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Hey Google, welcome to the family?!

Taking a differential perspective on the selection and use of smart speakers in families

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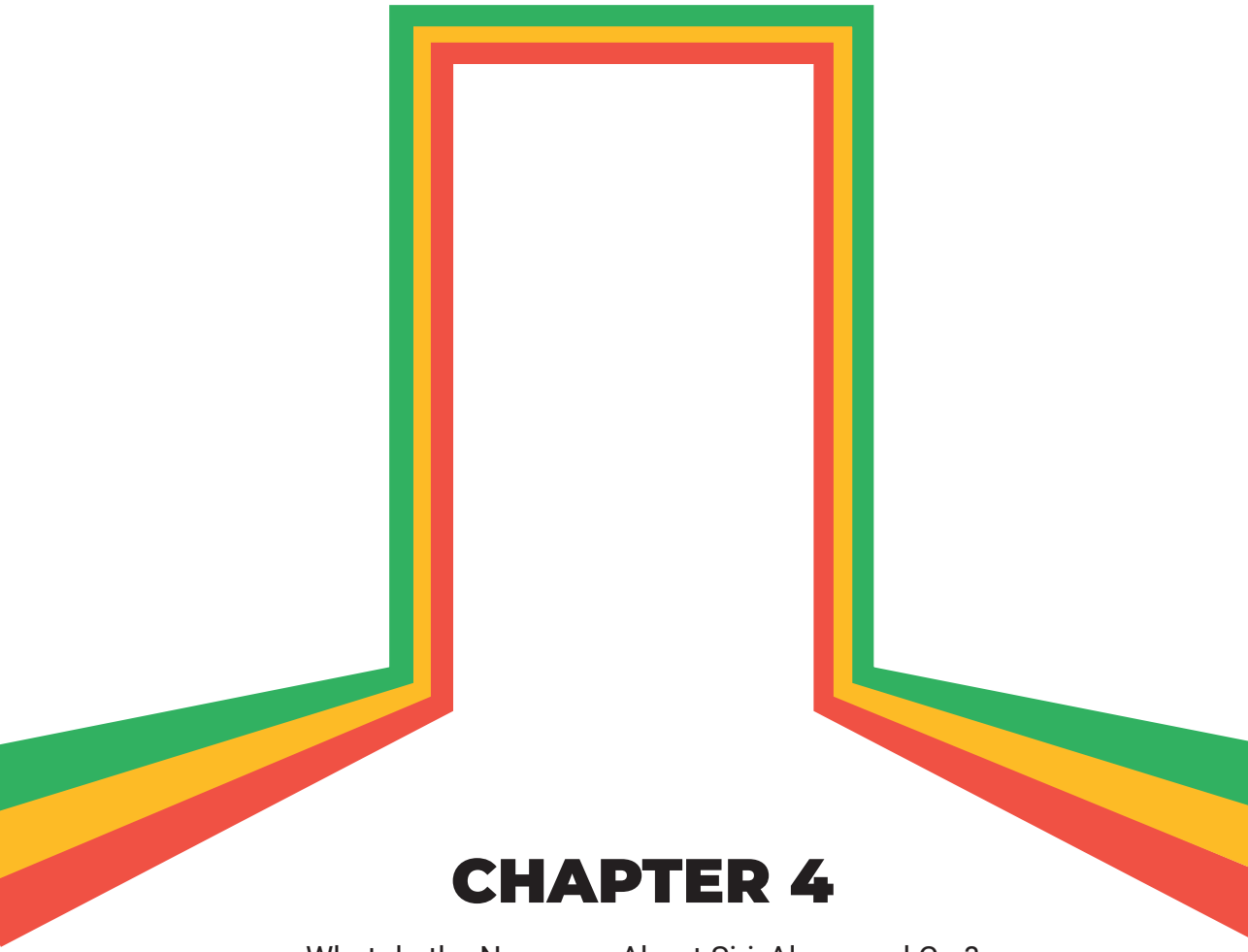

CHAPTER 4

What do the News say About Siri, Alexa, and Co.?
A Topic Model Network Analysis of News Messages
About Virtual Assistants in the Last Decade

WHAT DO THE NEWS SAY ABOUT SIRI, ALEXA, AND CO.?

“It feels like it’s [AI] everywhere, in every headline.
But, honestly, I don’t even understand what I’m hearing, enough to know if I’m worried about the right thing.”
(Knowing machines podcast - Avishai, 2023)

CHAPTER 4

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About Virtual Assistants in the Last Decade

Abstract

Literature on Virtual Assistants (VAs) thus far lacks insights on how VAs are represented in the news media. This study uncovers how VAs have been framed in the Dutch news (2011-2022) by employing the Analysis of Topic Model Networks on *N* = 2,059 news messages. News attention peaked in 2019 but recently shows a decline. Two frames (i.e., AI and society frame, Voice assistants and their users frame) emerged, resembling aspects of societal and personal impact framing. Findings reveal how the public dialogue about VAs has evolved over time and inform future media effects studies regarding VA-adoption.

A version of this chapter is currently under review as:
Wald, R., Araujo, T., van Oosten, J.M.F., & Piotrowski, J.T. (under review). What do the news say about Siri, Alexa, and Co.? A topic model network analysis of news messages about virtual assistants between 2011 and 2022.

Supplementary materials to this article can be found online at https://osf.io/39tsh/?view_only=ad1fbefde15c44d4967ac2e08b21d894 (link is blinded for ongoing peer-review at journal)

In today's rapidly evolving landscape of technologies that are powered by Artificial Intelligence (AI), public portrayals of these innovations influence how individuals understand, interact with, and ultimately accept them in their daily life. The media – and particularly so the news media – offer valuable information and orientation for the public to combat potential insecurities, to learn about the functionality of new technologies and their influence on individuals and society.

One emerging technology that has become popular in recent years are Virtual Assistants (VAs). VAs are conversational agents that engage in human conversation through Natural Language Processing and that reside in devices such as smartphones, smart speakers, and other internet-powered applications (Hoy, 2018). To better understand their growing public adoption, scholars have mainly looked at individual factors of people by investigating their specific motivations for as well as patterns of VA-use (Beneteau, Guan, et al., 2020; Kowalczuk, 2018; McLean & Osei-Frimpong, 2019; Wald et al., 2023). However, studies that extend this perspective to contextual factors, such as media representations of VAs, that may impact people's adoption remain scarce. This is problematic since theory in the Human-Machine Communication (HMC) field makes clear that attitudes towards technologies are crucial to explain people's engagement with and acceptance of them (Ajzen, 1991; F. D. Davis, 1989; Venkatesh et al., 2012). And yet, little is known about the origin of those attitudes and their formation by narratives of the news media.

Although first scholarship exists on the news media portrayals of related topics such as AI, automation, and robotics (Brantner & Saurwein, 2021; Chuan et al., 2019; Köstler & Ossewaarde, 2022; Vergeer, 2020), certain aspects are challenging to translate for the case of VAs, since compared to these broader technologies, VAs are quite specific: They are typically disembodied conversational agents that are operated via human language (voice or text) and that are being deployed in smart speaker devices, as device features in existing devices (e.g., in smartphones, cars, etc.), or within online services on apps and websites (e.g., chatbots) to perform defined tasks (Ammari et al., 2019; Hoy, 2018; McLean & Osei-Frimpong, 2019). This distinguishes them from other technologies that were previously studied under the umbrella terms of AI, automation, and robotics (i.e., recommender systems on social media platforms, algorithmic decision-making, self-driving cars, social robots, or automated manufacturing) (Brantner & Saurwein, 2021). Eventually, this also means that the public portrayal of VAs is likely to be different, which is why it is important to add knowledge about news media representations of VAs to the body of existing HMC-literature, going beyond Arifin & Lennerfors (2021)'s work on ethical aspects of VAs.

To thus acknowledge the powerful force of the news media for the formation of people's attitudes towards VAs, which helps to better contextualise and understand the ongoing public adoption of VAs, we ask: *How have VAs been framed in the Dutch news media since their commercial rise (2011 – 2022)?* Built upon the research tradition of emphasis framing (Entman, 1993), we inductively detect

frames around VAs through the computational Analysis of Topic Model Networks (ANTMN; Walter & Ophir, 2019). We do this over the last decade, starting with the introduction of Apple's Siri in 2011 and ending in 2022 – the time point of conducting this study. We chose the Netherlands as our country of focus for two reasons: Empirically, the Netherlands is a European country that has recorded a recent increase in VA-adoption (Wald, Piotrowski, et al., 2024) despite delays in the launch of U.S.-originated products and services (Pridmore et al., 2019). Thus, this allowed us the opportunity to map the news coverage during an acute period of VA-adoption. Pragmatically, we had access to a database that comprehensively mapped the news body of the Netherlands, allowing us a robust assessment of the news space.

THEORETICAL FRAMEWORK

The role of news media frames for technology adoption

Successful diffusion of new technologies is driven by a change in beliefs about the technology (Vishwanath, 2009). Along ecological systems theory, these beliefs are formed through people's own experiences, through interpersonal exchange with others (e.g., family, peers, etc.), and notably also through the mass media (Bronfenbrenner & Morris, 1998). And the information that the media share is hereby key.

The media spotlight certain parts of a story to make them stand out more and through that convey a certain meaning. This powerful way to curate information is called 'framing'. While there are different forms of framing, 'emphasis framing' refers to the systematic selection and salience-making of specific aspects of reality in a given communication context (Entman, 1993), which subsequently shapes how audiences perceive and understand the topic being covered. From a conceptual viewpoint, a specific meaning in a message is referred to as a *frame* or *frame package* (Van Gorp, 2007). Hereby, certain linguistic elements – or 'devices' as Van Gorp (2007) calls them – occur together across time and jointly express this specific meaning. Respectively, multiple different meanings, and therefore frames, can be included in one message.

One specific type of mass media that is particularly powerful in the provision of information and that is known for the use of framing is the news media. News media refer to mass media organizations that provide information to the public about current events and developments (De Vreese, 2005). By *reflecting* how the public thinks about a new technology, the news media can provide orientation. At the same time, through how the news media portray this technology, they might also *influence* public perceptions of the technology (Chuan et al., 2019; Walter & Ophir, 2019), which can have consequences for people's adoption decisions. In an experiment Vishwanath (2009) showed that different types of frames (i.e.,

positive vs. negative, extrinsic vs. intrinsic, combined) can have an influence on people's intrinsic beliefs about an innovation, such as its ease of use and usefulness, and that these beliefs impact people's intention to use the technology. As such, "the frames become the lens through which the innovation is evaluated" (Vishwanath, 2009, p. 199), which signals the news media's power in the public adoption process of new technologies. Thus, as a first step in acknowledging the news media's role in the adoption process of VAs, we want to find out:

RQ1: What frames emerge from the Dutch news media coverage around VA-use?

Past history shows that the news coverage on emerging technologies typically orientates along two main directions – one positive and one negative: Underlying a positive benefit frame is often the idea of social progress that encompasses the creation of hope and the impression that technological opportunities are limitless (Brennen et al., 2018; Köstler & Ossewaarde, 2022). Negative risk frames illustrate dystopian pictures, often including risks of economic nature (e.g., job loss), ethics (e.g., misuse, privacy), and larger societal threats (e.g., technological singularity) (Brantner & Saurwein, 2021; Brennen et al., 2018; Chuan et al., 2019; Fast & Horvitz, 2017; Köstler & Ossewaarde, 2022). The latter appear to be more influential to change people's technological beliefs (Vishwanath, 2009).

Based on this empirical picture, we expect to find a similar two-sided view on risks and benefit frames in the news coverage around VA-use. However, given the differences of VAs to previously studied innovations (i.e., AI, automation, robotics), it is imperative to leave room for new and potentially different frames to emerge as well. We thus approach our first research question in an inductive manner, as in doing so we can uncover unexpected insights and nuances that may not have been apparent from a deductive analysis of pre-determined frames.

The role of time

Looking at VAs as an emerging technology means looking at an innovation that receives changing attention in society over time. And this fluctuation can be expressed in two ways: One way is through the *volume* of the news coverage during specific time periods, so *how much* was reported about VAs. The other one is through the *content* itself during specific time periods, so *what was said* about VAs over time.

According to the issue-attention cycle, news media attention to a public issue naturally rises and falls (Downs, 1972). The issue hereby goes through different stages that indicate an increase or decrease in news attention. Similar to this, previous research shows that a time-pattern often seen is that of 'hypes and busts cycles' (e.g., 'AI-winters') (Harguess & Ward, 2022), where public attention alternates between high and low levels, with a period of extended coverage in-

dicating a hype-, and a period of little to no coverage suggesting a bust-period.

A public issue typically starts out on a smaller scale before it is being catalysed by either alarming or enthusiastic perceptions (Downs, 1972). To illustrate, Vergeer (2020) previously detected a linear increase in media attention about AI in Dutch newspapers between 2000 and 2018, and a similar increase in attention was found to be exceptionally sharp in the Austrian coverage between 2015 and 2018 (Brantner & Saurwein, 2021). Next to the volume, also the prevalence of certain frames over time, for instance the prominence of benefit- versus risk-oriented frames, can provide indicators for such periods. Here, an investigation on the ethical portrayal of AI in English media revealed an increase in critical viewpoints between 2013 and 2018 (Ouchchy et al., 2020). Now, although it is likely to find a similar increase in news attention for VAs, given that in 2018 Google Assistant came to the Netherlands being the first and so far only VA available in Dutch language (NL Times, 2018), it remains to be seen whether this increase pattern holds and, in particular, what specific frame(s) might dominate.

After this spike in attention, society often realizes that the problem surrounding the issue is intertwined with the benefits that arise for some, which makes finding a solution to the issue complex (Downs, 1972). What follows is a gradual decline of interest. And indeed, previous work (Arifin & Lennerfors, 2021) finds initial indicators for a potential decline in news attention on VAs after 2019. Yet, these first insights specifically refer to ethical aspects in Indonesian media texts, thus leaving open how the broader coverage of VAs has evolved over time and specifically so in the Netherlands.

Altogether, depending on the volume and content of the Dutch news coverage on VAs over time we might be able to infer different stages of the issue-attention cycle as well as different VA-hype- and bust-periods. Our goal is therefore to identify cyclic patterns and validate whether the news attention resembles linear or even exponential patterns seen in previous research, or whether a change of this pattern (i.e., quadratic) can be observed. We respectively ask:

RQ2: To what extent has the volume of news messages in the Dutch news media coverage around VA-use changed over time (2011 – 2022)?

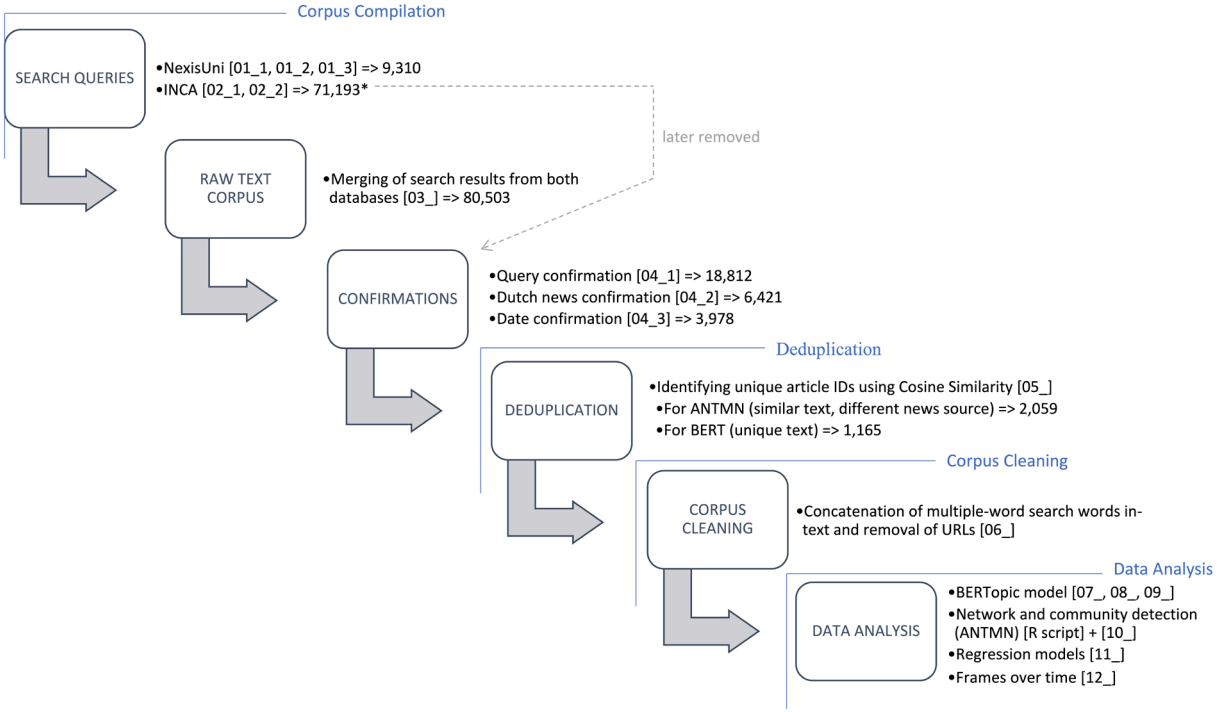
RQ3: To what extent has the frequency of identified frames changed over time (2011 – 2022)?

METHODS

Figure 1 shows the data collection and analysis procedure. The study's proposal was officially approved by the university's ethics committee (2021-YME-13887) and respective data management guidelines were followed. The preregistration plan, its amendment, as well as the supplemental materials including coding

Figure 1

Coding pipeline



*Messages scraped from the second database were removed due to scraping-inconsistencies over time. We found too few messages from that database in most recent years, which caused suspicion. We still report it in our manuscript for transparency reasons and because content of this database let us to confirm our search queries extra carefully in terms of news type and publication date.

scripts can be found on OSF (anonymous link for ongoing peer review: https://osf.io/39tsh/?view_only=ad1fbefde15c44d4967ac2e08b21d894).

Corpus compilation

We queried an existing database from a university full-text news article provider (i.e., NexisUni) for Dutch news media messages on VAs between 01/01/2011 and 24/02/2022 using the following search terms (issued in Dutch language[2]): *voice assistant, house assistant, virtual assistant, voice-controlled technology, smart speaker, Alexa, Google Home, Google Assistant*. We considered news media messages in form of (a) written text that consisted of (b) title and main body text, messages that were (c) created by an individual or a group of individuals either (d) independently or as part of a publisher (e) with the intent to inform a public audience about an issue, event, or development. A message could hereby derive from a (f) traditional public or private news outlet, and from alternative sources that cover news, such as blogs, to align with the current shape of the Dutch media sphere (Costera Meijer & Groot Kormelink, 2021). Furthermore, the message had to be written (g) in Dutch language and it had to be (h) accessible online by the wide public.

We followed three main steps to compile our final corpus: (1) We removed search results where the title and/or body text did not contain the necessary combination of keywords (e.g., 'Google' and 'Home', but not 'Google Home'), and we checked whether keywords stood in relation to our study objective (i.e., 'Alexa' standing in relation to 'Amazon'). (2) We removed messages written in non-Dutch language with the help of a language detector and that did not meet our definition of news (e.g., press releases). In addition, (3) we removed messages that were published before 01/01/2011 and after 24/02/2022 to confirm our time-period of interest. Eventually, this led to a corpus of N = 9,313 news media messages.

De-duplication

We differentiated between two types: (a) Similar text from the same news source, leading to a corpus that only contained unique news media messages ($N_{(a)}$ = 1,165) and (b) similar text but not from the same news source, leading to a corpus that also contained similar news media messages published in different news outlets ($N_{(b)}$ = 2,059). Different news outlets might namely pick up the same news from press releases, which means there might be similarity between messages but differences between news outlets. Respectively, $N_{(a)}$ was later used for topic modelling, $N_{(b)}$ for network and community detection. In total, the final news

2 Search terms arose from an internal review of academic papers as well as relevant published news. More details can be found in the supplemental materials on OSF.

media messages stemmed from 64 different Dutch news sources (see supplemental materials on OSF).

Corpus cleaning

We concatenated words that resembled search terms of multiple words (i.e., virtual assistant = virtualassistantant) and removed any URLs from the text. No further text pre-preprocessing was needed.

Data analysis

Analyses were conducted in Python (Python Software Foundation, 2023) and R (R Core Team, 2023). To answer RQ1 (emerging frames), we followed Walter and Ophir (2019) and first identified topics in our corpus that are conceptualised to represent linguistic frame elements. For this, we used an unsupervised machine learning technique called BERTopic modelling (Grootendorst, 2022) (Bidirectional Encoder Representations from Transformers). BERT is a language model that leverages a deep-learning approach using sentence transformers and TF-IDF (term frequency-inverse document frequency). To balance out meaningfulness and replicability of the final model, we underwent a thorough exploratory comparison of different models with different random seeds. The comparison led to a final topic model solution that distinguished between eleven topics that build the elements for the later identified frames. Two coders independently inspected, labelled, and described each topic based on an additional inspection of the top word lists and a close reading of ten full documents that were most representative per topic (D. Maier et al., 2018). Conflicts were resolved through discussion.

We then inspected the network of the identified topics to see how they cluster together (Walter & Ophir, 2019). For this, we used network and community detection analysis, which allows to visualise co-occurrences of topics across our entire corpus. After applying a selection of different alpha hyperparameters to the network, which determines how likely documents are to consist of many or few topics, the network with best interpretability as well as density and modularity measures was chosen through discussion within the research team. While a higher density indicates that more nodes in the entire network are connected to each other and less nodes are isolated, higher modularity signals a better-defined community structure whereby nodes within a community are more closely connected to each other than to nodes in different communities. The higher the modularity, the stronger the communities. Our final network (see Figure 2, created with Gephi) distinguished between two communities, resembling two frames respectively. Frame labels were determined based on the understanding of topics previously identified. For reasons of reliability and credibility we share detailed memos of this qualitative inspection in the supplemental materials on OSF.

To answer RQ2 (change in volume over time), we performed four different re-

gression models: linear, exponential, and quadratic regression as preregistered, and an additional polynomial (i.e., cubic) regression model post-hoc. All models used time (year-month) as the independent and the number of articles about VAs (volume) as the dependent variable. The model with best statistical fit served to answer the research question. Descriptive analysis was used to answer RQ3 (change in frequency of identified frames over time).

RESULTS

Emerging frames (RQ1)

Topics

Our final topic model suggested eleven topics with one additional topic representing outliers (topic -1, 40%). We labelled the eleven topics as follows (see Table 1; further topic-visualisations are shared on OSF).

Bigger (philosophical) questions about ethics of AI. This topic (16%) relates to AI and society more broadly, highlighting ethical/moral questions that arise in the context of AI-systems and in relation to VA-products that support the creation of smart homes (e.g., lamps, curtains). It refers to the role and influence of AI in/on society hereby in particular highlighting themes of societal diversity, equality, and responsibility.

Big Tech providers. This topic (15%) is about new developments by Big Tech companies, such as Facebook, Google, and Amazon. Many (legal) issues with regards to data privacy and abuse of societal as well as economic power are highlighted. VAs are, among others, mentioned as products and services provided by Big Tech players. Only sometimes news media messages refer to voice-assistant-specific issues (e.g., data privacy).

Use and benefits of smart speakers for voice and audio. This topic (9%) circles around the creation and consumption of audio media, whereby VAs offer a new form of access to voice-products and -services. In some parts, it refers to the benefits of smart speakers' modality as a driving force for the music and radio industry (e.g., listening to radio, podcasts, and music). In other parts, the topic takes a futuristic stance describing how big voice technology may become and what one can use it for in (future) homes.

Table 1

Topics and Frames

Topic	Size	Top words[3]	Topic label	Element in frame
0	189 (16%)	people-year-intelligence-artificial-go-smart-new-artificial-intelligence-ai-home	Bigger (philosophical) questions about ethics of AI	AI systems and society
1	178 (15%)	google-facebook-users-amazon-year-company-people-apple-new-smart	Big Tech providers	AI systems and society
2	105 (9%)	radio-sono-music-via-speakers-podcast-podcasts-year-sound-smart	Use and benefits of smart speakers for voice and audio	Voice assistants and users
3	65 (6%)	amazon-bezos-company-year-billion-jeff-prime-jeff bezos-billion-whole foods	Expansion, critique, and power of Amazon	AI systems and society
4	33 (3%)	samsung-note-glasses-nokia-device-galaxy-screen-lumia 800-smartphone-lumia	Smart gadgets' connectivity to VAs	AI systems and society
5	33 (3%)	robots-robot-astro-darling-human-humans-furby-roomba-ai-pepper	Robots as assistants helping humans	AI systems and society
6	31 (3%)	alexa-amzon-echo-smart-google-voice-assistant-echo-demon-assistant-employees	User experiences with VAs (mostly Alexa)	Voice assistants and users
7	23 (2%)	volvo-auto-xc40-recharge-electric-rover-range-c40-range-full-electric	Reviews of electric cars with access to VAs	AI systems and society

8	21 (1.9%)	apple-iphone-4s-iphone 4s-siri-new-facebook-iphone 12-2019-march 2019	Tech developments of Apple	Voice assistants and users
9	15 (1%)	chatbot-chatbots-rauw-kuyda-bot-tess-circle-people-olds-questions[4]	(Service) text-based chatbots	AI systems and society
10	11 (0.1%)	apple-siri-child abuse-google-recordings-conversations-users-messages-listen in-facebook[5]	The privacy dilemma	Voice assistants and users

3 This table shows the English translation of Dutch top words. Original top words are shown in Table 6 in the supplemental materials on OSF.

4 Top words ‚kuyda', ‚rauws', and ‚olds' refer to persons being interviewed about the history of chatbot development.

5 Top word ‚kindermisbruik' (Dutch)/'child abuse' (English) relates to the detection of content exchanged through VA-related platforms that cause suspicion of child abuse. Exemplarily highlighted are Apple's actions to counteract and prevent child abuse by obtaining access to private conversations which again means an invasion of users' privacy.

Expansion, critique, and power of Amazon. This topic (6%) is about Amazon's corporation, its economic and political power, and growing range of products (e.g., marketplace, logistics, cloud storage, media, hardware). Voice assistants are mentioned as one of the success products. Risks for users (e.g., employees listening in on conversations) are highlighted and critique about actions of Amazon's former president and CEO Jeff Bezos (e.g., power-abuse, working conditions, tax avoidance) is expressed.

Smart gadgets' connectivity to VAs. This topic (3%) discusses a range of smart products (e.g., smartphones, watches, glasses, etc.) by Samsung as well as Apple, Amazon, and Google that allow access to VAs. Emphasis here lays on VAs as a product feature.

Robots as assistants helping humans. This topic (3%) deals with the emergence of robots and other smart appliances in everyday life (i.e., smart homes), ranging from functional to social robots that interact with humans (e.g., robots in education, robotic vacuum cleaners, Amazon's Echo Show, Astro robot). Amongst the risks mentioned are technology misuse and data privacy. At times, robots and VAs are referred to as synonyms, other times, robots are described as a more sophisticated version of VAs.

User experiences with VAs (mostly Alexa). This topic (3%) encompasses reviews and reports about new technological functions of VAs (mostly Alexa), how users experience the technology in their everyday life (e.g., efficient), and what type of (functional) challenges occur (e.g., unavailability in Dutch language, privacy issues due to eavesdropping).

Reviews of electric cars with access to VAs. This topic (2%) resembles reviews of electric cars and the integration of a VA (e.g., Google Assistant, or Alexa). Added voice-features in cars are hereby presented as a functional asset, being particularly suitable for hands-free control while driving. Functional access to VAs is also mentioned in the context of other smart (household) products, such as automatic curtain systems, air conditioning, and energy pumps, yet only rarely.

Tech developments of Apple. This topic (1.9%) centres around promotional announcements of new products from Apple that include, or can be used with a VA and smart speaker devices (i.e., Homepod). Siri is mentioned as the most important innovation of the iPhone 4; critique is issued rarely. Smartphones are compared to smart speakers, with the former said to remain most popular for the near future.

(Service) text-based chatbots. This topic (1%) is about (service) chatbots on specific platforms with a focus on text-based interactions. It discusses how chatbots are programmed, how well they can maintain (human) conversation, and for what purpose chatbots are used (e.g., information, companionship). Frequent conclusions are that chatbots cannot replace people and often need a human in the loop as back-up.

The privacy dilemma. This topic (0.1%) is about incidents or new regulations regarding privacy and data collection principles. Specific cases mentioned are data sharing with third parties, eavesdropping incidents, the need for required consent and more active involvement of users, and specific measures that are taken to prevent issues (i.e., child-abusive content). Privacy regulations of different providers are hereby contrasted (e.g., Google versus Apple).

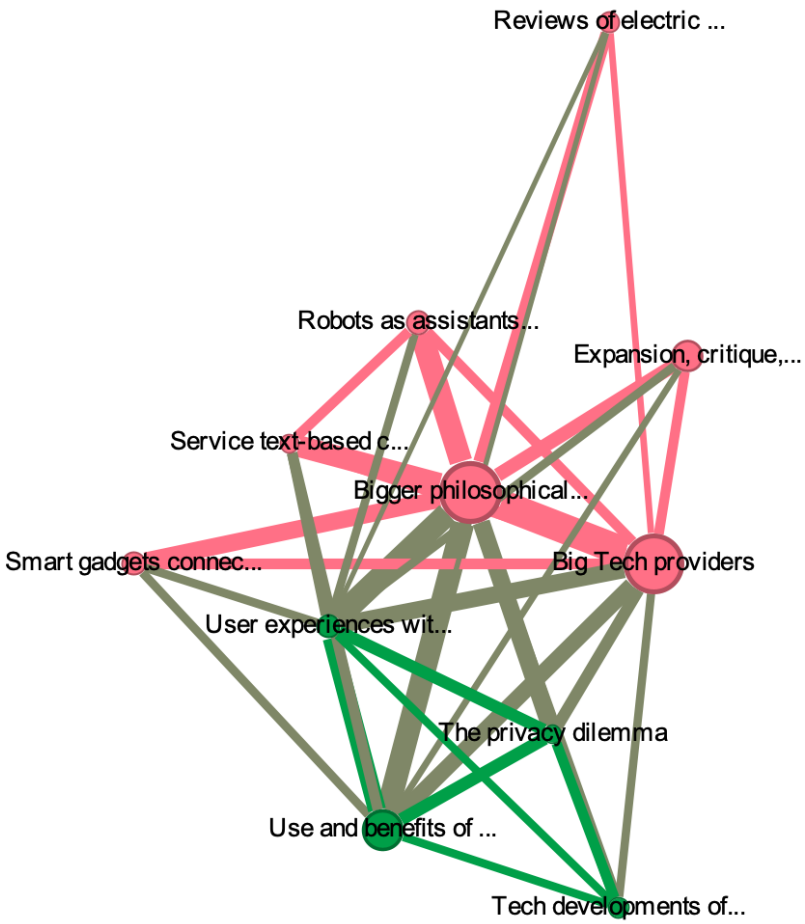
Frames

Two communities (i.e., frames) were identified (Figure 2), which together answer RQ1 (see also Table 1).

AI systems and society. The narrative of this frame is formed by the bigger network community (72%) that consists of topics that either emphasise larger viewpoints on society and the impact of certain actors on the market, or that extend perspective on VAs to AI, including robots, chatbots, and other smart devices. Consequently, this frame speaks of VAs in a broader sense, presenting information from a societal perspective that goes beyond specific device functions and

Figure 2

The topics network



Note. Nodes represent topics; Edges represent co-occurrences of topics in documents (calculated using cosine similarity); Size of nodes illustrates topic size; Node thickness equals edge weights (network prevalence); Colour of edges distinguishes between communities (red = *AI systems and society-frame*, green = *Voice assistants and users-frame*). Network is weighted, fully connected, and undirected. Network density = 0.636. Modularity = 0.022 (with a resolution of 0.7).

(individual) user scenarios. Critical reflections regarding socio- political and economic consequences, especially regarding ethics and the role of providers, come to the surface.

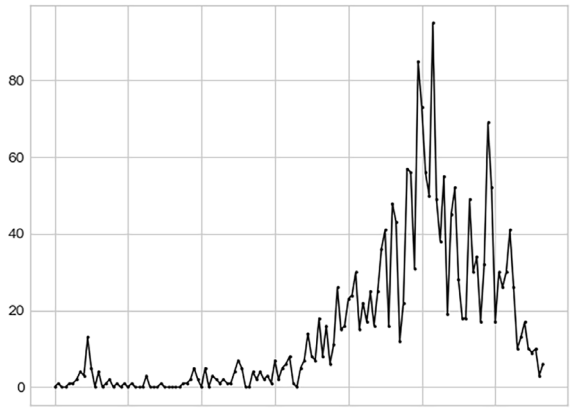
Voice assistants and users. The narrative of this frame is built up by the smaller network community (28%), including topics that specifically highlight voice-controlled agents, like Siri, Alexa, and Google Assistant. Information presented through this frame circles around concrete user experiences and emphasises certain (launches of) devices, functions, and measures that relate to voice and audio. In that, this frame underlines the impact of VAs on a more individual user level.

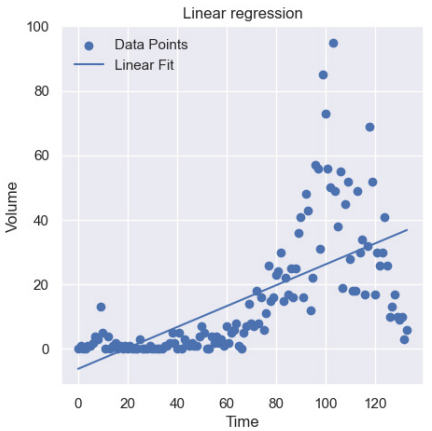
Frame connections. Despite differences between the two frames, the topics network also showed several connections between both communities, illustrated through high edge weights that are frame-unassigned (i.e., see Figure 2). For instance, while the largest topics *bigger (philosophical) questions about ethics of AI* and *Big Tech providers* are anchored in the *AI systems and society-frame*, they also seem to co-occur in news media messages with topics that are grounded in the *Voice assistants and users-frame* (i.e., *user experiences with VAs (mostly Alexa)* and *use and benefits of smart speakers for voice and audio*). Corresponding to the moderate density (0.636) and low modularity score of the network (0.022), this means that the topics are fairly connected amongst each other and that there are instances in which messages contain elements of both frames.

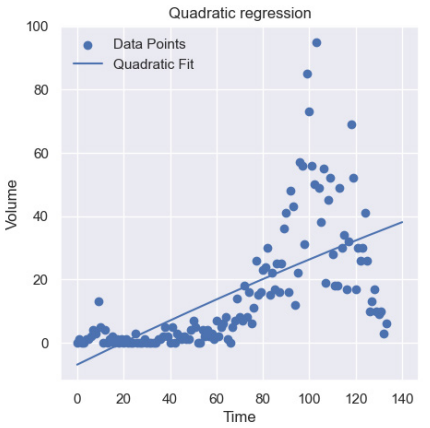
Changes in volume over time (RQ2)

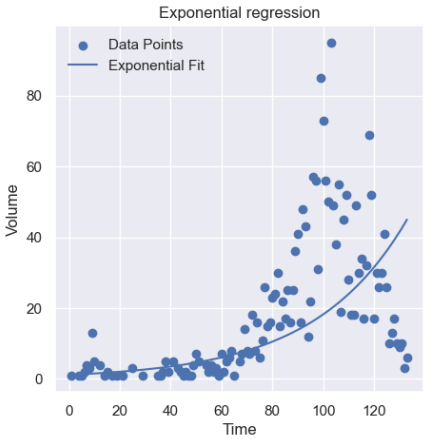
We see an increase starting in 2011 with a peak in 2019. A decline follows in the years thereafter (2020-2022), to the point that the volume in 2022 returned to a similar level as it was in 2016 (see Figure 3). Results of the linear regression model showed that time overall was a significant predictor of the volume of VA-news coverage (R^2 = 0.41, F(132) = 92.06, p < .001, CI [0.26; 0.39]). Entering time as a quadratic term neither revealed significance nor improved model fit (R^2 = 0.41, F(131) = 45.75, p = .78, CI [-0.002;0.002]). In contrast, the exponential regression model was significant and showed improved model fit compared to the linear one (R^2 = 0.57, F(132) = 143.38, p < .000, CI [0.022863, 0.031934]). Given the shape of the development of volume especially in more recent years, we additionally conducted polynomial regression with an added cubic term post-hoc. Results were not significant and did not clearly improve model fit (R^2 = 0.42, F(132) = 47.33, p < .17, CI [-1.62e-05; 2.81e-06]). Therefore, the exponential regression model fit best to how the number of articles (volume) about VAs has evolved over time and thus answers RQ2, even though not all statistical assumptions for this type of analysis were fully met (i.e., independence and normality of errors were met, linearity in the exponent and homoscedasticity were not; see script on OSF).

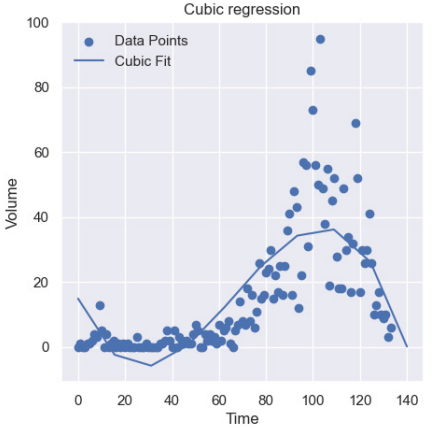
Figure 3
Number of articles (volume) over time with respective regression models; 0 representing the first month (01-2011) and 133 representing the last month (02-2022[6] of the investigated time-period











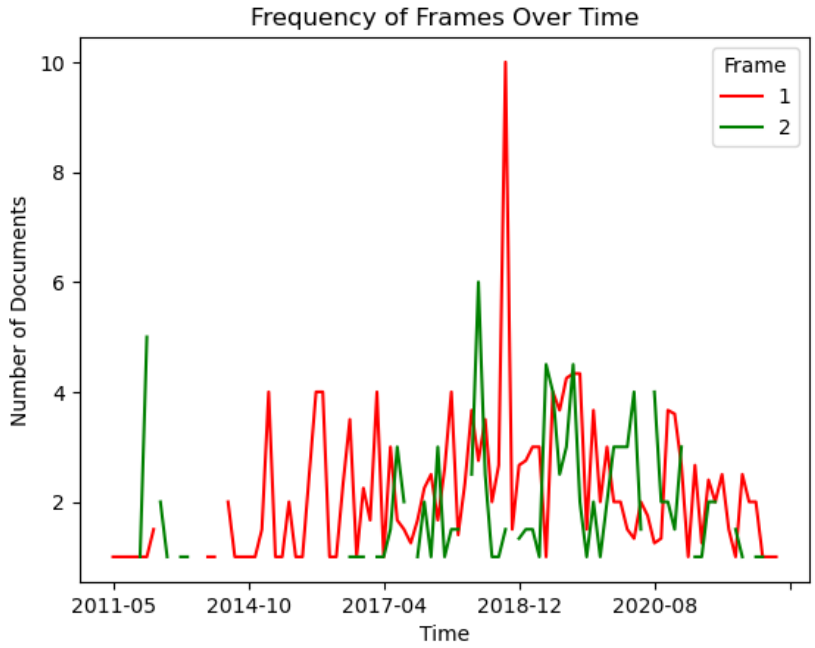
6 Note here that 2022 only contains data of the first two months (until 24.02.2022).

Changes in frequency of frames over time (RQ3)

Overall, the *AI systems and society-frame* was most prominent throughout the investigated time-period. It started to appear more frequently between 2014 and 2016, with a peak in 2018. After 2018, the frequency of the *AI systems and society-frame* fell back to the same level as it was before 2018. In 2020, we see a drop in presence. Afterwards, the *AI systems and society-frame* gains attention again before declining parallel to the general decrease in volume in most recent years (see Figure 4).

The *Voice assistants and users-frame* occurred once at the beginning of the investigated time-period (i.e., 2011 and 2012) and then shows no presence until 2017. Only since 2017, this frame has become more established in the news, occurring concurrently to the *AI systems and society-frame*, particularly in 2017 and 2019. 2020 marks the only time-period (except for 2011-2012) where the *Voice assistants and users-frame* was more prominent than the *AI systems and society-frame*. Again, parallel to the overall decline in volume, the frequency of the *Voice assistants and users-frame* decreased in most recent years (i.e., 2021-2022). Additional information about nuances detected *within* the two frames over time found post-hoc are reported in the scripts on OSF.

Figure 4
Changes in frequency of frames over time (frame 1 = AI systems and society-frame, frame 2 = Voice assistants and users-frame)



DISCUSSION

Theory makes clear that the news media form an important contextual factor for people's adoption of new technology (Vishwanath, 2009) by reflecting and influencing how the public thinks and feels about technological advancements (Chuan et al., 2019). Yet, prior to this study, we lacked knowledge about media representations of VAs. To begin filling this gap, we investigated how VAs have been framed in the Dutch news coverage since their commercial rise (i.e., Siri in 2011). For this, we used ANTMN (Walter & Ophir, 2019) as an automated inductive framing approach. Our results highlight two frames and give rise to important public discussions about how VAs, and perhaps emerging technology more generally, are evolving in society.

From hype to bust?

Over the past eleven years, we recorded an increase in news volume about VAs (RQ2), which aligns well with previous research (Brantner & Saurwein, 2021; Chuan et al., 2019; Vergeer, 2020) and the arrival of Google Assistant in the Netherlands in 2018. Results showed that an exponential trend describes this increase best. Yet, this growth in volume only lasted until 2019. Since then, we observe a decline in VA-news coverage as was implied by Arifin and Lennerfors (2021). For the Netherlands, this is an interesting new finding: Previously, scholars uncovered a 34% VA-adoption rate based on data from Dutch family households in 2020, concluding that VAs are indeed finding strong routes into Dutch homes, similar to the U.S. (Wald, Piotrowski, et al., 2024). Considering our new knowledge about the Dutch news media coverage on VAs, we may further contextualise this finding now. One the one hand, the strong adoption rate might have potentially been fostered by the peak in public VA-attention until 2019. On the other hand, given the recent decline in news attention, the adoption rate from 2020 might have dropped since and will benefit from continued monitoring.

Detecting a recent downward trend in VA-attention can mean that we are witnessing the natural flow of the issue-attention cycle and the occurrence of a beginning bust-period. A similar drop in public AI-attention has been noticed before in the 1970's, late 1990's, and early 2000's (Harguess & Ward, 2022) – commonly known as periods of 'AI-winters'. This knowledge about the public perception of VAs helps us to uncover hidden mechanisms in technology adoption- and use-behaviour that otherwise remain invisible. For instance, signs of resistance (e.g., non-adoption, fear, mistrust) might be, in parts, explainable by a lack of media attention and knowledge provision.

Besides these arguments that signal a beginning bust-period, it is also likely that the presence of other socio(-political) issues around the globe in the years past 2018/9 factored into the decline in VA-news coverage. We refer specifically to the Covid-19 pandemic or the conflict between Russia and Ukraine. Either way,

as Downs (1972) notes, once an issue has gone through this cycle it continues to typically have a higher average level of attention than pre-discovered issues, which means that despite the signs of a drop in news media attention, the issue of VAs is likely to remain on the public agenda. Nevertheless, to draw more robust conclusions about this, more research is needed to keep monitoring the development of news volume during the time past our investigation, especially given the launch of ChatGPT later in 2022.

How VAs are framed

Societal and personal impact framing

We found two frames emerging from the Dutch news coverage around VA-use (RQ1). The most frequent frame was the *AI systems and society* (72 %) frame, in which VAs were recognized as one of many smart systems that are being implemented in society. Given that content presented through this frame mainly touched upon discussions around broader societal decisions (e.g., ethics policy, and law), we see resemblance to what scholars define as *societal impact framing* (Chuan et al., 2019). In this type of framing, consequences of a given development or event are communicated on a larger scale, not per se as affecting single individuals but more society as a whole. In contrast to this, the other, less frequently detected frame was the one on *Voice assistants and their users* (28 %). As this frame presented a narrower perspective on VAs, highlighting the modality of voice for individual users in specific contexts, it can be regarded as the respective counterpart, coined *personal impact framing* (Liberman & Chaiken, 1996). This type of framing communicates news stories with a stronger focus on the opinion of individuals, their experiences, and, as such, underlines specific impacts on smaller scale.

When looking more closely at the dynamic between the two frames over time (RQ3), we see that the *Voice assistants and users-frame* most often preceded the *AI systems and society-frame*. As such, VAs started out as a niche theme and slowly emerged to become an issue of wider interest with more and more people getting affected by it (Chuan et al., 2019). In 2011, Siri was introduced on Apple-smartphones, marking a novel innovation, and the Dutch news media seemed to have presented it mainly by framing its unique voice aspects for individual users – possibly because a larger societal viewpoint was not yet in sight. Only in the years after, the *AI systems and society-frame* emerged and started to dominate the news discourse. Similarly, in 2018, the *Voice assistants and users-frame* peaked before the *AI systems and society-frame* reached its highest frequency. That year, Google Assistant was launched in the Netherlands, being the first and, thus far, only commercial voice assistant available in Dutch language (Pridmore et al., 2019). Presumably, the arrival of Google Assistant in the Netherlands has functioned as a catalyst for news attention on VAs (see also the development of topics over time on OSF). This first led to an emphasis on potential consequenc-

es on smaller scale for users personally, and then to a longer and bigger discussion about effects for society writ large. Lastly, in 2020, when Amazon expanded its marketplace to the Netherlands (Day One Team, 2020), the *Voice assistants and users-frame* was again dominating the news discourse and shortly after the *AI systems and society-frame* took over, following the same pattern.

Finally, while it is rather typical to find the overall majority of information about a new technology as being presented through the societal impact frame (Chuan et al., 2019), the effect of information presented through personal impact frames should not be underestimated. Research shows that the consumptions of personally relevant information can have a stronger influence on shaping attitudes, especially in contexts where existing knowledge about an issue is low (Liberman & Chaiken, 1996). In the Netherlands, public knowledge about AI-related technologies has recently been found to be poor across generations (De Vries et al., 2022). Thus, in that way, even few messages that frame information about VAs as personally impactful might have strong effects on attitude formation. People will consume those messages less critically and more heuristically as they lack the knowledge to contextualise and potentially counterargue the media message. Hence, despite the smaller community size, scholars should pay equal attention to both types of framing moving forward.

A mixed view of risks and benefits

The juxtaposition of risks and benefits also formed, as expected, a substantial part in how the Dutch news reported about VAs. We mainly saw this in the inspection of frame elements (i.e., topics). Among the risks mentioned were points of social responsibility, a general lack of legal foundations for data sharing and privacy rules, as well as economic power abuse and technological misuse. This is in line with previous literature on AI and other recent innovations discovering risk-oriented frames (Brantner & Saurwein, 2021; Chuan et al., 2019; Vergeer, 2020). In terms of benefits, we also see overlap with previous findings (Köstler & Ossewaarde, 2022), particularly regarding the economic driving force of the voice modality for the audio world and the growing convenience for consumers. At the same time, the increasing supply of voice technology in the Netherlands is a specific asset in the Dutch context in comparison to other previously investigated media spaces.

Interestingly, though, an opposing view of risks and benefits was not separately presented in the two frames, such that one frame would highlight risks whereas the other would emphasize benefits. A clear indication of a more benefit- or risk-oriented viewpoint could also not be seen on frame-element-level with certain topics reflecting risks and others predominantly benefits. Instead, both frames and topics showed a combination of the two views. As this was unexpected, it points towards the general negligence in framing research of the combination of opposing frames that might create certain ambivalence for audiences, because

the public issue of VAs is presented from both, promising and critical perspectives, with lacking clarity as to whether it is now a good or bad technological development (Borah, 2011). This, in turn, may have different effects on audiences' technological beliefs than specific positive and negative frames tested previously (Vishwanath, 2009).

To that end, finding mixed-frames that include risks as well as benefits demonstrates the mission of the news media as an information and orientation source. With the goal to educate citizens about VAs as a public issue, the news media offer a balanced perspective. At the same time, it might also signal the remaining amount of public uncertainty around VAs, which might lead the news media to weigh risks and benefits more often against each other rather than framing messages as clearly as the one or the other.

Future research

Uncovering how the Dutch news media frame VAs was a first step in generating more knowledge about the potential origin of VA-relevant attitudes that are theorised to play an important role in technology adoption. A natural next step is to test for concrete media effects. Here, we see different ways in which future research can tie in. One is through the investigation of people's media consumption habits and their recognition of the identified frames. Experimental studies which test for effects of different impact frames (i.e., personal vs. societal impact frame) would be equally interesting. Here, we would hypothesise that personal impact framing has a stronger effect on people's VA-attitude than societal impact framing, especially if applied in a context with poor existing AI-knowledge.

Furthermore, despite the differences between the two frames, we pledge for caution to see them as fully distinct. Our topics network showed several strong connections between elements of the two frames, indicating that messages did, at times, contain elements of both. Framing literature has established that it is quite usual for news articles to contain more than one frame. However, what future research is further encouraged to disentangle is when these connections between elements of both frames are indeed a sign for frame co-occurrence, and when the strength of those connections rather provides support for an additional frame that constitutes a combination of the two.

Limitations

Our investigation focuses on the Dutch news media landscape, which might make generalisability to other media contexts difficult. Comparative investigations from different countries as well as other media formats (e.g., social media) are valuable additions. Methodologically, while our choice for an unsupervised machine learning approach was motivated by the under-researched topic of VAs' media representations and the large text corpus available (Walter & Ophir, 2019),

full objectivity in our findings is not guaranteed. The final manual interpretations of automatically identified topics and frames are based on previous knowledge and intuitiveness of the researchers. To combat this, we provide accompanying details and memos of the interpretation process to strengthen validity and reliability (see OSF).

Lastly, another limitation lays in the robustness of the detected frames. Even though interpretability of the two frames was coherent and in line with existing literature, we cannot say with certainty how likely the frames are to appear in a second set of news media messages and to what extent the topics covered all essence of the content, as only 50% of the entire corpus was meaningfully captured by the topics. This is due to the inductive nature of the framing approach and further corroborated by the low modularity score of the community structure. Hence, scholars are encouraged to apply ANTMN to other VA-related text corpora and validate our results and method through confirmatory studies.

Conclusion

The growing body of literature on VA-adoption has left contextual factors, such as media representations of VAs, fairly neglected. Following theory highlighting the role of the news media for technological attitude formation, this study investigated how VAs have been framed in the Dutch news between 2011 and 2022. We uncovered an exponential increase in news attention on VAs starting in 2011 with a peak in 2019. Most recently, we notice a decline in volume, potentially indicating a bust-period as a natural development in the issue-attention cycle. Two central frames emerged: a frame on *AI and society* and one on *Voice assistants and users* that resemble aspects of societal and personal impact framing respectively. With this, the present study complements the existing body of literature on related developments like AI, automation, and robotics with insights about the (Dutch) news coverage on VAs. It enables the scientific community to continue monitoring the dialogue about VAs for comparison with other time-periods, contexts, and technologies. Furthermore, this study builds the basis for media effect research looking into the impact that VA-frames have on people's adoption- and use-behaviour. Accounting for the powerful role of the news media for the formation of public opinion is crucial. Otherwise, we might be missing an important contextual influence in people's environment that can provide us with answers to pressing questions about hidden mechanisms in the adoption of emerging technologies.