Exploring Trust and Mistrust Relating to the MMR Vaccine in Danish Newspapers Using Computational Analysis and Framing Analysis

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Abstract

The aim of this paper is to investigate how the MMR vaccine debate was framed as a matter of public trust or mistrust on Danish newspaper media. Our results, based on computational analysis of the information dynamics of 231 newspaper articles from 2001 to 2019 and subsequent qualitative framing analysis, provide additional information about MMR vaccination coverage in the three major Danish national newspapers, *Politiken*, *Berlingske* and *Ekstrabladet*. We used a Latent Dirichlet Allocation (LDA) model to train article-level dense low-dimensional representations and explored the information dynamics using Nielbo et al.'s [1, 2] approach to change detection in news-based information signals. In addition, we used Entman [3] to identify and analyse frames that related to trust and mistrust of MMR vaccination. We found that the Danish MMR debate followed patterns of novelty and resonance that typify the expected dynamics of news reporting by legacy news media when news is not catastrophic or shocking [2]. Supporting this finding, the framing analysis showed that the three newspapers promoted vaccines as safe and valuable for society throughout the period. Drawing on interdisciplinary perspectives from cultural studies, science studies, public health, computational humanities and media studies, this study presents a methodologically innovative approach to studying historical and near-real time framing of (mis)trust of vaccination in newspaper articles. Recent debates about the safety of Covid-19 vaccines underline the importance of quantifying and qualifying vaccine discourses and paying attention to legacy media's overall agenda-setting role.

Keywords

Newspapers, diachronic approach, information dynamics, framing analysis, trust, MMR

1. Introduction

Heated debates on social and legacy media about the safety of Covid-19 vaccines [4] and long-standing research engagements with the ways in which the media affect public support for vaccination programs [5 - 8] highlight the importance of focusing on vaccine debates in the context of the mediascape [9] in which they occur.

In response to ongoing vaccine controversies and falling vaccination uptake rates, the World Health Organization [10] announced that vaccine hesitancy was one of ten primary threats to global health, defining vaccine hesitancy as the "reluctance or refusal to vaccinate despite the availability of vaccines". One of the most prominent historical cases of vaccine hesitancy occurred in the wake of the 1998 *Lancet* publication of Dr. Andrew Wakefield and colleagues' paper that linked the measles, mumps, rubella (MMR) vaccine to autism. Wakefield's study and the MMR-autism link was later refuted, and the paper rejected by *The Lancet*. Nevertheless, the study results lingered and continued to be circulated in the media, catalyzing distrust of the vaccine [11]. MMR vaccine uptake rates that were already suboptimal in many parts of the world [12] dropped even further after the Wakefield scandal, with many European countries losing their measles-free status at the end of the last decade [13].

Analysis of British media coverage of the MMR vaccine has employed content analysis [8], while an investigation of the news media's attribution of responsibility — the "blame frame" — for the MMR controversy in ten different countries, highlighted the importance of Andrew Wakefield in the framing of blame for the MMR–autism link and subsequent effects on trust of the MMR vaccine [7]. In exploring the MMR debate, of particular interest are "traditional media" that have "previously served as a moderating force, filtering scientific information and fact-checking, however imperfectly, for their audience" [14: e258].

In previous work, we have used discourse analysis to study HPV vaccine skepticism expressed on social media and found polarized discourses [15, 16], and we have conducted ethnographic field research in the Danish context to investigate HPV vaccine skepticism [17]. Most Danes believe that vaccines generally are safe, effective, and important for children [18], yet, as shown in our research, a public debate about the safety of HPV vaccines led to concerns about the vaccine from 2013 onwards [15]. There were also concerns that social media would lead to further vaccine controversies and public mistrust of vaccination programs, which underlines the importance of developing methods that map out and characterize online vaccine debates.

Regarding MMR vaccination, figures from Statens Serum Institut [19], which monitors infectious disease and preparation against infectious disease in Denmark, show a reduction in uptake of both MMR1 and MMR2 where MMR1 uptake fell from 95% for children born in 2015 to 90% for children born in 2020, and uptake of MMR2 similarly fell from 93% for children born in 2012 to 91% for children born in 2017. A retrospective study of the MMR vaccine in the period 1997-2014 in Denmark found a correlation between media coverage and vaccination activity following the publication of the Wakefield paper that falsely claimed links between MMR and autism [20]. With this study, we aim to advance what is known about Denmark's experience of vaccine hesitancy by engaging empirically and conceptually with coverage of MMR vaccination in three Danish newspapers. Given the centrality of trust of science and scientific authorities to the issue of vaccination [11, 21], our aim in this paper is to explore newspaper framing that might promote trust and mistrust using a mixed methods approach.

2. Methods

This study draws on a mixed methods approach to document analysis and is based on an analysis of newspaper articles in three Danish national newspapers.

The first method (computational methods) was used to understand the general dynamics of the newspaper discourse over time and find salient lexical themes, which enabled us to quantify continuity (resonance) and surprise (novelty), but also to identify two main accounts (mainstream vs. alternative, see below) and extract representative documents. The second method (frame analysis) was used to understand the main categories of discourse in the most important articles that define those two accounts. Used sequentially, the two methods are complementary, as results generated by framing analysis are used to elaborate or clarify results generated from the computational method.

We selected two broadsheets with different political orientations and one tabloid to provide an authentic representation of the printed Danish debate on MMR vaccination: *Berlingske Tidende* (right-wing conservative), *Politiken* (centre-left), and *Ekstrabladet* (tabloid). Our analysis focuses on all newspaper content (e.g., news articles, editorials, and letters to the editor), published over a 19-year period from 1 January 2001 to 31 December 2019. We applied for all available national newspaper data that dated back to 1990 in the Danish media archive Infomedia, an online provider of Danish print, broadcast, and online media. We focused on the years 2001-2019 as they represent a particularly interesting phase: during this time, a strong printed press faced competition with the birth of online newspaper platforms, social media started to become popular, and several vaccine debates emerged in Denmark. As "MFR" (the Danish for "MMR") refers to the measles vaccine, we used the simple and inclusive search string "MFR" to identify articles with "MFR" in the headline or text body. The study is based on a dataset of the 231 articles that included the "MFR" string from 2001 to 2019. The total number of articles included from each newspaper in the final data set were: *Berlingske* (N=84), *Politiken* (N=94), and *Ekstrabladet* (N=53).

2.1. Information dynamics of MMR in legacy media

We used Nielbo et al.'s [1] approach to change detection in news-based information signals – a computational method that would allow us to explore the newspaper articles' degree of *novelty* in order to empirically identify major events related to MMR vaccination during the whole time period, in which case we could direct our attention to selected time periods and conduct the qualitative framing analysis using a subset of the whole data set. Our aim with this approach was to examine the information dynamics of MMR in the newspaper articles that contained the "MFR" string (N=231). Before analysis, the newspaper content was lemmatized and case-folded. To transform the text data into dense vector representations, we trained a Bayesian model, specifically a simple Latent Dirichlet Allocation (LDA) model, that represented each article as a probability distribution over a small set of latent variables [22]. Definitions of novelty (i.e., an article's reliable content difference from the past) and resonance (i.e., the degree to which future articles conform to an article's novelty) were based on [1].

2.2. Qualitative framing theory

The second stage of the analysis involved analyzing qualitatively the framing of MMR vaccination in the articles. Framing is a commonly used analytical optic in media research [23, 24], and in research examining health communication about vaccinations [25]. Due to the results of the information dynamics, see Section 3, we did a close reading for framing relating to trust and mistrust in the articles with the highest signals for "alternative" and "mainstream" accounts, instead of close reading for framing in all 231 articles, which would have been highly labor-intensive. Such accounts were identified using the latent variable approach [22], described in Section 2.1; all three newspapers contained both "alternative" and "mainstream" accounts. In practice, this meant performing a qualitative frame analysis of those articles where a higher probability of MMR vaccine debate-related words like "Wakefield" in connection with "autism" suggested "alternative" accounts, and a higher probability of public health institution-related words indicated "mainstream" or "scientific" accounts. We focused on the newspaper articles with the strongest signals for "alternative" and "mainstream" accounts (i.e., maxima of explained variance, see Figure 2), as mistrust of the MMR vaccine is associated with Wakefield controversy [7, 8] and trust of the vaccine is associated with trust of science [11, 21]. We did not exclude any newspaper article type as our focus was on how MMR vaccination was represented generally in these newspapers.

To identify the articles with the strongest signals for "alternative" and "mainstream" accounts, we put the articles for each newspaper in sequence with respect to the strength of their signal for both "alternative" and "mainstream" accounts, respectively. When conducting the frame analysis, we drew on Entman's [3: 52] definition of framing as "select[ing] some aspects of perceived reality and mak[ing]

them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described". We used these four theoretical categories to search the data for content relating to those categories in the text of the articles. Whether a frame is positive, negative or neutral is most evident from the third category, moral evaluation [26]. The frames became more difficult to identify as the signals got weaker, so we stopped analysis after exploring in depth the first 25-35 articles in each newspaper for each variable, as no new frames were emerging. However, this does not exclude the possibility of other frames existing in the entire dataset.

3. Results

With respect to the computational approach, following Nielbo et al. [1, 2], we initially inspected novelty and resonance slopes, see Figure 1, for any anomalies in the news stream. Given the controversial nature of the MMR vaccine debate, we had considered that MMR-related content might show a decoupling if "alternative" stories took hold, where we could expect high levels of resonance associated with low levels of novelty, such as those identified in Covid-19 news stories in Denmark at the start of the pandemic [1, 2], However, this was not evident in our data. The linear fit of resonance on novelty, the $N \times R$ slope, did not deviate from what is to be expected from a regular news cycle. This was interesting as it suggested that the coverage of MMR in Danish newspaper articles behaved like most conventional news stories.
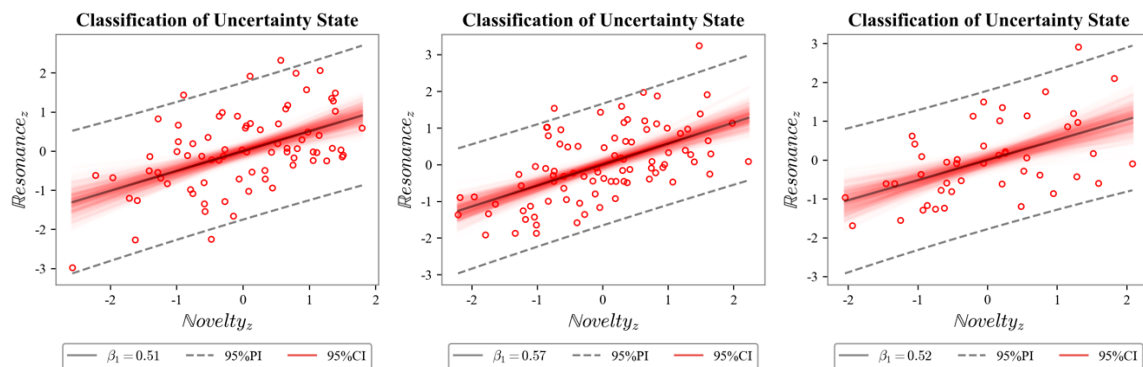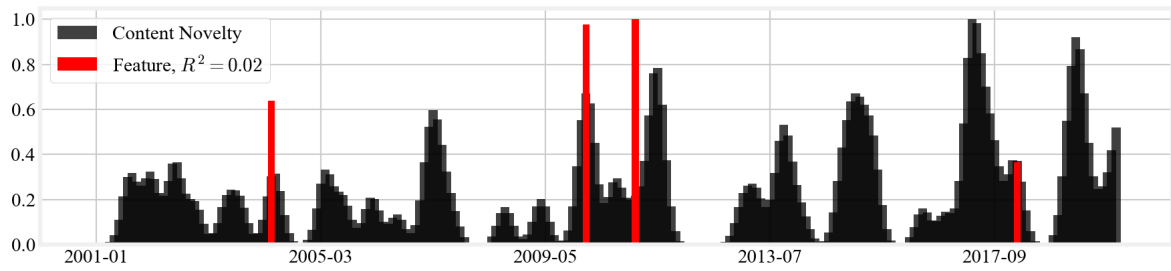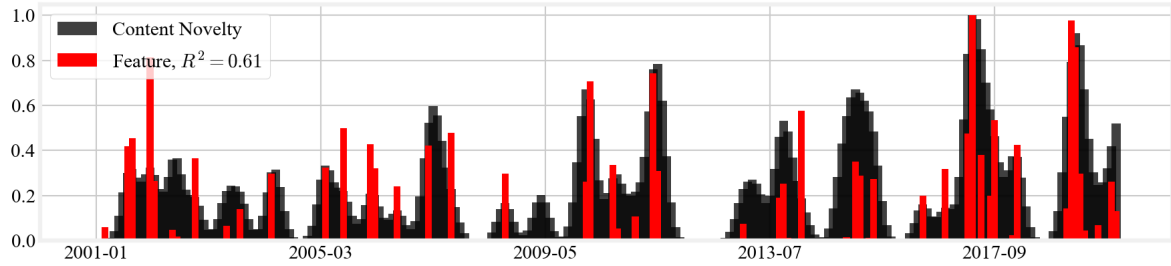

Figure 1: The figure displays the linear fit of resonance (R) on novelty (N) for three newspaper sources, where $N \times R$ slopes for *Berlingske, Politiken*, and *Ekstrabladet* (left to right) do not deviate from the expected baseline: $M_\beta = 0.56, SD_\beta 0.06$, although a few article anomalies can be observed outside the 95% prediction interval (stippled lines).

Then, to explore how specific types of MMR-related content contributed to the novelty of articles, we identified two latent variables that encoded either *mainstream scientific accounts* (i.e., high probability of inclusion of official health institutions) or *alternative accounts* (i.e., high probability of Wakefield and autism co-occurring) of MMR. We then modelled the prevalence of each variable over time and compared it to the novelty signal for the data set over time per newspaper, see Figure 2. The approach we used is representation-agnostic (with minor modifications to the distance/divergence measure) [1]. All hyper-parameters of the models were optimized using grid search optimizing for topic coherence (UMass and cv), following the same procedure as [1]. While we cannot guarantee that the representations are good or representative of newspaper discourse as such, we can guarantee that they are the least bad and are based on all lexical content associated with MMR.
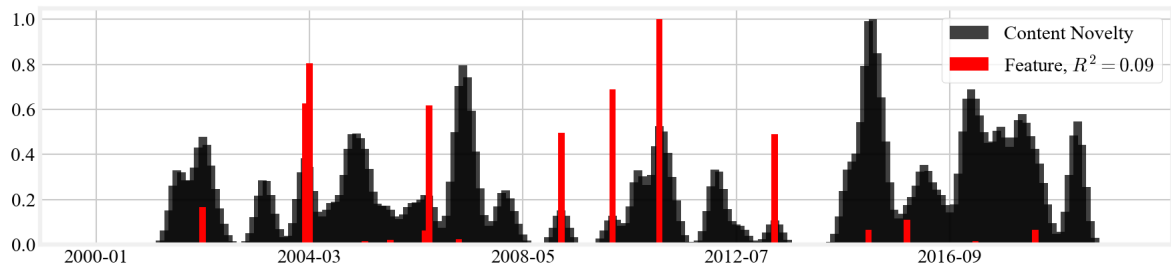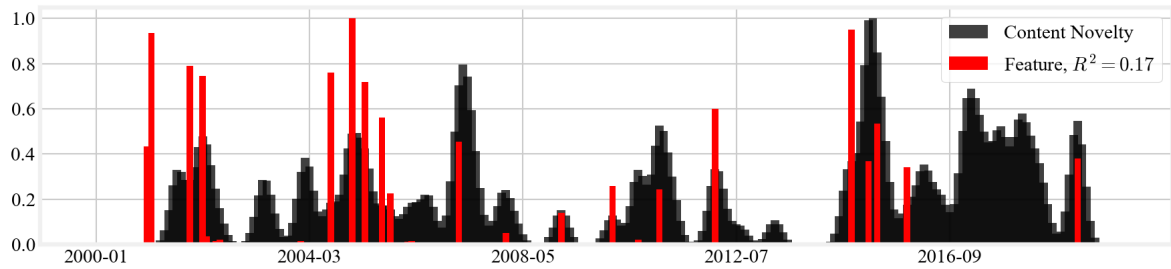
Berlingske: Alternative
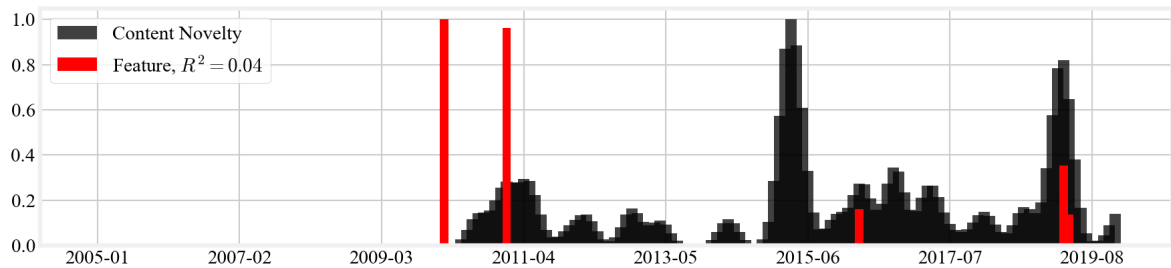

Berlingske: Mainstream

Politiken: Alternative

Politiken: Mainstream

Ekstrabladet: Alternative
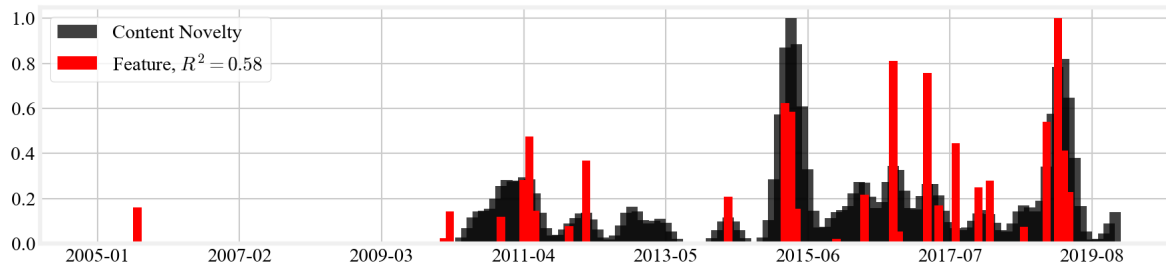

Ekstrabladet: Mainstream

Figure 2: Content novelty compared to variable prevalence displayed over time (Alternative, Mainstream) for *Berlingske, Politiken* and *Ekstrabladet*. Alternative accounts are much more sparsely distributed than content referencing the official scientific account. R^2 represents the proportion of variance in novelty that is predictable by the alternative or mainstream variable, respectively. It can be observed that the mainstream variable is more successful at predicting content novelty (closer alignment between the red feature lines and novelty peaks) than the alternative variable in all newspapers. Notably, in our data set, there was only one article earlier than 2010 for *Ekstrabladet*.

Independent of newspaper type and political orientation, "mainstream" accounts were more prevalent and accounted for substantially more variation in novelty of content. One way of explaining this is that "mainstream" accounts served as the frame of reference when MMR news appeared in Danish newspapers. "Alternative" accounts, on the other hand, were limited in presence and only played a minor role in the newspapers' representation of MMR.

Summing up the results of the computational analyses, the Danish newspaper coverage of MMR showed "nothing out of the ordinary" in terms of novelty/resonance, suggesting no major event-driven shifts, as well as a tendency to reflect scientific ("mainstream") content, even in the tabloid newspaper. As the information dynamic analysis did not direct us to moments of likely controversy in the newspaper coverage of MMR that we could explore in more detail using framing analysis on a subset of the whole data set, we drew on the findings from the first analysis and explored the documents that contributed the most to the lexical content of the "alternative" and "mainstream" accounts respectively (i.e., the documents that had the highest probability of the two latent variables), as outlined in Section 2.2, and identified the following two main frames.

The scientific frame: The MMR vaccine is safe and scientifically well-attested. Leading public health institutions endorse the vaccine.

> **Problem definition:** Measles is a dangerous and highly contagious disease. If not enough people are vaccinated, it can lead to an epidemic in Denmark, as has been witnessed in other countries.
> **Causal interpretation:** Some parents may not vaccinate their children due to skepticism caused by the Wakefield controversy.
> **Moral evaluation:** The science behind the vaccines is certain and the vaccines are safe, according to leading health institutions. Not vaccinating one's child can have consequences for the child and society at large.
> **Treatment recommendation:** Parents should trust the MMR vaccine and ensure that their children are vaccinated.

The misinformation frame: Controversies can cause confusion and individual risk-taking behaviours in relation to MMR vaccination. They can lead to public mistrust of scientific expertise and undermine vaccination programs.

> **Problem definition:** Controversies and conspiracies tend to proliferate, also given the rise of social media and online connectivity, despite efforts to address them.
> **Causal interpretation:** Misinformation is the root of vaccination hesitancy. Many people encounter false stories and conspiracy theories about MMR's supposed link to autism, which leads to doubts about the safety and efficacy of vaccination.

Moral evaluation: This is wrong because vaccines can save lives, including the lives of those who are weaker in society. Science is valorized positively.

Treatment recommendation: More effective science communication with broader outreach as well as countering misinformation on all platforms are recommended.

Similar to the results suggested by the computational analysis, there were no great differences in the frames across the newspapers. Qualitative analysis showed that "mainstream" accounts supported science, and when the "alternative" variable was present in the newspapers, it was refuted or discredited. The framing of the MMR debate in the three newspapers was thus pro-vaccine: the MMR vaccine was validated, misinformation was discredited, and the MMR vaccine was presented as scientifically proven, the "right choice" for parents and their children, and worthy of public trust.

4. Discussion

This study was undertaken in order to investigate how and when trust and mistrust relating to the MMR vaccine were framed in three Danish newspapers. Trust and mistrust of scientific expertise were conceptualized as cultural phenomena evident in the frames that were used to present them in newspaper media. Framing is important, not just because it impacts how objects — such as the MMR vaccine — are represented, but also because such frames can shape the health decisions people take [27]. Thus, frame analysis has much to contribute to public health inquiry [28].

Often, the norm of presenting "both sides of the story" is evident in professional journalistic practice [29], although balance can lead to a disconnect between media discourse and science discourse in the case of high levels of consensus in scientific results [30]. It has, for example, been concluded that MMR vaccine hesitancy in the UK was promoted by newspapers' reliance on "showing both sides of the story" and the sensationalism of breaking news — the "scoop" [8]. However, this was not evident in our data: despite the differences in the three newspapers' ideologies (right/left) and style (broadsheet/tabloid), there was remarkable consistency across the newspaper articles in terms of framing MMR vaccines as good/beneficial, and skepticism towards the vaccine as misguided/wrong. The pro-science frames in the Danish newspaper articles may reflect news media's agenda-setting role — "the concept that the news media guide public awareness and opinion by emphasizing certain issues or issue attributes" [7: 693] in keeping with public health guidelines. There is thus, in our data, ample evidence of journalists' framing in line with the "supposed national or general interest" [31: 134], reflecting normative journalistic practice [32]. The identification of pro-vaccine frames in the three newspapers cannot, of course, be generalized for Danish news media more generally, but it resonates with understandings of legacy media as upholding prevailing values in society, such as the value of science and vaccination programs. It may also be relevant to mention in this context the high levels of institutional trust in Danish society; Denmark has recently been described as a country where "trust regulates everything" [33: 11].

To identify relevant data, we used the "MFR" string, so our data set for that string was comprehensive. However, only using "MFR" means that articles that did not include "MFR" but used other referencing terms (synonyms) will have been omitted. A future study could extend the search beyond the search term "MFR", and beyond the newspapers we explored.

One of the strengths of this article is its use of mixed methods: first, a computational approach to gain an overall impression of the dynamics and topics of Danish newspapers' discourse on the MMR vaccine; second, the qualitative and interpretative approach of frame analysis, where we focused on the newspaper articles' framing of MMR in relation to trust and mistrust of the vaccine's underlying science. Bridging the two approaches, the latent variable approach made it possible to identify the strongest signals for the "alternative" and "mainstream" accounts. Due to the documented effects of the Wakefield controversy on public trust of the MMR vaccine [7, 8], and given the presence of the "alternative" variable (where there was higher probability of "Wakefield" and "autism" co-occurring) in all three newspapers, we used the "alternative" variable as a way of identifying mistrust in the newspaper articles. However, it was necessary to take a closer look at the text of the articles to understand that the "alternative" variable, when present, served refutational or myth-busting purposes.

As such, both the computational and the frame analyses were necessary: the computational approach allowed us to identify the articles that looked to be most relevant for our focus on trust and mistrust and notice general patterns in the information dynamics, and the framing analysis allowed us to explore how such content functioned in the newspapers. This two-part method could be adopted by other studies seeking a strategy for finding the most relevant articles in large data sets for subsequent qualitative frame analysis.

The combination of the two methods meant that we entered new methodological territory as an interdisciplinary group, where dialogue helped to ensure that we grasped the logic behind each other's methods. As textual data is now mainly only available in digitized form and given the rise of the digital humanities field, we expect that the need for such interdisciplinary methodological collaborations will increase in the future.

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6. References

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