to cover a period of several years. Data collection took place in 2019.

Second, to operationalize correspondence between popular media coverage and scientific publications, we analyze if the general topic of a scientific article that received a noticeable amount of news media attention (operationalized via the MSM-Score ≥ 100) significantly increased within scientific journals in the aftermath (H1).

To capture potential increases of topics within scientific journals, we used the 'similar articles'-function of *PubMed*. *PubMed* is a database that records more than 32 million abstracts and citations of literature from biomedicine, life sciences, chemical sciences, behavioral sciences and bioengineering (PubMed, 2021a). *PubMed*'s similar articles-function shows all documents that are the most similar (in terms of content) to the original document you searched for. This is done by a word-weighting algorithm that basically compares words from the title, the abstract, and the so called 'MeSH terms' that are usually added to a document. MeSH is a comprehensive, controlled vocabulary for indexing journal articles and books in the life sciences. For a more detailed description of the process of identifying similar articles, see (PubMed, 2021b). We validated the precision of the similar articles-function by manually checking all similar articles which *PubMed* has identified for two research articles from our list of 1 068 scientific papers with an MSM-Score ≥100. In sum, we checked n = 387 similar articles for their content fit to the topic of the respective MSM-Score ≥100 paper. We found that in one case 46 percent of all analyzed similar articles fit to the topic of the original paper and in the other case 51 percent.

In a third and last step, to answer our research question, we defined which scientific journals we regard as 'opinion-leader journals' (to compare their degree of correspondence to the popular media agenda with those of 'non-opinion-leader journals'). By opinion-leader journals we mean first of all that these scientific journals enjoy a special reputation among science journalists. Secondly, they also enjoy a great reputation in the scientific community. As measurable criteria to determine scientific opinion-leader journals, we 1) chose those journals that have published together at least one third of all MSM-Score ≥ 100 papers from our list of 1 068 papers. Further, these journals must 2) noticeably differ from all other journals that published MSM-Score ≥ 100 papers, so called 'outliers'. A simple and typical way to identify outliers is to determine them based on the number of standard deviations from the mean. Our criterion to identify outlier-journals was to only choose those journals that differed more than three standard deviations from the mean regarding their number of published MSM-Score ≥ 100 papers. The journals that fulfill both of the aforementioned criteria are: *Nature*, *Science*, *New England Journal of Medicine* (NEJM), *Proceedings of the National Academy of Sciences of the United States of America* (PNAS), *The Lancet*, and *Journal of the American Medical Association* (JAMA). These six journals together published 379 of the 1 068 MSM-Score ≥ 100 papers between 2014 and 2018 which corresponds to about 35.45 percent.

That this selection of opinion-leader journals also seems to be meaningful in terms of content is the fact that they highly correspond to those journals that are repeatedly named as the scientific journals on which journalists base their selection of scientific papers (see e.g. Kiernan, 2016; Lehmkuhl & Promies, 2021; Pahl, 1998; van Trigt et al., 1994).

4.2 Data preparation

Of the 1 068 research articles with an MSM score of ≥ 100, 983 could be identified in the *PubMed* database. That not all of the 1 068 papers are included in the *PubMed* database is mainly due to the fact that this database is a collection of publications from biomedicine, life sciences, chemical sciences, behavioral sciences and bioengineering. Publications from other disciplines are only covered to a limited extent. At the time of the data retrieval (January 2021), a total of 185 166 articles were assigned to the 983 articles as so called 'similar articles'; since a variety of articles could be assigned to several of the 983 MSM score ≥ 100 articles (because they deal with the same topic), this number is reduced to 157 643 unique papers.

In a next step, we counted the number of similar articles before and after the publication of each associated MSM ≥ 100 article. Due to the limitations of the *PubMed* data, only the publication year (contained in the 'PubYear' variable) is available as publication date (no specific indication of month or day). Similar articles that appeared in the same year as the associated MSM ≥ 100 article were therefore not considered for analysis. In order to analyze symmetrical observation periods, only those similar articles were considered that were published in the two years before and after the publication of the MSM ≥ 100 article. We have chosen the observation period of two years for the following reasons:

Firstly, we had to consider how long it takes till scientist can react to popular media coverage by conducting studies that correspond to scientific topic(s) covered by popular media and to publish them within a scientific journal. Several studies that investigate publication delays – that is delays from submission to publication of an article in a scientific journal – show that they turn out to be very different, depending on the journal itself, the scientific discipline, and several other factors (see e.g. Björk & Solomon, 2013). Further, an increase in the publication delay over time can be observed (e.g. Shen et al., 2015). For journals like *Nature* and *Science* we find time spans from submission to publication around 100-120 days (Shen et al., 2015), for biomedical journals of nearly ten months, and for the social sciences even around 24 months. Across different disciplines the publication delay lies between 6-24 months (twelve months on average) (Björk & Solomon, 2013).

Secondly, most of the studies on publication delays look at the delay on a journal basis, not at an individual paper basis. This means that the publication delay values must usually be obviously higher for individual papers, as they are ordinarily not submitted to one journal only, but to several (e.g. Björk & Solomon, 2013). Hence, we conclude that we must consider an observation period of a minimum of twelve months (the average value across disciplines according to Björk and Solomon (2013)). As we analyze publications in a broad range of scientific journals, in several cases twelve months will be calculated too short, as the overview of Björk and Solomon (2013) shows. Therefore, we decided to use a longer observation period of two years.

This decision thirdly and additionally follows the idea that lies behind the calculation of Journal Impact Factors that also measure a citation window of two years, which has been empirically validated (Leeuwen, 2012; Tort et al., 2012). Here, too, it is assumed that it will take about two years until a new paper is created that can cite the 'original article'.

Further, we have taken into account that the publications recorded by the *PubMed* database have steadily increased from 532 423 in 2000 to 1 617 971 in 2020. The simple ratio is biased in favor of later time points by this effect if the proportion of publications on the topic remains constant. For this reason, we use a corrected variant in which the number of similar articles published in a year is weighted by the number of publications included in *PubMed* (e.g., $1/n_{2005} + 1/n_{2005} + 1/n_{2006} + 1/n_{2007} + \ldots$). When comparing papers in a particular journal, we used the publication counts of that journal.

5 Data analysis and results

To test our hypothesis, we compare the quotient of the number of similar articles related to a certain research topic published by scientific journals from the period before and after the publication of an MSM ≥ 100 article (that received noticeable media attention) as a simple measure for change.

Assuming H1, that a scientific topic that attracted popular media attention will attract greater attention in scientific journals, we expect an increase in the number of thematically relevant scientific publications after an MSM ≥ 100 paper was published. To prevent the general increase in the number of published scientific articles from leading to this effect, we used the values weighted by the annual publication numbers in the analysis.

In the analyses, there are always cases where no similar articles could be found for a paper either in the period before the publication of an MSM ≥ 100 paper or afterwards. In order that a weighted value can also be calculated in this case (it is not mathematically possible to divide n=0 similar articles by an unknown number of annual publications (because no publication year is available)), pseudo counts are used. The year with the highest publication numbers was chosen as the weight (1/1 617 971) so that a weight as small as possible is used, namely 0.000000618058.

Fig 1. Increase respectively decrease of similar articles after publication of each MSM ≥ 100 paper. Based on: 983 MSM ≥ 100 papers. 15 Papers needed pseudo counts.

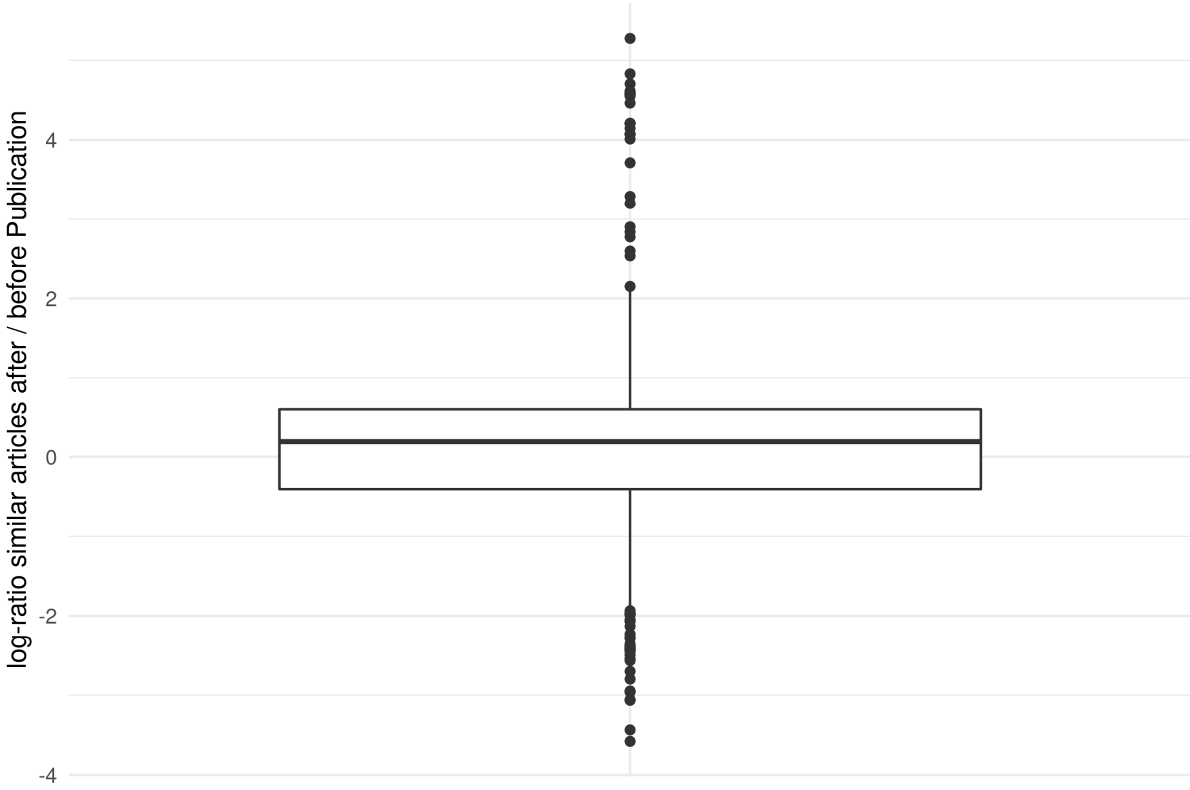


Fig 1 shows the box plot of the distribution of the quotients of the number of publications before and after the MSM ≥ 100 paper. That the median line is above zero means that in more than half of the MSM ≥ 100 papers more similar articles on the topic were published in scientific journals after their publication than before. At the median, weighted publication numbers in the thematically related topic area increased by 21 percent in the two subsequent years after an MSM ≥ 100 paper was published. In sum, there was an increase of thematically relevant publications in 59 percent of all cases after popular media coverage. H1 therefore can be confirmed.

To cite a few concrete examples from our data: The topics of the top ten scientific papers that were published more frequently in scientific journals *after* popular media attention than before media attention now appeared there 65-199 times more frequently than before. All of these top ten papers date from 2016 and dealt with the Zika virus, an infectious disease declared a public health emergency of international concern by the *World Health Organization* (WHO) in February 2016. Also among the top 20 papers whose topics were covered 18-199 times more frequently in scientific journals than before popular media attention, the Zika virus topic dominates (only two papers are on other topics, the prescription opioid and heroin crisis and polymyxin resistance). Concerning the Zika virus, one can assume that, due to its acute social relevance at the time, it would have attracted increased scientific attention even without media coverage. We cannot say exactly whether and to what extent the popular media coverage increased scientific attention. In any case, the popular media recognized the social relevance of the topic and picked it up relatively early (at a time when only a few scientific Zika studies had been published). However, also other scientific topics, which did not represent general and acute social threats at the time of their publication, received increased attention in the scientific community after prominent media coverage, such as colorectal cancer (13 times more frequently published after media attention), migraine (12 times more frequently published), cometary science (11 times more frequently) or atopic dermatitis (8 times more frequently), to name just a few examples.

The general effects observed by our data are rather small at the aggregated level. On median, eleven similar articles were published for one MSM ≥ 100 paper both before and after its publication. An increase of 21 percent would therefore mean that only two more publications on the respective topic were published after the MSM ≥ 100 paper (overall average). In individual cases this increase can of course be considerably higher.

Of course, it should also be mentioned that there were scientific papers as well whose topics were published less frequently in scientific journals after popular media attention than before media attention. In these cases, we definitely cannot speak of an agenda setting effect from popular media coverage – although the topics of the scientific papers do not seem to be socially irrelevant. Among the ten papers that most often had fewer similar articles published after media attention (11-33 times fewer) than before, are the topics: Zika virus, influenca vaccine, clean energy, breast cancer, noninvasive blood tests for fetal development and others. All of these ten papers have been published between 2017-2018, when the Zika virus, for example, was no longer so acute. In these cases, the popular media have paid attention to the respective research topics (much) later than scientific research (a certain body of scientific publications already existed at the time of the media coverage). Probably, in these cases the scientific publication served as source of idea and information for media coverage.

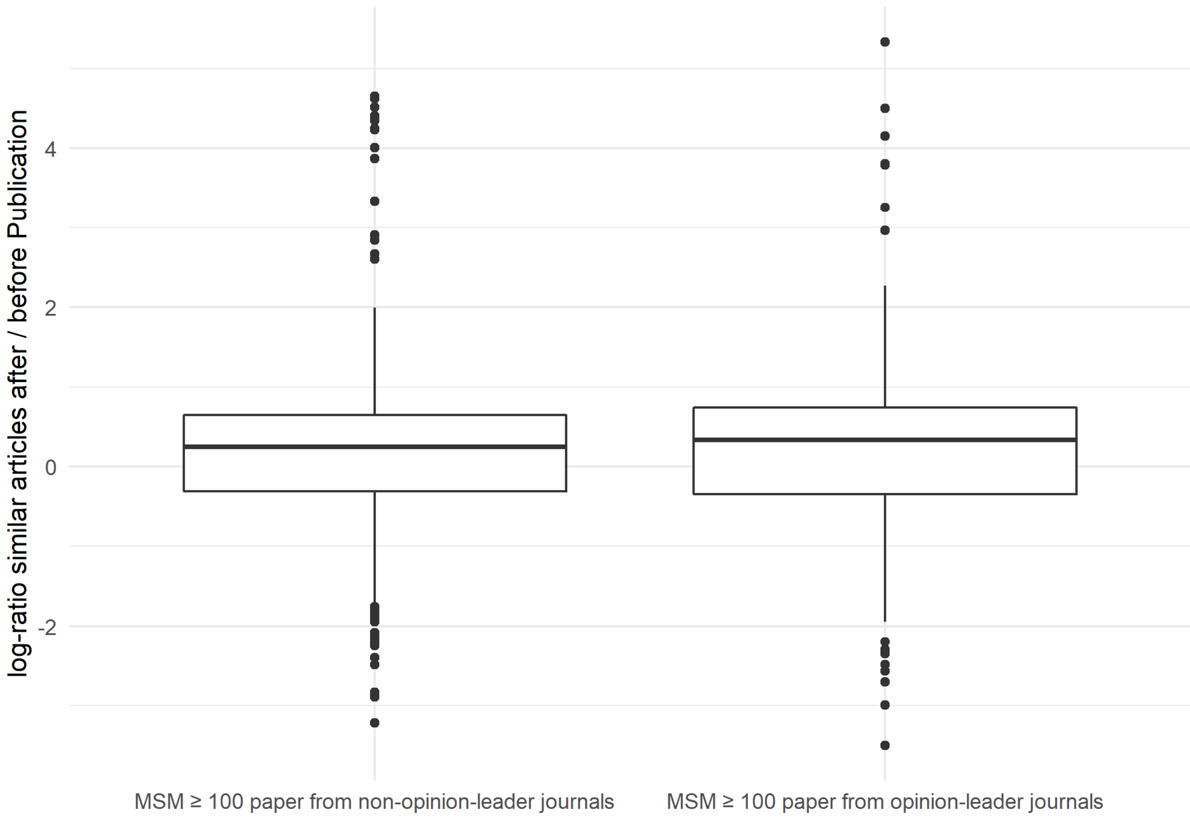
In a next step, we want to answer our research question and differentiate between scientific opinion-leader journals and non-opinion-leader journals. We compare, whether there is a difference in the amount of attention correspondence between news media and scientific opinion-leader journals that serve as intermedia agenda setters for science journalism and those who do not. We ask, if the confirmed correspondence occurs in scientific opinion-leader journals in the same way as in non-opinion-leader journals.

The comparison between opinion-leader journals and non-opinion-leader journals regarding their quotients of similar articles before and after the publication of MSM ≥ 100 papers is not that easy. At the median, weighted publication numbers in the thematically related topic area increased in opinion-leader journals by 50 percent in the two subsequent years after an MSM ≥ 100 paper was published, in non-opinion-leader journals the increase was 30 percent. However, even though the medians differ, we are reluctant to compare or to interpret the two distributions. Especially with regard to the opinion-leader journals, we have many missing values in the similar articles. Only in 317 (of 983) cases similar articles were found in opinion-leader journals before or after the publication of an MSM ≥ 100 paper. For 309 publications no similar articles were found in opinion-leader journals before *or* after the publication of MSM ≥ 100 papers. In 357 cases no similar articles were found in opinion-leader journals before *and* after the publication of MSM ≥ 100 papers. This leads to the fact that the method for the calculation of the pseudo counts has a direct influence on the first and third quartile, which are essential for the calculation of box plots. In sum, there was an increase of thematically relevant publications in opinion-leader journals in 55 percent of all cases, in non-opinion-leader journals in 62 percent of all cases. Therefore, the answer to our research question is twofold. On the one hand, we see a difference regarding the medians that point into the direction that the degree of attention correspondence between popular media and scientific journals is higher in scientific opinion-leader journals compared to non-opinion-leader journals, but we do not want to overinterpret this finding because of the high amount of pseudo counts. On the other hand, the increase of similar articles was in sum slightly higher within the non-opinion-leader journals – however, we see an increase in more than 50 percent of the cases in both type of journals (they react similarly to media coverage).

To check the robustness of our general result that there is an increase in the publication of thematically related articles after a scientific study received popular media attention, we checked whether it makes a difference whether the paper that received media attention (the MSM $\geq$ 100 paper) was originally published in an opinion-leader journal or in a non-opinion-leader journal. The idea behind this test is, that we already know from previous analyses that especially scientific opinion-leader journals, who enjoy a high reputation among scientific actors, steer the attention of science internally, so that probably other scientific journals also orient (e.g. their topic selection) towards them (e.g. Franzen, 2011). So, if we would *not* find an increase of thematically related publications in scientific journals after the publication of MSM $\geq$ 100 papers from non-opinion-leader journals, then we could not assume a feedback effect from media coverage, but only an effect of the reputation of the journal that published the paper which received popular media attention. For our analysis, we separated the MSM $\geq$ 100 papers examined into the 380 papers that appeared in one of our six defined opinion-leader journals and the 603 papers that did not and run the same analysis as before.

Fig 2 shows the bean plots of the two distributions. We see that the median number of papers published on a certain topic increased by 28 percent for the MSM ≥ 100 papers from non-opinion-leader journals, while the median increase for the other papers was 39 percent. Nevertheless, both scenarios lead to an increase in the proportion of thematically related publications within scientific journals (median line above zero in both cases), which is why we still see hypothesis 1 as confirmed.

Fig 2. Comparison of increase of similar articles after publication of each MSM ≥ 100 paper originating from non-opinion-leader or opinion-leader journals. Based on: 603 MSM ≥ 100 papers from non-opinion-leader journals and 380 from opinion-leader journals



However, this finding suggests that the reputation of the journal of the original publication also has an (additional) effect on the increase (there is at least a small difference between opinion-leader and non-opinion-leader journals regarding the median number of similar articles published). Therefore, in a next step, we test the effect of the journal type respectively check whether there also is an increase in thematically relevant papers after a scientific paper has *not* received any noteworthy news media attention (but has ‘only’ appeared in a scientific opinion-leader journal). Such a finding would suggest that not media attention but the reputation of the publishing journal triggers the increase of thematically related publications. For the analysis, we have created another dataset that consists of all scientific papers that have been published in the scientific opinion-leader journals *Nature* and *Science* – often referred to as the two *most* prestigious (e.g. Franzen, 2012) scientific journals – in the same time period (2014 to 2018) with an MSM score less than 50. These papers should according to (Kohler et al., 2020) not have received a noticeable amount of news media attention. We run the same analyses for these 4 824 papers, as before and thus compared the quotient of the number of similar articles related to the research topics from the period before and after the publication of an MSM < 50 article published by *Nature* or *Science*. We then compared the increase of similar articles of the MSM < 50 articles from *Nature* and *Science* with the increase of similar articles of the MSM ≥ 100 articles from *Nature* and *Science*.

Fig 3. Comparison of increase respectively decrease of similar articles after publication of MSM < 50 respectively MSM ≥100 papers from *Nature* or *Science*. Based on: 179 MSM ≥ 100 papers and 4,824 MSM < 50 papers from *Nature* and *Science*.

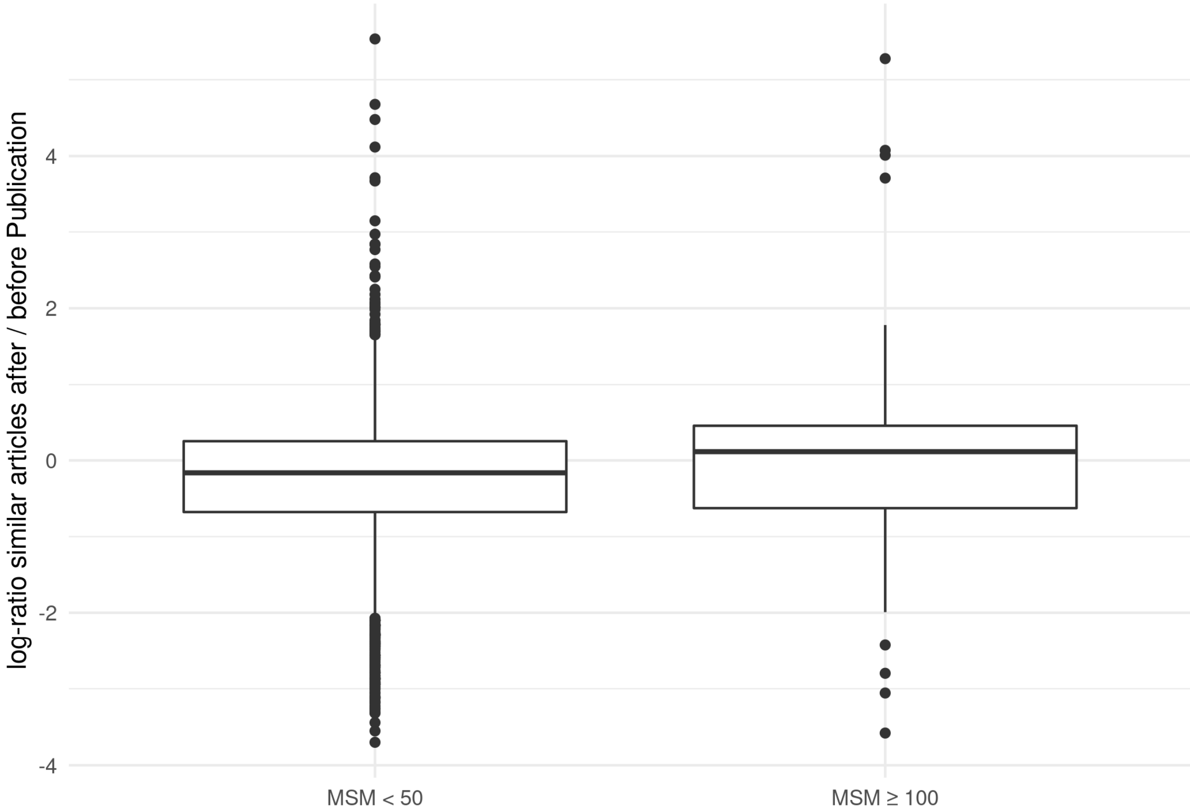


Fig 3 reveals a significant difference in the two distributions. While the MSM ≥ 100 articles showed a median weighted increase of 12 percent, the studied topics of papers with MSM score < 50 showed a decrease of 15 percent (median line below zero). This finding shows that there is a difference between those papers that received a noticeable amount of news media attention and those which did not. For us, this is another clear indicator that our first hypothesis is confirmed, namely that scientific topics that attracted media attention will attract more attention in scientific journals.

6 Summary and discussion

The aim of our analysis was to shed some light on potential feedback effects of popular media coverage on the scientific system and to examine how a scientific topic develops in scientific journals over time, namely before and after a point of conspicuous news media attention. In summary, our results reveal a relationship between the amount of attention scientific papers receive through popular media and the amount of attention the overall topics of these scientific papers receive from scientific journals. Our analysis showed at the aggregated level that after the publication of a scientific paper that received a noticeable amount of news media coverage (MSM ≥ 100 paper) in more than 50 percent of the cases also more similar articles on the topic were published in scientific journals than before. Our hypothesis, namely that a scientific topic that attracted popular media attention will attract more attention in scientific journals, is thus confirmed. Here and there, one could conclude, journalism can be considered as an agenda setter for the choice of topics in academic journals. In this respect, we found no clear differences between scientific opinion-leader journals and non-opinion-leader journals – for both types of journals we find the described correlation between popular media coverage and scientific journal publishing, but depending on the dimension on different levels. Furthermore, the correlations between popular media coverage and scientific journal publishing seem to be relatively robust, as they apply to both scientific papers that were originally published in renowned opinion-leader journals as well as in less renowned non-opinion-leader journals but not for scientific papers that have not received a noticeable amount of news media coverage.

Our results can be interpreted in two ways:

1) According to the so-called *earmark hypothesis*, news media “cover certain scientific studies because of their intrinsic value” (Anderson et al., 2020, 2) and thus select scientific studies whose topics are also viewed as impactful by the scientific community. In this

reading, journalists and scientific journal editors have similar selection or attention criteria and/or have a similarly good sense of which scientific topic will become an important or 'trending' topic in the near future. This would at least speak for a correspondence of topic attention between popular media and scientific journals (in the sense of a necessary but not sufficient condition for feedback effects). However, this hypothesis predicts that the studies who have gained popular media attention would have garnered the same amount of scientific attention without the benefit of news media exposure (Anderson et al., 2020, 2). But as we have shown in our last analysis step, scientific papers published in prestigious scientific journals like *Nature* or *Science* that did not receive a noticeable amount of news media attention did in the aftermath not attract more attention in scientific journals. This could speak in favor of the second way of interpretation:

2) According to the so-called *publicity effect*, popular media coverage provides a scientific attention boost for scientific studies or topics that they would not have received without news media coverage (Anderson et al., 2020). When a certain media reporting threshold of a scientific study is exceeded, the perception and perceived importance of the corresponding topic within the scientific community increases (more strongly than without media coverage) and thus the likelihood of the topic being published in scientific journals in the future (feedback effect). In a positive interpretation (according to Habermas, 1969), popular media coverage of certain scientific studies could even prevent the drying up of communication flows across specialisation boundaries in the scientific system.

In sum, we see no need to fear far-reaching negative consequences emanating from this possible kind of feedback effect for the scientific system. When interpreting the results, one has to keep in mind that we speak of a very small proportion of scientific papers which receive notable popular media coverage, namely one in 10 000 papers (Lehmkuhl & Promies, 2020). So, in the overall structure of all scientific papers that are annually published, we can only speak of minor feedback effect on the scientific system (even more so if you consider the low absolute values of the increase of topics). And if we additionally assume that science journalism selects mainly impactful scientific topics, then these impactful topics would probably also have gained a certain amount of attention in the scientific community even without media coverage. Nevertheless, we see a clear and stable pattern in our data that indicates, that popular media and journal selection of scientific papers do correlate to a certain degree.

While communication science already provides numerous explanations for and studies on the selection processes of journalists (e.g. news value studies), we think that there is a lack of empirical work that analyzes and describes the selection behavior of scientific journals (editors), like the work of Franzen (2011), for example. Editorial observation studies or surveys of scientific journal editors seemed particularly interesting to us (albeit probably difficult to achieve). As Anderson et al. (2020, 12) put it: "Much remains to be discovered concerning interactions between popular media, generally produced by and for non-scientists, and the scientific literature which has historically been written by and for the scientific community."

As a limitation of our study we need to mention that we – as most agenda setting studies – are not able with our data to draw the causal conclusion that the popular media agenda affects the scientific journal agenda in the strict sense (since it is not possible to analyze the influence of popular media coverage isolated from other possible influencing factors), although our analysis takes the temporal sequence of popular media attention and publications in scientific journals into account, which is an advantage over some other studies. Further, our validation of the 'similar articles'-function of *PubMed* to capture potential increases of topics within scientific journals showed that the topic fit of this function is not as satisfactory as we would have expected. Therefore, there is a considerable amount of noise in our data, that is additionally increased by the rather unspecific information provided on the publication date of the analyzed papers (no specific indication of month or day in *PubMed*).

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