See what I mean?

Meaning-making by Visualisations in Policy Controversies over Energy and Food Technologies

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To Miri and Yossi

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CHAPTER 1

Introduction

1.1 The power of visualisations in policy controversies

Visualisations on the Internet and social media are increasingly influential in policy controversies (Hendriks et al., 2016; Niederer, 2018; Pearce et al., 2020; Rojas-Padilla et al., 2022). Policy controversies are the processes that arise when two or more persons or groups have incompatible objectives or understand an issue from competing framings (Dodge & Metze, 2017; Schön & Rein, 1994; Wolf & Dooren, 2021). The controversy over genetically modified organisms (GMOs) is one example in which visualisations showing potential risks were prevalent in the online campaign and influenced decision-making and public opinion about GMOs (Clancy, 2017; Clancy & Clancy, 2016). Today, the successful visual campaign against GMOs is utilised in the CRISPR online debate, where visualisations are widely used to oppose CRISPR technology by portraying it as indistinguishable from genetically-modified organisms (Rojas-Padilla et al., 2022). Another illustrative example is the visualisation of flammable drinking water in the controversy over hydraulic fracturing for shale gas ('fracking'). This visualisation, widely reproduced and shared online, was engraved in people's minds as proof of the link between fracking technology and risk and has influenced public opinion and technology governance in the Netherlands (Metze, 2018b). Visualisations in these online controversies are not merely 'condensed graphical elements depicting realities, knowledge, ideas, or messages'; they are also 'capable of packaging cognitive, normative, and emotional information in non-necessarily verbal form' (Rojas-Padilla et al., 2022, p. 105).

Visualisations play diverse roles in policy controversies, as has been revealed in domains such as food (e.g., Baker & Walsh, 2020), energy (e.g., Devine-Wright, 2011; Metze, 2018) and the Syrian war and resulting refugee crisis (e.g., Geboers, 2019). A recent review shows that in the academic literature of policy and political sciences, visualisations are considered (1) sense-making devices, (2) strategic emotional triggers, (3) political meaning-makers, (4) icons conveying social norms and (5) portrayals of underlying values (Rojas-Padilla et al., 2022). Visualisations have been shown to influence the perception and memory of a policy problem, persuade the trustworthiness of particular facts and shape the way solutions to the policy problem are perceived (Bleiker, 2018; Metze, 2020; Schneider & Nocke, 2014). Within a policy controversy, visualisations can also help gain political traction for concepts and knowledge claims (Morseletto, 2017) or support a particular

interaction with a policy issue (Metze, 2020; O'Neill, 2013). Digital visualisations, in particular, can impact policy controversies as they can affect relations that are part of social life (see Marres, 2017, pp. 25–27), for example, between citizens and governmental actors involved in a controversy.

Among the various policy controversies in which visualisations are used, controversies about energy and food technologies are particularly noteworthy. Energy and food revolve around technologies essential to our daily lives. Energy and food innovation can contribute to sustainable development in line with Sustainable Development Goals to 'ensure access to affordable, reliable, sustainable and modern energy for all' (SDG 7) and 'end hunger, achieve food security and improved nutrition and promote sustainable agriculture' (SDG 2) (United Nations, 2015). Energy technology can offer, for example, renewable energy sources that provide a reliable supply of cost-effective low-carbon energy (Jayachandran et al., 2022); food technology can offer, for example, preservation techniques that address safety challenges and fortified foods to mitigate nutritional deficiency (Mensi & Udenigwe, 2021). Despite these promises, innovation in the energy and food domains sparks controversies among scientists and in society. These controversies might arise when risks associated with technological innovation are considered in different ways (Clark, 2013; Dodge & Metze, 2017). Visualisations increasingly play a role in these controversies. They assign meaning to a policy issue, and this can influence public opinion and the governance of a controversial policy issue in diverse ways. In this thesis, I address the role visualisations play in policy controversies by considering them as meaning-makers.

1.2 Visualisations as meaning-makers

Visualising is a way to make meaning. As meaning-makers, visualisations can be seen as part of the cognitive-mental schemata activated when information is interpreted, namely as a framing device (see Rojas-Padilla et al., 2022). As a framing device, visualisations influence the way issues are publicly debated and people understand the world, because visualisations 'lie at the heart of how we see and understand the world' (Bleiker et al., 2013, p. 414). In policy controversies, where facts and knowledge are often framed by various actors (Dewulf et al., 2005; Fletcher, 2009), framing often takes place as part of the negotiation of the dominant meaning of the policy issue (Biltekoff, 2016; Metze, 2017). Intentionally

or not, actors also employ visualisations in the process of framing (Messaris & Abraham, 2011). Hence, when giving meaning to an issue, actors use visualisations – intentionally or not.

The meaning visualisations give to an issue can forcefully influence individual and collective ways of thinking about it, as shown in the GMO controversy, where iconic imagery was strategically used by GMO opponents to visually refute the coherent sound science argument for GMO safety and to create negative associations of GMOs, notably with risk (Clancy, 2017; Clancy & Clancy, 2016; Rodriguez & Asoro, 2012). However, negative associations of a technology are also determined by what is lacking in prevailing visual representation. In the UK, during 2006-2007, in a time of debate about future energy policy, newspapers predominantly portrayed members of the public as passively accepting renewable energy technologies, and visual evidence of opposition was missing in this media coverage, contributing to the delegitimisation of opposition and the rejection of individual participation in decision-making about energy (Devine-Wright, 2011).

1.3 Research gap and research question

As meaning-makers, visualisations can help map the various meanings given to an issue by those who are impacted by its policy. This mapping is crucial for improving policy design and implementation for controversial issues because it allows for an understanding of the ways different actors make sense of the policy issue. Meaning also constructs political action, or in Wagenaar's words: 'meaning does not merely put a particular affective or evaluative gloss on things, but … it is somehow constitutive of political actions, governing institutions, and public policies' (Wagenaar, 2015, p. 4). The ways people give meanings to a policy issue are guided by their 'set of values, beliefs, and feelings' (Yanow, 2000, p. 10), which can be studied through visualisations as visualisations can reveal 'what the policy controversy entails, which disagreements over facts, norms and values are deemed important' and what are the 'dominant cultural beliefs and interpretations' (Metze, 2018b, pp. 166–167).

Considering visualisations as meaning-makers, some scholars look into well-known and influential visualisations and point out their effect in the context of a specific controversy (e.g., the diagram 'Burning Embers', from the 2001 IPCC report,

which has been adapted and contested over time, see Metze, 2020; see also the discussion about influential visualizations in Morseletto, 2017). Other scholars who consider visualisations as meaning-makers examine collections of visualisations related to a topic, used in the media or by other actors. These collections – which can be, for example, visualisations from specific media sources, stock photography, scientific illustrations or memes – are shown to reflect and also shape aspects of contemporary culture (Shifman, 2014) and specific discourses related to the examined topic (Aiello & Parry, 2020; O'Neill, 2013; Schrickel, 2014).

A better understanding of the meanings which actors give to contested energy and food technologies can contribute to responsible innovation, a transparent and interactive innovation process that incorporates social and ethical values (Koops, 2015). Such a responsible process considers and responds to the concerns of those affected by the innovation, and those concerns can be reflected in the meanings actors give to the innovation. Responding to the concerns (by, for example, considering them when setting research agendas or in the development of innovation) improves the chances of innovation being accepted and used in society (Cuppen, Bosch-Rekveldt, et al., 2016; Macnaghten et al., 2015), thus bringing us closer to a sustainable future.

Despite its prevalence and importance, the phenomenon of giving meaning to a policy issue by using visualisations remains understudied. This dissertation aims to fill this gap by (1) crafting a conceptual framework for the study of the different aspects that create composite meanings of visualisations, (2) developing methods for studying these meanings and (3) exploring the ways in which digital visualisations are used in policy controversies over energy and food technologies and the meanings they give to contested issues. The dissertation aims to expand the knowledge about meanings visualisations convey in policy controversies, intending to contribute to better policies and their implementation. Hence, the general research question of this thesis is:

What meanings do visualisations convey in policy controversies over energy and food technologies?

The next sections will first introduce the conceptual framework I developed based on existing approaches to the study of visualisations' meaning-making. With

the conceptual framework, the research sub-questions will be introduced. This introduction will be followed by an overview of the methods used in the empirical chapters and an outline of the dissertation.

1.4 Conceptual framework: three aspects of visual meaning-making

Before introducing my approach to answering the research question and the conceptual framework that I developed, I explain my use of the term policy controversy. I use this term to denote a conflict, developed or emerging, in which 'groups of citizens, civil society groups, governments and/or companies manifest the belief that they have incompatible objectives with regard to a technology or policy option' (Cuppen, 2018, p. 28). In a policy controversy, there is not simply a dispute about the data; rather, the issue is understood through competing frames (Dodge & Lee, 2017; Durnová & Hejzlarová, 2022; Schön & Rein, 1994; Verhoeven & Metze, 2022). Frames are 'structures of belief, perception, and appreciation' (Schön & Rein, 1994, p. 23). In science and technology-related controversies, where there are disagreements about what knowledge is considered certain or uncertain and what the points of contention are (Rip, 1986), framing and the meaning different people give to the policy issue are central (Schön & Rein, 1994; Wagenaar, 2015).

An interpretive approach is taken to answer the question: 'What meanings do visualisations convey in policy controversies over energy and food technologies?' An interpretive approach seeks to understand 'socially constructed meaning(s) within and across groups', and by collecting and analysing data on the different points of view in society, it produces deep insights into societal practices (Appe & Dodge, 2022, p. 1157). An interpretive policy analysis, in particular, leads to an analysis that is aware of the consequences of the policy to a range of relevant publics (Yanow, 2000). These relevant publics may share a set of values, beliefs and feelings – reflected in shared thought, speech, practice and their meanings – and form 'interpretive communities' (Yanow, 2000, p. 10). Considering the use of visualisations as a societal practice employed by various interpretive communities, in this thesis, I aim to reveal the meanings different publics give to contested policy issues by using visualisations, with the goal of having a deep understanding of the social phenomena of using visualisations in policy controversies.

Interpretive research starts with a puzzle and offers interpretations that make sense of it (Schwartz-Shea & Yanow, 2012, p. 28). Hence, in this thesis, I start with a puzzle about visualisations as powerful meaning-makers in policy controversies. By interpreting them, my aim is not to reveal any 'truth' about what visualisations represent (such a 'truth' might be, for example, that a specific technology is good for society), but rather I interpret visualisations to explicate their power as meaning-makers and do that while acknowledging that what they represent could mean different things for different people.

The conceptual framework I developed is based on the idea that to fully understand the making of meaning by visualisations in a policy controversy, this meaning-making can be analysed from three perspectives of the visualisation: (1) the type and content, (2) the narrative it conveys and (3) its circulation. These three perspectives, or aspects, which are both static and dynamic, collectively form the overall meaning of the visualisation. The aspects are not independent, but interact to create a composite meaning (Figure 1.1). In the remainder of this section, I elaborate on these three aspects and the three approaches to the study of visualisations' meaning-making they are based, namely approaches that pay attention to (a) stages of meaning-making, (b) layers of meaning-making and (c) the process of meaning-making. Together with the elaboration on the three aspects of meaning-making which compose my conceptual framework, I introduce the research sub-questions, each derived from one aspect.

Figure 1.1. Three aspects of visualisations' meaning-making

1.4.1 First aspect of meaning-making (sub-question 1): Type and Content

The first aspect of meaning-making in this conceptual framework is about the type and content of the visualisations. This aspect takes place in two specific stages, also referred to as sites or moments: the production-process of the visual and the meaning-making embedded in the visual itself. The meaning-making sites come from Rose's (2016) framework of four 'sites' in which the meaning of a visualisation is made: (1) production, (2) the image itself, (3) circulation and (4) 'audiencing'. Drawing on Rose's earlier framework and other sources, O'Neill and Smith (2014) further develop Hall's (1980) conceptualisation of 'moments' in visualisations' communication process and identify three such moments: production, (visual) text and consumption. For Hall, O'Neill and Smith, Rose and other authors who take the approach of stages of meaning-making, each stage (or site, or moment) influences the meaning of a visualisation in a particular way. The image itself, for example, for Rose, includes spatial organisation, which offers a particular viewing position and hence creates a specific effect. The moment of consumption, for O'Neill and Smith, affects the 'interpretive package' (see also Gamson & Modigliani, 1989) that visualisations offer, which helps people construct meaning about an issue (O'Neill & Smith, 2014, p. 81). Although authors who use an approach that attends to stages of visualisation meaning-making usually acknowledge that these stages are intertwined, in conceptual terms they approach them separately.

The first aspect of my conceptual framework, type and content, is situated in the stage of production and the stage of the image itself – or in Hall's (1980) words, the (visual) text. In the stage of production, the technology in which a visualisation was produced results in a specific visualisation type. This type 'may contribute towards the effect they [visualizations] have' – types such as a photograph, map or diagram, have an effect on a visualisation's meaning, and that is mostly because they raise specific expectations about it (Rose, 2016, p. 27). As an example of expectations associated with a particular visualisation type, Rose gives a photograph, and more specifically a photograph belonging to the street photography genre, which aims at capturing life as is. This photograph, according to Rose (2016, pp. 27–29), is expected to show the viewer some truth. However, nowadays, when referring to digital visualisations, the consideration of the expectations that particular types of visualisations raise should be made with caution, given the accessibility of technologies that enable editing and manipulating visualisations with ease (Rose, 2016, pp. 4–7).

In the stage of the image itself (or the (visual) text), the content of a visualisation, what is depicted in it – e.g., people, landscape, food – reveals what is 'said' in the visualisation in a straightforward way (Rose, 2016, pp. 85–86) and therefore helps in examining its meaning. Noticing the content of a visualisation – typically by defining content categories and quantifying each category's prevalence in a dataset – enables making 'general statements … about aspects of representation which non-specialists, journalists and experts alike can understand' (Bell, 2001, p. 13). Quantifying the prevalence of content categories can also reveal whether visual content is unique to a topic. This is important because unique imagery can affect public discourse (Pentzold et al., 2019), contribute to the construction of political narratives (Baker & Walsh, 2020) and increase the chances of the topic being acknowledged as a political and public problem (Doyle, 2014). Additionally, statements about content prevalence can lead to in-depth discussions when the quantifying of content prevalence is contextualised by examining other aspects of meaning-making (e.g., circulation, see below), which put the quantitative results in a broader social context (see Aiello & Parry, 2020, pp. 209–232).

Visual content should be considered in combination with the means used to produce it (Aiello & Parry, 2020, p. 5); in this thesis, the type and content are addressed as a single aspect of the meaning of a visualisation. Hence, the first sub-question is:

What patterns of type and content can be revealed in an online policy controversy?

1.4.2 Second aspect of meaning-making (sub-question 2): Narrative

The second aspect of meaning-making in my conceptual framework, narrative, attends to meaning that is made at the connotative level of visualisations, where visual signs are read in a 'connotive' way (Rose, 2016, p. 121) and ideas or concepts that are attached to them are revealed, based on widely accepted conventions (Rodriguez & Dimitrova, 2011, p. 56). In this type of reading, it is recognised that a narrative can be narrated in visualisations through the use of specific visualisation type and content. As such, it is linked with the first aspect of meaning, type and content. However, narratives can also be 'told' using specific techniques, such as taking a photograph from a particular angle. These techniques can result in specific qualities which can construct particular narratives (Rose, 2016).

The noticing of the connotative level of visualisations is based on an approach to the study of visualisations' meaning-making which attends to different layers of meaning. Taking inspiration from Barthes' (1977) visual semiotics theory of denoted and connoted messages in visualisations, authors of this approach recognise different possible readings of a visualisation, at different visualisation layers. These readings lead to the decoding of multiple meanings in visualisations, ranging from explicit meanings, derived from noticing what is visually represented, to hidden meanings that are based on the interpretation of underlying ideas and values. For example, Van Leeuwen (2001) attends to layers of meaning-making by relying on the visual semiotics theory of Barthes and on Panofsky's (1970) iconography. In an analysis based on iconography, Van Leeuwen makes a distinction between different 'layers of pictorial meaning'. Similarly, Rodriguez and Dimitrova (2011) introduce a layer model to study visualisations' meanings, and they associate it with visual framing. Both Van Leeuwen's three-layer model of pictorial meaning and Rodriguez and Dimitrova's four-layer model of visual framing first reveal meanings derived from a straightforward visual representation, followed by meanings derived from widely accepted conventions. The last layer in both models reveals meanings derived from underlying principles or ideology. However, when revealing meanings derived from conventions, Rodriguez and Dimitrova distinguish between stylistic conventions and ideas or concepts attached to what is being depicted.

Authors who study visualisations while attending to layers of meaning-making may consider the context in which a visualisation is produced and read. For example, when analysing an artwork, iconography considers the period in which it was made (Van Leeuwen, 2001, pp. 101–102). However, this approach to the study of meaning-making from visualisations is limited in the attention it pays to – borrowing Rose's framework terminology – sites other than the site of the image itself. It ignores the meaning made, for example, when producing or selecting a visualisation or when circulating it.

In my conceptual framework, narratives of two types are noted: storylines and frames, sometimes combined with an analysis of sentiments (tone of voice). A storyline is a narrative with 'a beginning, middle, and an end' (Hajer, 2006, p. 69). Based on this notion of storylines in a discourse (Hajer, 1995, 2006), I developed a new concept: *visual storyline*. This new concept focusses on how visual content,

qualities and techniques convey specific meanings of reality and is applied to examine the use of visualisations to convey specific meanings of a sociophysical reality. A frame in a visualisation is a graphical capture of the essence of an issue or event that makes it easier to understand and remember (Rodriguez & Dimitrova, 2011, p. 51). In policy controversies, storylines and frames are worthy of attention because actors use them to negotiate the meaning of an issue, gain support and credibility or challenge competing discourses (Metze & Dodge, 2016).

To effectively analyse visual narratives, attention should be paid to the textual context within which they are used (Bleiker, 2018; Doerr & Milman, 2014; Rodriguez & Dimitrova, 2011; Rose, 2016, p. 121) to the extent that visualisations and text can be seen as constructing a single narrative, namely an *image–text storyline*. The concept *image–text storyline*, aided by the multimodal approach (see Kress, 2001, 2010), considers visualisations and text as constructing a single multimodal storyline. It integrates visual and textual elements to reveal various ways actors understand an issue while acknowledging that information communicated about the issue, especially online, is often multimodal (Kress & Van Leeuwen, 2021).

As objects constructing narratives, visualisations have the ability to form online publics, loose networks of actors that are organised around issues they are affected by (Marres & Rogers, 2005, p. 929). Online publics 'may disclose the work of articulation and organization – the formatting of issues, the mobilization of actors and the preparation of events – that enables and/or announces a public's eventual "coming out"' (Marres & Rogers, 2005, p. 928). In an online policy controversy, online publics may form discourse coalitions – loose networks of actors who share a way of interpreting the policy issue (Metze & Dodge, 2016). Online publics, however, may also form other types of coalitions in an online controversy. In this thesis, acknowledging the 'networkedness' of visualisations – the idea that online visual content is networked (Niederer, 2018; Niederer & Colombo, 2019) – I expand the notion of online publics by considering both words and visuals as means of forming online publics, and I put the two means one against the other. Hence, the second sub-question is:

How do coalitions in a policy controversy use visual and textual narratives?

1.4.3 Third aspect of meaning-making (sub-question 3): Circulation

The third aspect of the conceptual framework I develop is circulation. It is based on an approach to the study of visualisations' meaning-making that attends to the *process* of meaning-making, to the meaning that changes in different contexts and over time. Circulation is a dynamic aspect that recognises the mobility of visualisations and potential changes. In Chapters 2 and 5, I identify three ways of circulating: within a platform, across platforms and across topical contexts.

Visualisations, especially digital ones, are rarely used in one place; they can be used simultaneously by different accounts or actors and can be used independently on social media and different websites. They can also travel from one place to another (be it from the TV screen to a mobile phone screen or from a news website to a social networking platform) (Niederer, 2018; Rose, 2016). Although visualisations circulate, they can be studied as being connected. Visualisations can be connected ('networked'), for example, by being used in conjunction with a hashtag (Niederer & Colombo, 2019, p. 43). This hashtag then indicates the topical context of the visual. However, the topical context should also be studied in more depth. Of course, the topical contexts within which a single visualisation is used can differ from its original topical context. For example, scientific visualisations such as graphs can be used in a non-scientific context, without the text that originally accompanied them, and can 'serve various interest groups, trigger different associations and offer new perspectives' (Schneider & Nocke, 2014, p. 17; see also Aiello & Parry, 2020, pp. 209–232). Additionally, circulating increases visualisations' potential for visualisations to interact with (new) audiences (Rose, 2016, p. 288). These (new) audiences interact with visualisations by perceiving, interpreting, sometimes reworking and republishing them, which can reframe a policy topic and convey new meanings (Van Beek et al., 2020).

Authors who appreciate visualisations' circulation consider it an important aspect of their meaning and pay attention to changes in meaning over time in different ways. For example, Aiello and Parry (2020, pp. 209–232) note changes in meaning over time by tracing different contexts that specific visualisations are used within. Analysing the ways visualisations of a specific collection are used, Aiello and Parry compare these uses with the stated purpose of the collection creators and conclude about the 'lives' of these visualisations, which expand beyond the platform where they were 'born'. Similarly, Van Beek and colleagues (2020) study

the change in the meaning of specific visualisations that travel across contexts. Van Beek and colleagues, however, also note modifications made in visualisations. Conceptually, Van Beek and colleagues associate changes in meaning with the dynamic nature of visual framing and the fact that framing occurs in different stages of visualisations' meaning-making. In doing so, they pay much attention to the connectivity of the different stages. Niederer (2018) studies the change in visualisations' meaning over time from a slightly different angle. Niederer considers networked visual content a subject of study. For her, changes in visual content networked by means of, for example, links between pages, offer answers to questions about meaning that is changing over time, for example, as a response to specific political events.

In this dissertation, I study the circulation of specific visualisations, similar to Aiello and Parry (2020) and Van Beek et al. (2020), and changes in visual networked content, similar to Niederer (2018). In line with Van Beek et al., I acknowledge the connectivity of the meaning-making stages. However, I extend this acknowledgement to also include means of meaning-making other than visual framing.

The circulation aspect is crucial for a complete understanding of the meaning of a visualisation, especially given the ever-intensifying process of circulation on social media platforms (Rose, 2016, p. 288). Furthermore, in the context of policy controversies, a change in the meaning of visualisations while they circulate can be significant because it can reveal an interaction between actors and negotiations between them about the meaning of the policy issue (Rojas-Padilla et al., 2022). Hence, the third sub-question is:

(How) does the meaning of visualisations related to a policy controversy change when they circulate?

1.5 Method

1.5.1 Case selection

In answering the research questions, the empirical chapters of this thesis study multiple cases of emerging and more developed technologies in energy and

food. The idea behind selecting multiple cases when taking an interpretive approach is to enable one to study a phenomenon in different contexts. This helps the research to be 'sufficiently contextualised' (Schwartz-Shea & Yanow, 2012, p. 46) and to explore multiple interpretations of actors of the studied phenomenon (Boswell et al., 2019, Ch 2 and 4).

In this thesis, I chose to study the phenomenon of online visualisations in controversies. I am interested in illuminating as many faces as possible of this understudied phenomenon. Hence, I selected controversies that are diverse in their stage of development, from an emerging controversy to a developed one, and I ensured that these controversies are about technologies in different stages of development, from newly emerging (see Krabbenborg, 2019) to an already-embedded technology. The broad and diverse social contexts of the cases I selected lead to a holistic understanding of how actors give meaning to contested issues through visualisations. See Table 1.1 for an overview of the cases and their variety.

Table 1.1. Varieties enabled by the selection of the cases

	Hydraulic fracturing for shale gas extraction ('fracking')	Food processing	Nanotechnology in food and food packaging
Domain in which technology can facilitate a transition toward sustainable development	Energy	Food	Food
Controversy stage of development	Developed controversy	Emerging controversy	Emerging controversy
Technology stage of development	Emerging technology	Already-embedded technology	Newly-emerging technology

There is one case selected from the energy domain (the controversy about fracking) and two cases from the food domain (food processing and nanotechnology in food and food packaging). Fracking is a 'technique that injects water and chemicals under high pressure to "frack" deep shale layers, enabling extraction of previously inaccessible gas resources' (Metze, 2017, p. 49). Several publications have indicated that the policy and societal debates about this technique are complex and sit within a discursive tension of, on one hand, considering fracking as necessary for a transition fuel towards a more sustainable energy future and,

on the other, as harmful to the environment (Dodge & Metze, 2017; Weible et al., 2016; Williams et al., 2017). Food processing, in this thesis, is defined as the industrial process of transforming (raw) food materials into food products. Food processing is a multi-interpretational term that for some means an answer to the need to feed the growing world population in a sustainable and environmentally responsible manner (Eicher-miller et al., 2012; Floros et al., 2010), while for others it is a dubious practice with a negative influence on health and the environment (Monteiro et al., 2018; Popkin et al., 2012). Nanotechnology in food and food packaging denotes the use of processes, materials and tools on a nanometre-size[1] scale for the production, processing or packaging of food (Chaudhry et al., 2017, p. 6). Nanotechnology in food and food packaging is an innovative field that can fundamentally contribute to a more efficient and sustainable food system, but the field also has knowledge gaps and is associated with potential risks to human health and the environment (Chaudhry et al., 2017; Handford et al., 2014; Henchion et al., 2019).

1.5.2 Method for gathering and analysing data

In studying the multiple cases, I integrated different research methods into a new research protocol. The new protocol combines digital methods with stakeholder analysis and interpretive methods.

To gather data, I used text search keys, such as hashtags and keywords relevant to the specific case studied. I integrated digital and non-digital techniques, for example, anonymised Google searches, scraping tools and reverse image searches together with manually identifying relevant online actors. The data in each chapter consists of text and visualisations found on webpages or tweets. I gathered data from websites of different types of actors involved in the controversies (e.g., official websites of governments, companies or non-governmental organisations; blogs of individuals; online encyclopaedias such as Wikipedia) and Twitter. Websites are a meaningful source of information about science and technology topics and a meaningful source for us, scholars, when we aim to learn about science and technology controversies in society (Marres, 2015). Social networks and Twitter, in particular, are important sources in the study of views on contested energy and food technologies in society (Boscarino, 2022; Hopke & Simis, 2017; Tabei et al., 2020).

1 Nanometre equals to one thousand-millionth of a metre.

In the analysis of the data, before analysing the visual and textual content, for the most part, I conducted an actor analysis to acquire familiarity with the actors active in the controversy studied. When analysing the gathered data for their visual and textual meanings, I followed the advice of scholars from various disciplines to note the textual context when analysing visuals (e.g., Bleiker, 2018; Doerr & Milman, 2014; Rodriguez & Dimitrova, 2011; Rose, 2016, p. 121). Hence, in all chapters, I applied textual coding for sentiments or tone of voice (i.e., positive, negative, neutral/balanced). In Chapters 2, 3 and 4, I first coded the textual content and then the visual content. In Chapters 3 and 4, I also coded the text separately from the visuals for storylines and frames of the technology studied. Textual codes were defined according to the specific research question which I was answering. In Chapter 5, I applied a multimodal approach and coded the visualisations together with the text for image–text storylines. For Chapters 3, 4 and 5, I further developed existing code books based on inductive coding of samples of the data. For visual analysis, I inductively developed code books for each chapter.

To guard the rigour and relevance of the analysis and to prevent biases, I took several measures. When using digital tools and wherever possible, I followed recommendations to mitigate bias characteristics of the tools (for example, recommendations on how to avoid getting personalised Google results, Rogers, 2019, p. 33). I discussed the code books and the results of the interpretative analyses in routine meetings with my co-authors and made sure that we agreed on them. I also organised coding-in-action sessions and sessions of reflection on the results with various groups of researchers and other participants, such as members of the Public Administration and Policy Group, the consortium members of the project this PhD dissertation is part of 'Travelling of Framed Facts and Uncertainties' (TOFU), the international valorisation panel we launched for this project, other scholars involved in the study of policy controversies and stakeholders specific to a technology (e.g., invitees from the Dutch food information centre, Voedingscentrum). Table 1.2 summarises the method used for each chapter.

The abovementioned research protocol of first conducting a stakeholder analysis, then scraping websites and Twitter, and analysing for storylines, frames and sentiments was specified for each empirical chapter. In Chapter 2, which takes a digital methods approach, a variety of digital tools are used and significant effort is put into grounding them by linking them with the happening in the studied

geographical areas results (see on grounding Rogers, 2019, pp. 4–6). In Chapter 3, to have interesting empirical findings, I focus on groups of visualisations with some resemblance. In Chapter 4, a sentiment analysis was conducted manually, whereas most studies conduct this analysis in an automated-computed way (e.g., Cambria et al., 2017; Jeffares, 2014). In Chapter 5, I integrated scraping Twitter data (through Twitter API for Academic Research[2]) and Google reverse image search to enable an analysis of visualisations that are found both on the open Web and on Twitter. To reduce the amount of tweets, I applied a Twitter engagement analysis and selected the tweets that were retweeted at least ten times to manually analyse visual–textual storylines.

Table 1.2. Summary of the research question and sub-questions and the method(s) used to answer them

Research (sub-) question	Method	Mainly answered in Chapter
Sub-question 1: What patterns of type and content can be revealed in an online policy controversy?	Actor analysis Textual content analysis to label actors' stance Visual automatic network analysis of type and content	2
Sub-question 2: How do coalitions in a policy controversy use visual and textual narratives?	Actor analysis Textual manual analyses of frames and/or sentiments Visual manual analysis of type and content and frames/storylines	3 and 4
Sub-question 3: (How) does the meaning of visualisations related to a policy controversy change when they circulate?	Twitter engagement analysis Textual tone and topical context analyses Image–text storyline analysis	5
Main question: What meanings do visualisations convey in policy controversies over energy and food technologies?		6

1.6 Outline of the dissertation

This thesis presents four empirical studies and a concluding chapter, comprising Chapters 2 to 6. These chapters aim to address the main research question of the thesis through three sub-questions. Figure 1.2 presents an overview of the dissertation and the text below introduces an overview of the following chapters.

2 With a special thanks to Prof. dr. Art Dewulf

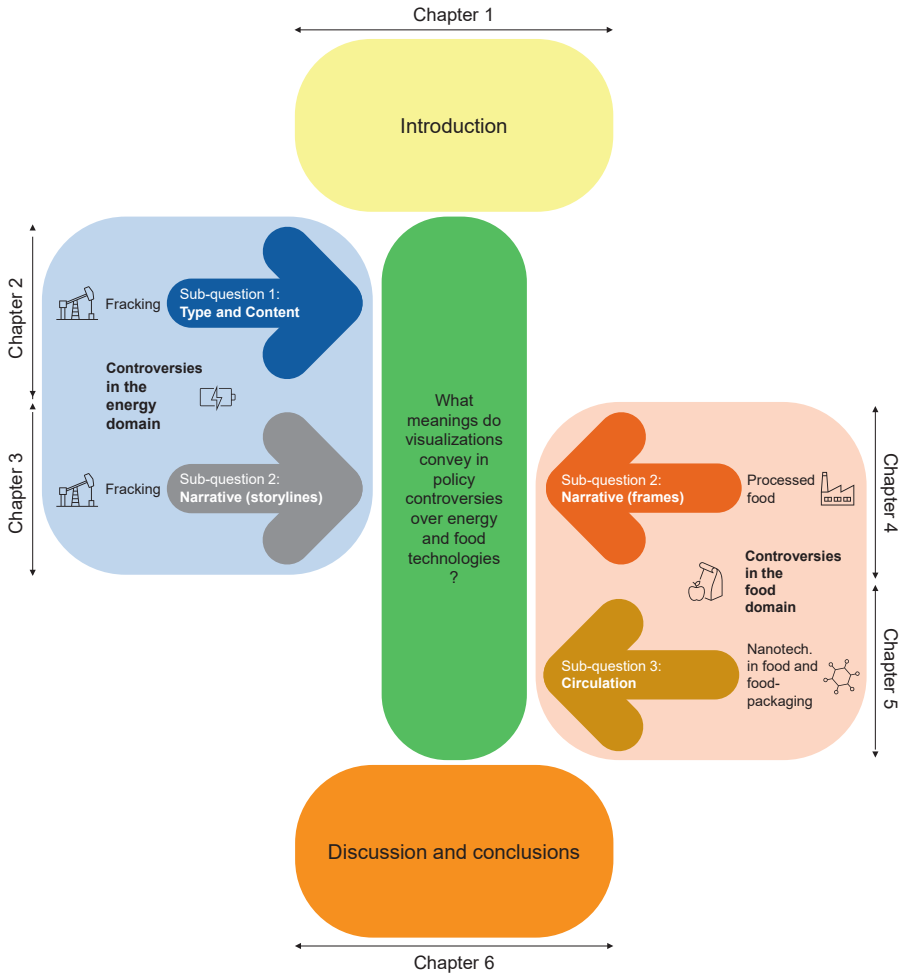

Figure 1.2: An overview of the dissertation

Chapter 2 focusses on the first aspect of meaning-making – the type and content of visuals – and explores the use of visualisations on the open Web by actors in the controversy about hydraulic fracturing for shale gas extraction in South Africa, Mexico and the United Kingdom, at two points in time, 2018 and 2019. The study takes a controversy mapping approach and employs digital methods to reveal the actors involved in the controversy, their stances, the types of visuals they use, the visual content and the evolution over time. The findings illustrate the relationship between different types and content of visualisations and different aspects of the controversy: topic, views and stage of development.

Chapter 3 focusses mainly on the second aspect of meaning-making – narrative – and examines the role of visualisations in shaping the discourses around hydraulic fracturing for shale gas extraction. It illustrates how visualisations can contribute to discourse formation by networking or isolating content and actors. The chapter introduces the concept of *visual discourse coalition* and uses examples from the Netherlands, New York State and South Africa to illustrate four ways in which visualisations can influence the dynamics within and between discourse coalitions.

Chapter 4 focusses mainly on the second aspect of meaning-making and analyses the use of visualisations in the communication of information about processed food, comparing textual and visual framing. The chapter introduces the notion of an *online sentiment coalition* and uses Google queries to construct a dataset, which is analysed to uncover the positive, negative and balanced sentiment coalitions and the text and visualisations they use. The results highlight the different meanings of processed food in society and the contribution of visual analysis to understanding these meanings.

Chapter 5 focusses mainly on the third aspect of meaning-making – circulation – and examines visualisations of nanotechnology in food and food packaging on Twitter and the open Web. The chapter studies circulating visualisations within-platform, across Twitter and the open Web and in different topical contexts. It also provides an in-depth analysis of storylines about nanotechnology-in-food on Twitter and the open Web. The chapter takes a multimodal approach and, using Twitter API and Google reverse image search, shows the dynamic meaning of visualisations by analysing textual tone, image–text storyline and how these change over time and during visualisations' circulation.

Chapter 6 summarises the main findings revealed in the empirical chapters and answers the thesis's sub-questions and general question. On the basis of these answers, the chapter draws conclusions and includes a discussion of them. It also reflects on methods, suggests directions for future research and offers advice to those who study policy controversies and those who visualise the issues at their hearts.

CHAPTER 2

Patterns of Type and Content in an Online Policy Controversy

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Abstract

The internet is an increasingly influential actor and arena for debating emerging sustainability controversies, but studies often overlook the role of visualisations in online spreading of information. This paper offers a way to better understand this role: what images do competing online actors use, are there differences between opponents and proponents, differences between internet regions, and are there shifts in their online visualisations over time? Adopting a controversy studies perspective and the digital methods approach, we studied the online spread of visual information. We compared the use of visualisation about shale gas on top-ranked pages in the internet regions of South Africa, Mexico and the United Kingdom in 2018 and 2019. The results indicate a connection between the actor's standpoints in the controversy and the type of image used. In Mexico, proponents and neutrals used, most of all, photographs of people (officials). Opponents posted more data visuals. South African and British neutral actors used more data visuals, while proponents posted landscapes and opponents photographs of people (protesters). Also, we noticed that changes in the actor's position in the controversy between 2018 and 2019 coincided with changes in the use of type and content of visualisations. Context-specifics of each country offered possible explanations for these shifts in standpoint and visualisation of the controversy. Our study indicates that visuals are highly relevant digital objects in public debate and the decision-making process.

2.1 Introduction

Public debates about sustainability issues often become highly politicised and these debates increasingly shape policies for environmental and sustainability issues (Dodge & Metze, 2017; Hansen & Cox, 2015; Williams & Sovacool, 2019). Although almost everyone will support sustainable and environmentally friendly policies and attitudes (Lindahl et al., 2016); many issues, such as new energy technologies or siting issues have an impact on public perception, and may induce public and policy controversies (Boudet, 2019).

Hydraulic fracturing or 'fracking' for shale gas is a relatively new technology that generated a global controversy (Dodge & Metze, 2017; Hopke & Simis, 2017; Williams et al., 2017). The debate consisted of diverging interests and has a geopolitical dimension all discursively uttered in disagreements about shale gas exploration as an environmental risk and economic opportunity (Bomberg, 2017b; Bugden et al., 2017; Dodge & Lee, 2017; Lis & Stankiewicz, 2017; Valerio-Ureña & Rogers, 2019; Williams et al., 2017; Williams & Sovacool, 2020). Some studies highlight the debate's visual aspects, as they influence how this controversy has evolved in different domains (Hendriks et al., 2017; Krause & Bucy, 2018; Metze, 2017; Sarge et al., 2015). Among these, the internet is a particular arena where the shale gas controversy evolved (Metze, 2018b).

Online, different publics than in traditional media or in parliamentary debates engage around an issue (Rogers & Marres, 2000). They take stances, share information, and aim to gain attention for that information by use of visualisations. In addition, those internet actors often promote possible solutions. As such, the internet and social media platforms have become one of the main arenas where controversies are debated (Marres, 2015; Rogers, 2013). Understanding the internet as a field of governance, we acknowledge it as a space for public and networked production, circulation and exchange of information, that is ultimately shaping behaviours, decisions and alignments (Castells, 2008; Mol, 2006). The internet is no longer merely a space, a medium and a source; rather, it has become an influential actor. Websites and digital platforms – such as Twitter, Facebook, Google, Wikipedia, etc. – are non-human actors with affordances, content, and dynamics of circulation of information. They are fundamental to understanding social practices and decision-making dynamics (Rabello & Gouveia, 2019; Rogers,

2019; Stevens et al., 2016). They also have an important role in making information accessible and created an overabundance of information for the general public (Camargo & Grant, 2015).

Within this data-profusion, visual content is essential as it engages the public by telling a story about the policy issue, which can significantly affect the public's interpretation and alignment to sides of the contest (Hullman & Diakopoulos, 2011). As digital objects and networked content, visuals cross boundaries, influencing the problem definition and pointing to specific positions and solutions (Metze, 2020; Niederer, 2018; Van Beek et al., 2020). For instance, images of flames from tap water from the documentary *Gasland* circulated online and can be considered an essential element in how the debate about shale gas exploration evolved. For instance, in the United States, visuals strengthened the association with risk (Gommeh et al., 2021; Mazur, 2016). In the Netherlands, visualisations contributed to a frame-shift and possibly to the debate's evolution until the technology was banned (Metze, 2017, 2018a, 2020).

In this paper, we investigate the visual aspects of the online debate about hydraulic fracturing in three different internet regions, or web spheres.[3] The countries associated with these spheres were each in a different stage of the emerging controversy in 2018. In the United Kingdom (UK) it was a full-fledged controversy (Bomberg, 2017b); in South Africa (SA), it was becoming contested (Atkinson, 2018; De Wit, 2011); and in Mexico, governing actors were still exploring the potential of shale gas production (Valerio-Ureña & Rogers, 2019).

In this exploratory study, we aimed to gain more insights into the importance of visualisations as distributors of information in emerging online controversies. We identified how proponents, opponents and neutral actors visualised the controversy at two different points in time: 2018 and 2019. The research questions were: a) who are the online actors involved in the controversy (the online public); b) which types of visuals does each position – pro, anti or neutral – use to support their standpoint? c) Are standpoint and type and content of visualisations shifting over time? d) What are possible country-specific explanations of these shifts?

3 Here, we borrow the idea of web spheres from Rogers (2013) to characterize internet domains related to countries (ex: ".uk", ".mex", and ".sa"). According to the author's discussion, what happens in these internet "regions" is somehow connected and representative of the geographic setting. Therefore, mapping the web sphere would allow us to "ground" digital research results.

Below, we first give a short overview of the shale gas controversy's contextualities in each country. Second, we conceptualise the role of visuals on the internet, especially in debates like shale gas exploration, and the relevance of applying digital methods to understand them. Third, we present our methods for selecting, gathering, and analysing the data. Fourth, we present the results of the visual analysis and actor analysis. To conclude, we explore possible explanations for the shifts in the standpoints and use of visualisations over time for each country.

2.2 Country background information

The three regions we selected, all considered shale gas a considerable potential source of energy based on numbers provided by, for example the US Energy Information Association,[4] about estimations of technically retrievable shale gas. In addition, academic publications indicate for each of the countries an emerging controversy. This makes them interesting cases to investigate the role of visuals on this online controversy.

Mexico has one of the largest gas shale reserves of the globe: ~545 trillion ft^3, (EIA, 2011). In 2014, the at the time President Enrique Peña approved the Hydrocarbons Law and several thousands of wells have been installed. In parallel, environmental organisations and political opposition groups have pointed out the potential negative consequences of this activity (El Universal, 2018). In August 2018, the newly elected President Andres Manuel López Obrador announced the intention to end shale gas production practices (Reforma, 2018). In contrast, public figures, such as the former president of Mexico Vicente Fox, continued to support hydraulic fracturing (Loredo, 2018).

In SA, shale gas reserves were estimated to be ~390 trillion ft^3, and contestation revolved around environmental risks, economic and energy opportunities, and the place of shale gas in a complete energy mix (Andreasson, 2018). The controversy in South Africa has unique characteristics. Particularly in the Great Karoo area, for which shale gas production was foreseen, there is a greater risk of water contamination. It is an arid area with low rainfall and scarce potable water reservoirs (De Wit, 2011; Tucker & van Tonder, 2015). Studies point out the dangers of fracturing for biodiversity and fragile flora. However, Karoo citizens live

4 https://www.investopedia.com/ask/answers/011915/what-are-effects-fracking-environment.asp

in extreme poverty and hydraulic fracturing is seen as an opportunity to create jobs in the region (De Wit, 2011).

In the UK, estimations of shale gas reserves were 1,329 trillion ft^3, and the national government attempted to position itself as a pioneer of European, safe, sustainable shale gas exploration. Some studies identified coalitions on both sides of the controversy. Bomberg (2017b) pointed to the anti-shale coalitions as the most successful and dominant until 2017. More recent studies indicate that pro-shale framing has become prevalent in the policy debate. Most UK governments have supported shale development over the last years (Williams & Sovacool, 2019, 2020). Nonetheless, the authors also found a high level of anti-shale framings, which suggests an ongoing contest at formal national political sites. These anti-shale discourses are more focused on land use issues and impacts on the landscape, like the claims identified by Bomberg (2017b), and point more specifically to governance affairs.

2.3 Digital methods for mapping visual aspects of online controversies

'Mapping controversies' originates from Bruno Latour's studies of scientific claims made to defend different perspectives, gain knowledge and engage in a public debate on science and technology themes (Latour, 1987). To map a controversy, we usually identify and track arguments and claims of expertise presented by opposing actors in a debate. It also allows understanding the complexity of the controversial object in the dispute (Latour, 2005).

Since his first writings about controversies, Latour has highlighted the importance of the visuals in a debate. Images are mobile, presentable, readable, combinable, and embeddable in different settings and contexts. Therefore, they are strategic elements for arguing and convincing someone of a particular perspective (Latour, 1986). In online controversy mapping, visual content has been considered a key aspect due to its networked nature, matching the same logics as the web (Metze, 2018b; Niederer, 2018; Pearce et al., 2019).

Studies about sustainability controversies have proposed digital methods for mapping online public debates and the many objects – visuals included – that are used in debates about controversial issues on digital platforms (Marres & Moats, 2015; Marres & Weltevrede, 2013; Metze, 2018b; Pearce et al., 2019, 2020; Rogers, 2013, 2015, 2019). Digital methods consist of 'the deployment of online tools and data for the purposes of social and medium (Rogers, 2019, p. 21). They can be used to study society with the web as a medium. It acknowledges the internet and social media platforms not only as a source of ephemeral information, but also as a non-human actor itself in the dynamics of social practices and decision-making (Marres & Moats, 2015; Marres & Weltevrede, 2013; Rogers, 2013, 2015).

Digital methods usually focus on an object or on a combination of them, such as a 'digitalised object' (e.g., text, images, profiles) or 'natively digital objects' (e.g., hashtags and URLs) (Rogers, 2013). As methodology, they help track how these objects or topics combine, travel, collapse and are repurposed online (Omena, 2019; Rogers, 2019). The analysis of digital objects can be conducted using open web content, such as links and web pages. Usually, from this data, we build lexical maps, source actors lists and perform visual analyses of the topic (Rogers, 2019).

These authors also acknowledge that, when mapping online controversies, the visuals, metaphor, issue, or any other digital or digitalised object can be central. Additionally, understanding the online debate by grounding it in its context is pivotal. The controversy will not be the same in one place as the other. In addition, we need to take into account actors and standpoints in the debate: to who is this topic controversial and what positions are defended by debaters? (Marres, 2015; Marres & Moats, 2015; Marres & Weltevrede, 2013; Rogers, 2015, 2019).

Building upon studies that used the digital methods approach to discuss phenomena of online public debates in different topics (Marres & Moats, 2015; Marres & Weltevrede, 2013; Metze, 2018b; Pearce et al., 2019, 2020; Rogers, 2013, 2015, 2019), for the shale case study, we focused on the visuals embedded on the URL's content, acknowledging them to be entities acting in the debate. Understanding these images as a networked artefact (Niederer, 2018), we conducted a visual network analysis, in which we read visual properties (what is in the image) and the network's spatial configuration (clustering of similar type of visualisations). In doing so, clusters of elements (here images) emerge based

on the type and number of connections between them. Clustering them by similarity in content and digital affordances like hashtags or hyperlinks rendering is a common way to create maps for illustrating these images' circulation across platforms (Pearce et al., 2020; Venturini, 2010; Venturini, Jacomy, et al., 2018).

2.4 Methods

To answer our research questions, we used academic literature and policy documents from the three countries to gain a contextual understanding of the controversies. In addition, we scraped text and visuals from the Google top-ranked URLs[5] in the web spheres of the United Kingdom, South Africa, and Mexico on 10 July 2018 and 19 December 2019.[6]

Our research protocol contained five steps: 1) mapping the actors and coalitions in the three-country web spheres involved in the shale gas controversy; 2) tagging the actors as a proponent, opponent, or neutral through a content analysis of their URLs; 3) running a visual network analysis by scraping the visuals each actor use to depict their point, determining how these actors frame shale gas exploration, and what kind of visuals clusters are used to illustrate these framings on the debate; 4) contextualising the visuals characteristics between proponents, opponents and neutral actors across these web spheres' local situation; 5) relating the findings to the context specifics of the controversies in each country.

Following Latour's concept of programme and anti-programme as opposite agendas in a controversy (Akrich, 1997; Latour, 1990, 2005), in the first step we chose keywords that represented different sides on the shale gas exploration controversy. As proposed by Rogers (2017, 2019), the term 'programme' refers to claims and efforts promoting a particular proposal campaign or project. Conversely, the 'anti-programme' opposes these efforts or projects. A third position

5 Google has different national domains (country-based versions). Top-ranked URLs are the top search engine results for three queries in distinct languages and distinct national domains of Google web search engine. Details on the researched domains and queries are given further in this section. For discussions and examples of national domains of Google's relevance for digital research, see Ben-David et al. (2018); Rogers (2013).

6 On 10 July 2018, during the Digital Methods Initiative Summer School at the University of Amsterdam, the team made the first data collection and decided to follow-up with a second time period to add a comparative analysis, after noticing shifting perspectives in the news and grey literature (e.g., El Universal, 2018; Loredo, 2018; Reforma, 2018) by the end of 2019. This comparison could offer insights about the topic and allow us to 'ground' the results seen in local context changes. The day of December 19th was random.

would be the neutral, which applies a neutral discourse aiming more to inform than to defend a position.

We first designed queries representing pro-exploration, anti-exploration and neutral positions. Based on Hopke and Simis (2017), we adopted the three keywords: 'fracking', to represent the anti-position (opponents); 'shale gas', as a pro-position (proponents); and 'hydraulic fracturing' as a neutral expression.[7] We opted to use Google to identify a source list of actors that debated it online. This search engine also operates as a ranker for actors (websites) in each social issue (keywords queried), which points to the trends of dominant voices online and their concerns (Rogers, 2017, 2019). Using the tool Googlescraper (Lippmannian Device)[8], we scraped top-ranked URLs per country, querying different searches for each keyword. We scraped the 15 most relevant results according to Google's rank algorithm (duplicates resulted in fewer data points). Then, we merged the outputs per search in a single list of the most significant actors and URLs per country.

The second step was manually classifying the URLs as an informant (a general website mentioning actors, news webpages like bbc.com) or an actor itself (an active person or organisation on the debate, like www.greenpeace.org). For informants, we registered the name of actor(s) mentioned, then merged the actors from original URLs with those referred by informants in one single list of actors. Finally, after entering each website and checking for direct declarations, two independent researchers (for validation and bias control) classified them as pro (proponent or supporter), anti (opponent or against) or neutral on shale gas exploration.

Our third step involved using the Google Image Scraper[9] tool to extract up to 20 top-ranked images connected to the shale gas controversy from their websites with the previously used queries. Obtaining the visual repertoire used by actors in shale gas controversy allows us to understand more about the connection with their positioning and the visuals they chose to adopt. In this step, we identified

7 The three keywords were also investigated in Spanish, in consideration to Mexican publications

8 Also known as 'The Search Engine Scraper', this tool allows scraping the search results for a given query. It has as output a list of results the search engine returned for the query, algorithmically ranking considered. You can choose which search engine you want to scrape. For this study, we searched on Google. See https://tools.digitalmethods.net/beta/searchEngineScraper.

9 This tool uses images.google.com to query specific sites for images connected to particular tags. For each URL given, Google is asked if a keyword occurs on each URL. Creators alert that Google uses its algorithms for determining if a particular image belongs to a specific keyword, so it is by no means exhaustive, correct or complete. See https://tools.digitalmethods.net/beta/googleImages.

recurring and connected visual content and type of visualisations posted by the actors of various stances in different countries. For this, we used the results from step 1 and 2, and in addition conducted a visual analysis to mapped the related images (Niederer & Colombo, 2019). The images were run through ClarifAI API (Sood, 2017), a computer vision algorithm that recognises tags (concepts, entities, or objects) in the content. The tagging was done through a web interface[10] developed by DensityDesign Lab. Images and tags by ClarifAI API were turned into nodes of a network[11] and connected when they share one or more concepts in the dataset. The network was visualised with Gephi (Bastian et al., 2009), an open-source programme that computes nodes' spatialisation based on how they are interconnected using a force-based algorithm, called 'Force Layout'. In addition, images were superimposed on the network using Adobe Illustrator (Adobe Inc., 2019) to obtain the final visualisation: the closer they are, the higher the number of tags they share.

The fifth step consisted of reading, interpreting and annotating results from the network through a visual analysis (Venturini et al., 2014). When clusters of similar images emerge and are highlighted, the stance of the actors that used them could be traced back from the original dataset. This procedure allowed us to examine the shale gas visual content on actors' websites. We ran a controversiality analysis comparing all the image networks per position and per country [actors-keywords-URL-images-position] with data visualisation techniques.

Finally, the actor analysis and visual analysis results were grounded and related to policy events in each of the country to explore possible explanations for shifts in the standpoints in the debate and the use of visualisations over time (Figure 2.1).

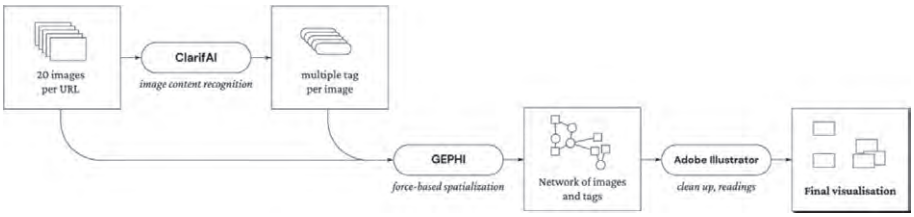

Figure 2.1. Visual rendition of the protocol to realise the networks of images later analysed

10 DensityDesign Lab's 'Image tagging tool interface': https://densitydesign.github.io/dd-image-tagging/.
11 Networks are comprised of nodes (entities, people, images, or others) and links, that define the connections between the various nodes, therefore building a network.

2.5 Findings

In this section, we answer the research questions a) who are the actors involved on the controversy online debate; b) which types of visuals does each position – pro, anti or neutral – use to support their position? c) Is the position in the debate and the use of type and content of visualisations shifting within one year? d) we ground these findings in the context-specifics of each country and explore possible explanations for the shifts over time.

2.5.1 Who is involved in the shale gas controversy in these countries and what do they defend online?

In 2018 the URLs of the Mexican web sphere were dominated by proponents of shale gas, such as the – at the time president of Mexico Enrique Peña Nieto, governmental departments, and public associations, such as Petróleos Mexicanos, Secretaría de Energía and Asociación Mexicana de Empresas de Hidrocarburos (Amexhi). In 2019, there were fewer proponents on the internet, and those in favour were mostly companies and international organisations that support shale gas exploration. Between 2018 and 2019, Centro Mario Molina was the only actor who shifted position from opponent to neutral. Other remarkable changes were governmental departments' positions, such as Secretaría de Medioambiente y Recursos Naturales, from neutral to anti-fracking, as well as Agencia de Seguridad, Energía y Ambiente, Petróleos Mexicanos, Secretaría de Energía that changed from pro-fracturing to neutral. As previously mentioned, the outgoing government's official position (2012-2018) was more pro-fracking, while the incoming government's initial position was more anti-fracking. A possible explanation for these changes most probably was the government change on December 1st, 2019.

The South African online debate included more, and more varied group of actors than in Mexico. Interestingly, there were no shifts in positions between 2018 and 2019. However, many actors from 2018 disappeared from the online debate in 2019 and new actors engaged in the second year, which indicates an ongoing controversy. In addition, this also seems to signal a minor shift from a general favourable online public to a more neutral one. For example, the Department of Science and Technology participated in de online debate in 2018 but disappeared in 2019. A possible explanation is that in 2018 there was a close collaboration between the Department of Science and Technology and the DMR (Department of Mineral Resources) and they both were in favour of hydraulic fracturing. In 2019, the head

of the Department of Science and Innovation (formerly Department of Science and Technology), Blade Nzimande, no longer prioritised fracking, and both departments were no longer visible in the online debate. In addition, the Supreme Court of Appeal ruled that the fracking regulations published by the Minister of Mineral Resources in 2015 would not be enforced (Andreasson, 2018; De Wit, 2011).

In the online debate of the web sphere of the UK, different actors participated in 2018 and 2019; however, the controversy remained balanced with opposing, proposing and neutral actors. Most striking differences in participating actors was the absence in 2019 of the previously opponents Quackers.org and the Scottish government, the European Commission and Historic England (neutrals), and the UK Onshore Oil and Gas (proponents). Newcomers were some opposing local committees, such as the City of York Council and the North Yorkshire County Council. Larger organisations, such as the National Park Authority and Young People's Trust for Environment, were also against hydraulic fracturing in the UK. In 2019, there were more academics active on the internet that had analysed possible impacts of fracking. Governmental organisations, such as the National Audit Office, the Oxford Institute for Energy Studies and the Royal Academy of Engineering published technical reports. Finally, Exxon Mobil, Shell and Tendeka participated in the online controversy as proponents and investors on the British shale gas market in 2019. Remarkable shifts were (1) those from neutral to anti-fracking from the Lancashire County Council and Oil and Gas Authority between 2018 and 2019. This shift may have been caused by the publication of studies about local impacts of fracking, leading these actors to adopt the opponent discourse online; and (2) the UK Conservative Party and the UK Government changed from proponents to neutral precisely during the elections and the Brexit debate. This suggests that this topic was relevant for politics. No listed actor shifted the position from opponent to neutral or proponent.

2.5.2 Which types of visuals does each position – pro, anti or neutral – use to depict their claims?

We retrieved visuals from the URLs of the actors identified in 2018 (2,341 images) and 2019 (2,167 images) in the three web spheres. We analysed these visuals for similarities and differences in type of image and content and we also checked whether different positions in the debate led to different visualisations. Figure 2.2 shows a network of resembling images that the online actors used in 2018. Figure 2.3 shows those from 2019.[12]

12 High-definition and interactive versions of these image networks are available in https://observablehq.com/@andreabenedetti/shale-gas-2018 and https://observablehq.com/@andreabenedetti/shale-gas-2019.

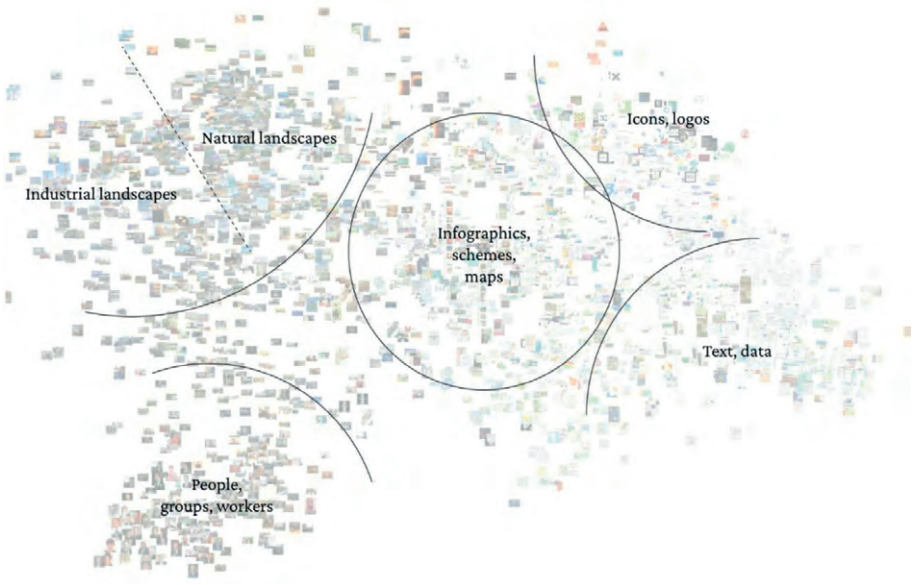

Figure 2.2. Visuals on the debate (all the images used by actors, 2018). The network is clustering the images per theme/content

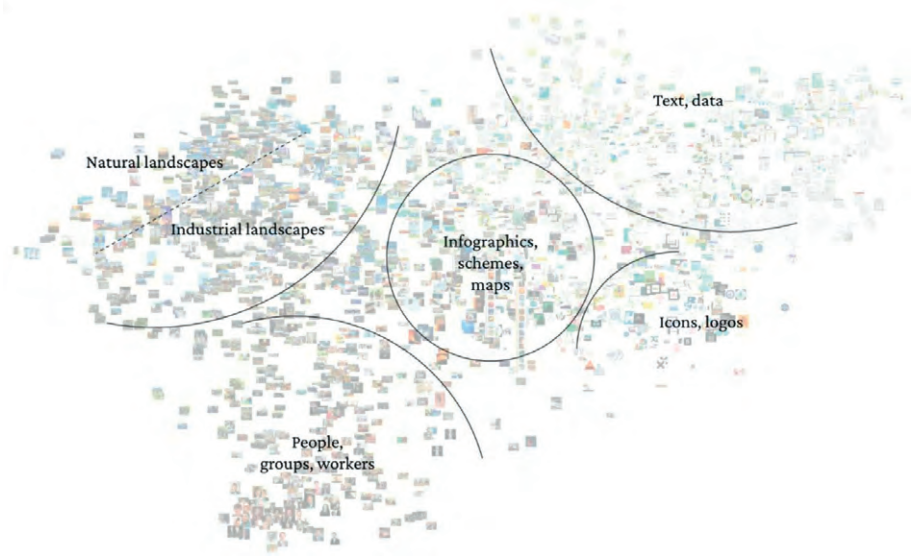

Figure 2.3. Visuals on the debate (all the images used by actors, 2019). The network clusters the images per theme/content

There are three general themes in the 2018 visuals: images depicting people, landscapes, and data. When taking a closer look, we identify six clusters in the image sort: on the upper left, there are industrial landscapes and hydraulic

fracturing fields, followed by natural landscapes. Down left, there are images of workers and people like politicians, spokespersons, and groups. On the right side of the network, there is a predominance of data in infographics and maps in the centre, together with a reasonable number of icons and logos on the upper right and text (mostly images of papers and statistics) right below.

Even though the online actors' composition was different between the three web spheres, approximately the same relative use of images in each cluster were detected in both points of time. The spread of use of the type and content of visuals was rather similar, which points to a thematic saturation of the shale gas online controversy.

We then investigated if certain image types and content were posted in relation to the actors' standpoint in the debate. Table 2.1 shows the number of images retrieved per year/country, according to the actor's position. The Figures 2.4 and 2.5 below depict the same clusters of images as shown in Figures 2.2 and 2.3, but now with each image coloured according to the actor's position who posted it: green for images used by pro-fracking actors, grey for images used by neutral actors, and red for images used by anti-fracking actors.

Relating the type and content of the visual to the debate's position, these networks in Figures 2.4 and 2.5 show that pro-fracturing actors use all kinds of images in South Africa and the United Kingdom. In Mexico, proponents and neutrals use more visuals depicting people (most of all officials), although data and logos/icons also appear considerably. South African and British neutral actors tend to use more visuals connected to all sorts of data and facts. Anti-fracking actors in both web spheres tend to focus more on landscapes and people (protestors). In the Mexican case, anti-fracking actors used all kinds of images to depict the debate, but they are using more infographics, schemes, and other data-related visuals most of all depicting environmental risks.

Table 2.1. Images retrieved per year/country, according to the actor's position

Country	Actor's position	N of images in 2018	N of images in 2019
Mexico	Negative	245	282
	Neutral	147	93
	Positive	239	123
Mexico Total		631	498
South Africa	Negative	192	296
	Neutral	340	276
	Positive	517	87
South Africa Total		1049	659
United Kingdom	Negative	100	316
	Neutral	194	301
	Positive	367	393
UK Total		661	1010
Grand Total		2341	2167

Figure 2.4. Visual network of shale gas controversy in 2018, per country. The colour of the images converted to dots represents the positioning of the actor on the debate. The place of the dot in the network represents the type of cluster the image belongs to (see Figure 2.2)

Figure 2.5. Visual network of shale gas controversy in 2019, per country. The colour of the images converted to dots represents the positioning of the actor on the debate. The place of the dot in the network represents the type of cluster the image belongs to (see Figure 2.3)

Comparing the predominance of coloured dots in 2018 and 2019, we observe a decrease in visual usage amongst pro- actors (green dots). The spreading of red dots in 2019 shows opponents using all types of visuals, which can point to their awareness of the impact of visuals on the debate. This increase of opponents visual is more prominent in South Africa and United Kingdom.

In 2019 the pro-actors in the United Kingdom again posted a broad variety of types of images. Neutral actors in South Africa started to use more data visualisations. In Mexico, there was a decrease in posting images of people, and an increase in data visualisations about environmental risks. Striking is also a higher number of pro actors' visuals in Mexican URLs.

In general, the little presence of academic or scientific entities' URL in the digital debate for the three countries must be highlighted. Furthermore, when manually coding the actors per position, we noticed that the political agenda largely dominated the internet's debate.

2.5.3 Grounding results

So far, we have explored possible connections between the content and type of posted images on one hand, and positions of online actors in a controversy on the other. We also compared this between three different internet regions and in two different points in time. These analyses indicated that shifting of positions relates to shifts in posting image types and content. In this section, we aim to explore possible explanations of these findings by linking these online debate findings with the events in each country. In digital methods, this is called 'grounding the debate' (Rogers, 2013, 2019), which allows a better understanding of the role of online visuals when depicting a local debate.

The Mexican data show that the prominent online actors in 2018 were most of all companies and the government that were promoting the shale gas agenda, and some civil organisations arguing against it based on the experiences and data from other countries. Images of people and groups – mostly governmental officials – were, then more prominent amongst proponents. In 2019, after a change of president and political party, and with a more technical and internationalised debate, Mexican pro-actors decreased (mostly companies), and some actors made a shift from proponent to neutral and from neutral to opponent. In 2019,

we see opponents using more types of images (e.g., data visualisations), while proponents, in general, spread the visual presence on the debate.

In South African results of 2018 and 2019, we see mainly four groups of actors: industry actors (who are, in general, proponents), activists and NGOs (which are typically opponents), governmental actors, and scientists. There is a lower rate of industry actors in 2019 top rank results than 2018, and a higher rate of activists and NGOs in 2019 than 2018. Besides, we see a lower rate of pro-actors and a higher rate of against-actors in 2019 than in 2018. The lower rate of participating industry actors, the higher rate of activists and NGOs, and the fact that they are mostly against-fracking actors might indicate a change in public involvement. In 2019, the presence of pro- hydraulic fracturing firms, at least in the digital sphere, is weaker, while actors that voice interests of specific populations (such as farmers) have a more substantial online presence. This observation is an important finding, as South Africa is a country in which interests of the community are rarely part of the discourse.

As for the UK, the controversy was as intense in 2018. Local associations were pressuring the government (pro shale gas exploration) to ban this method. In 2019, the government became neutral and signed no exploration agreements after some anti-fracking local pressure. This shifting was probably a consequence of imminent elections and Brexit discussions when many government sectors opted to 'neutralise' the discourse to preserve votes on other agendas. The British visuals in 2018 were linked to technocratic concerns (such as safe operations, economic viability) and possible danger to cultural and natural local heritage. Over the next eighteen months, more significant community protest groups put pressure on local governments, especially in areas where shale gas exploration was about to be implemented. It resulted in a higher prominence of these actors in the online debate in 2019, together with the presence of a more substantial visualisation against hydraulic fracturing in all clusters of images.

2.6 Discussion

This study was based on a conceptual approach in which visuals are digital objects in online controversy mapping, and we adopted digital methods to study the

spread of visual information by online actors with a positive, negative, or neutral stance about hydraulic fracturing for shale gas exploration. The results revealed (1) the top-ranked actors in the online debate in three different internet regions, (2) their positions in the debate, and (3) indicated patterns in the relations between position in the controversy, and the posting of particular image types. In addition, we showed that online actors do change their position over time, and the posting of visualisations changes accordingly.

One main conclusion is that there were no changes in the general spread of type and content of visuals, which in this case were people (spokesperson, protest groups, workers), landscapes (natural and industrial) and data (graphs, text, icons, and infographics). The division over these different categories remained the same between 2018 and 2019. This indicates a thematic saturation on shale gas controversy's visuals, meaning that there is a specific set of visualisation types (people, landscapes, and data) that are strongly associated with shale gas extraction discussions.

Besides, controversy stage, actor's position in the debate, and the use of these visuals seem to be related. In the early stages when shale gas seemed a promising energy source, governmental actors and industry dominated the online debates, and posted photographs of governmental officials (Mexico), but when the controversy intensified opponents varied more in types of images. They used relatively more data visualisations of environmental risks. In SA and the UK, the online controversy made significant shifts between 2018 and 2019. In SA, the opponents became more dominant in the online debate, mostly because of a drop out of proponents. In the UK, the debate became more neutral-negative, probably because of a shift in attention in the public and policy debates toward Brexit. This shift in issue attention is a phenomenon well known in media-attention studies (Downs, 1972).

Hence, when 'grounding' the results, local ephemerides in each country offer interesting insights about the differences in these images' usage when comparing places and positions over time. The findings were achieved through classic content analysis techniques, manual coding (for the identification of relevant actors' position), and automated visual network analysis (which relied mostly on computer vision for clustering images per type and content and identifying

stances). Therefore, when discussing the results, we must consider the dialogic interaction between human and machine involved. There is no 'human vision' opposing a 'machine vision'. Our results have analytical value when the machine mode of seeing is contextualised – what we explored when 'grounding' the online products (Rogers, 2019).

Moreover, when working with computer-generated visual networks, we must account for the implications of statistically treating visual content. The machine associates the image content based on a labelling and tagging system of the image, enabling the algorithm to operate to cluster the images. This approach is appropriate to specific research questions like ours, but it does discard other possibly relevant visual information. Due to the algorithm's dependence on the 'textual representation of the image' in the tag, we run the risk of considering the computer vision output as the truth. The manual interpretation of the visuals and relating it to context specifics – the 'grounding' – worked to address this limitation. This also helped to bridge the division between image and text. To integrate textual and visual analysis, without overlooking our main object – visuals – we used the actors' textual content to inform their positioning by integrating interpretive (qualified) and digital (quantified) understanding.

Another criticality is that many important actors in the controversy were not speaking for themselves online (through personal websites, for instance), being recognisable and reachable only through informants. To mitigate this bias, we included on our actor's list those who were mentioned by top-ranked news and stakeholders URLs (as explained on Methods section). We determined each actor's position based on their online content. Even though we were not able to verify whether this is their real position within the scope of this research, we minimised bias in the positioning with two independent researchers' assessment.

In the future, visual network and visual framing studies of all sorts of sustainability controversies can build on our automated visual analysis combined with actors' stances and improve the complementarity of interpretive and digital methods. Moreover, our exploratory study can be further strengthened by statistical analyses of the relations between actors' standpoints and the use of type and content of the visuals to better comprehend the role visuals play in spreading online information and misinformation.

2.7 Conclusion

This paper employed digital methods to map the visual elements involved in the online debate about shale gas exploration. We specifically investigated how actors used visuals to support their positions in the three different web spheres of Mexico, South Africa and the UK. We explored the role visuals play in depicting different sides of a sustainability controversy, and how it evolved.

We found that the shale gas controversy overtime was visualised in similar ways, pointing to an established visual vernacular for this topic. Landscapes (natural and industrial), people (individual and groups), and data (text, infographics, maps, icons) were types of visual used equally in both years and with different intensities by different actors and country-related web spheres. South Africa's actors used the highest number of images in the dataset, of which a considerable amount were landscape images. They also used research paper images in neutral and positive stances. The UK most neutral actors posted data visualisations from research papers. Mexican actors posted mostly photographs of people (proponents) and data visualisations of risks taken from research papers and maps (opponents).

Differences found in the usage of these images when comparing views on the debate led to the presumption that the shifting on certain actors' position over time, and consequently, the dominance of specific visual stances, can be explained by country specificities.

Overall, our results illustrate the web as a field of governance dynamics. As digital objects, visuals play an essential part in sustainability controversies, public debate, and decision-making process.

CHAPTER 3

Visual and Textual Storylines by Coalitions in a Policy Controversy

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Abstract

Attending to the role of visualizations in discourse formations allows for detecting the emergence of particular visual storylines. This article studies the emergence of visual storylines in energy policy, in particular shale gas controversies. The analysis is based on data gathered in three internet regions: the Netherlands, New York State, and South Africa. The analysis studies how visualizations may contribute to confirmation, disintegration, integration, or polarization of discourse coalitions due to similarities or differences between visual and discursive storylines. From the results, we suggest the notion of visual discourse coalitions (VDCs) to contribute to the study of visualizations and discourses in policy controversies. We define a VDC as a network of actors that share a similar discursive storyline and a similar visual storyline of the controversy. The article shows that visualizations and their graphic characteristics add another dimension to the formation of discourse coalitions and the way they develop, connect, or disconnect.

3.1 Introduction

The study of global politics engages more and more with aesthetics (Bleiker, 2017), and the visual is increasingly being addressed in the study of controversies – intractable policy disputes that are 'immune to resolution by appeal to the facts' (Schön & Rein, 1994, p. 4). More and more studies acknowledge the capacity of visual artefacts to influence our understanding of the world (Messaris & Abraham, 2011) and to shape dynamics of politics (Lilleker et al., 2019), to the extent that some perceive a visual turn (Bleiker, 2018). In controversies and networks, studies demonstrate, visuals play an essential role as they can exercise power, construct knowledge, affect attitudes, and mobilize publics (Latour, 1986; Latour & Weibe, 2005; Lilleker et al., 2019; Mattoni & Teune, 2014; Rommetveit & Wynne, 2017). Thus, the dissemination of visuals merits further investigation. And indeed, methodological, conceptual, and technical explorations have contributed to the emergence of various approaches in which the role of the visual in politically contested issues is analyzed (e.g., Campbell, 2007; Morseletto, 2017; Schneider & Walsh, 2019).

The study of using visuals in policy controversies usually focuses on the visual object: where and by whom images have been produced, with what aesthetic and graphic qualities, for what reasons, and with what effect (e.g., Clancy & Clancy, 2016; Krause & Bucy, 2018; O'Neill, 2013). This, to a large extent, overlooks the multidimensionality of the studied subject and decontextualizes the visual. Following recent work (Hendriks et al., 2017; Metze, 2018b), we take notice of the particular ways in which visuals are being used and develop a comprehensive approach whereby we analyze visualizations as part of a collection of ideas, verbal statements, and storylines. Visualizations can be concrete visual objects that represent reality (e.g. a printed photograph, a diagram on a screen) or mental or imaginary ones (see, for example, Rommetveit & Wynne, 2017). Using these visual objects is the essence of the practice of visualizing. Thus, visualization as a practice is a dynamic process in which visual objects are (re)selected and (re)interpreted to give information or tell a story in ocular ways (see also Van Beek et al., 2020). This conceptual approach is applied in this paper to controversies over shale gas.

The exploration of shale gas is controversial in most countries (Bomberg, 2017b; Dodge & Metze, 2017; Hopke & Simis, 2017; Metze & Dodge, 2016; Williams et al.,

2017). Contestation in the shale gas case commonly revolves around two types of tensions between conflicting framing: that of shale gas as an economic and energy opportunity or as a threat to the environment, and that of shale gas as a 'bridge fuel' to a carbon-free energy future or a delayer of a transition to sustainable energy (Dodge & Metze, 2017). This contestation is reflected in the various discourses – the 'ensemble(s) of ideas, concepts, and categorizations . . . through which meaning is given to physical and social realities' (Hajer, 1995, p. 44).

In the controversy over shale gas development, there are distinct alternative discourses and discourse coalitions. Discourse coalitions are networks of actors who share a meaning that is given to reality (Hajer, 1995; Metze & Dodge, 2016). This shared meaning of reality is important in the evolvement of policy controversies, as it may dominate how policymakers understand the issue and develop solutions for it (Feindt & Oels, 2005; Hajer, 1995; Hajer & Versteeg, 2005). The study of discourse has developed from being language-centered with a focus on the framing of issues to including various material relationships that establish discourses (Hansen & Machin, 2013). Yet, the role of the visual in the formation of discourse and discourse coalition deserves more attention and opens up particular ways to study the emergence of controversies.

In our study, we do not assume visualizations have a universal meaning; rather, they are being used to interpret the world and display it in a particular manner (Rose, 2001, p. 6), and therefore their meaning is negotiated. In a policy controversy, visualizations are used to tell a story that illustrates and depicts an issue. Hence, the study of the visual stories can reveal contested facts, normative concerns, and values that can be used for policy learning (Metze, 2018b). For discourse coalitions, because of their multi-interpretability, visualizations may be able to bridge competing coalitions and possibly also break up these interpretive communities (Metze & Dodge, 2016).

We study the shale gas controversy on the internet as the internet discloses online publics that are organized around a controversial issue and may affect the way it is being addressed (Marres & Rogers, 2005). Visualizations that are used by these online publics are part of a 'web sphere', an online space that is networked around an issue (see Rogers, 2013). This 'issue network', although virtual, is commonly territory-related, especially when controversial issues are debated (Rogers, 2013).

Yet, visualizations have the capacity to transcend geographic contexts and create a global community (Campbell, 2007), as the visualization of a flaming faucet did. This visualization, originally a frame from the documentary film *Gasland* that was produced in the United States, associated drinking water contamination with nearby hydraulic fracturing (also called fracking) (Mazur, 2016; Metze, 2017, 2018b). The visualization travelled from the United States to other countries, and accompanied by other visualizations that reproduced the scene from the film, created a global public of shale gas opponents (Mazur, 2016; Metze, 2018b). In this article, we use the notion of online publics to study discourse coalitions. Hence, the research question of this article is: How do visualizations influence dynamics within a discourse coalition and between competing discourse coalitions in the shale gas controversy?

We selected the web spheres associated with the Netherlands, New York State, and South Africa as sites for collecting data. We expected to detect similarities and differences in discourse coalitions in these three 'internet regions', as the three shale gas controversies introduce the common aforementioned competing framings but have also site-specific characteristics (see also below). A mixed collection of discourse coalitions enables a better understanding of the (online) global publics in the shale gas controversy and demonstrating the advantages of our framework in a compelling way.

The article first presents the conceptual framework. Second, it describes the methods used. Third, it presents empirical examples from our study to illustrate our framework. We end with a discussion and conclusions.

3.2 Conceptual framework: discourse coalitions and visualizations

The first question is: how do discourse coalitions and visualizations relate to each other? Our framework draws on work about discourse coalitions (Bulkeley, 2000; Feindt & Oels, 2005; Hajer, 1995) and the role of the visual in framing and politics (Bleiker, 2017, 2018; Clancy & Clancy, 2016; Doerr, 2017; Hendriks et al., 2017; Van Beek et al., 2020). We address policy controversies as struggles of competing discourse coalitions about the framing of a problem. Framing influences policy,

as defining the problem is also defining possible solutions (Feindt & Oels, 2005; Hajer, 1995, p. 83). Hence, competing discourse coalitions negotiate the framing of a policy issue and try to gain support and credibility for their discourse, or challenge other discourses, through the usage of storylines (Metze, 2017; Metze & Dodge, 2016). In answering the research questions, we want to better understand how visualizations contribute to this process in a particular way by producing a visual storyline, a narrative or a plot that is constructed through the use of visual techniques (such as zooming) and visual elements (such as flames) in a certain context (see, for example, Rose, 2001, p. 151). We are interested in studying the dynamics between the discursive storylines of discourse coalitions and the visual storylines they employ.

The role of visualizations in understanding a policy issue is acknowledged by scholars in communication and media (Domke et al., 2002; Messaris & Abraham, 2011; O'Neill, 2013; Powell et al., 2015), social movements (Doerr et al., 2015), political science (Grabe & Bucy, 2009), visual studies (Ludes et al., 2014; Mirzoeff, 1999) and policy (Jasanoff, 2004; Morseletto, 2017). The investigation of a visual object often starts with the type of visualization that proposes a set of 'rules' that defines the relationship between a visual and 'reality' (Hansen, 2011). Thus, for example, maps represent elements from reality differently than photographs do. Viewers are aware of these rules and expect different information from maps and from photographs. Also, the place where the visualization is used, like an informative page or an advertisement, raises expectations (Rose, 2001, pp. 80–81). The text accompanying the visualization is often an element that helps the viewer to identify the specific use and to form his expectations accordingly (Rose, 2001, p. 81). Because of this nature of visualizations, they can narrate, when used within a particular context, a visual storyline and can influence how we understand issues (Hendriks et al., 2017). As such, they have an effect on political mobilization (Doerr, 2017) and governance of policy controversies (Jasanoff, 2004).

Studying visualization can add an ocular dimension (see Green, 2010) to the dynamic discourse coalitions approach (see Metze & Dodge, 2016). The degree of coherence between visual storylines and discursive storylines may contribute to four forms of discourse coalition evolution: confirmation, disintegration; integration; polarization (see Figure 3.1).

1. A single discourse coalition may *confirm* its storyline through visualization. When confirmation occurs, a discourse coalition strengthens the interpretation of a policy issue. For example, the circulation of the known photograph[13] from the documentary film *Gasland* confirms a storyline of a discourse coalition on environmental risk: that of fracking posing a risk to drinking water (see also below).
2. A single discourse coalition may be *disintegrated* when visualization communicates multiple distinct visual storylines. For example, Uggla (2018) illustrates how using images in EU biodiversity policy brochures develops various, partly conflicting, themes (e.g. 'humans appreciate and are comforted by nature' and 'humans both use and destroy nature'). These various visual themes might contribute to the disintegration of a single discourse coalition that focuses on policy as a means to preserve biodiversity.
3. Multiple discourse coalitions may be *integrated* when visualization communicates a single visual storyline. For example, Doerr (2017) explores how far-right activists from different countries in Europe use cartoon images to create solidarity among publics from a spectrum of groups and countries. This might indicate the integration of different discourse coalitions.
4. Multiple discourse coalitions may be *polarized* when visualization communicates multiple visual storylines that are very different one from another. For example, Clancy and Clancy (2016) illustrate how the dissemination of images via the internet by GMO opponents contributed to a shift away from rationality in the GMO political debate. This might contribute to a polarization between two coalitions, pro- and anti-GMO, in the GMO debate.

13 In this article, we do not distinguish between a still camera and a motion picture camera, and we refer to the static images that are combined to create an illusion of motion, as photographs.

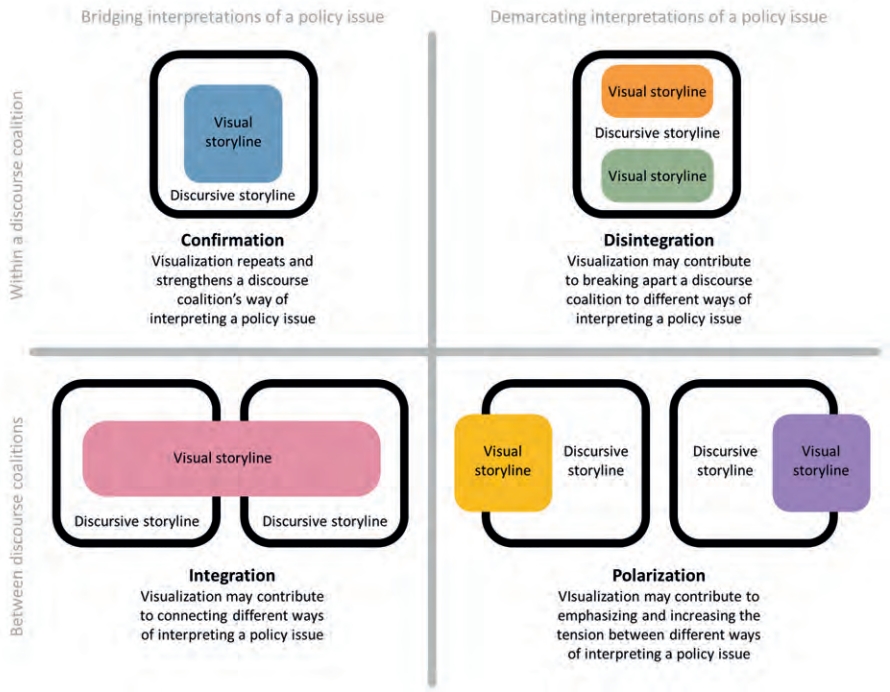

Figure 3.1. Four forms of discourse coalition evolution (adapted from Metze & Dodge, 2016).

3.3 Method of investigating the visual controversy

To explore how visualizations influence dynamics within a discourse coalition and between competing discourse coalitions in the shale gas controversy, we turned to the internet, as it is a source of studying society (Rogers, 2013) and a realm where controversial issues are debated (Marres & Rogers, 2005). We gathered data from webpages in the three selected internet regions. In the three regions, the two similar aforementioned discursive tensions are observed, one between the framing of shale gas as an economic opportunity and as an environmental risk, and another between the framing of shale gas as a transition fuel and as a delayer of the transition to renewables (De Wit, 2011; Dodge & Metze, 2017). However, in the literature, next to a similarity in mechanisms capable of influencing the dynamics of the controversy (see Metze & Dodge, 2016), notable regional differences are reported in the framing of the issue and the concerns about it; for example, in the USA the job-opportunity versus boom–bust economy framing was important (Dodge & Lee, 2017; Howell et al., 2017), in the Netherlands, 'business as usual' was a dominant frame when the controversy over shale gas arose (Metze, 2017), whereas, in South Africa, water shortages were a main environmental issue

(Andreasson, 2018). Hence, webpages from this range of internet regions gave us (a) a broad variety in discourse coalitions and (b) diversity in the visualizations used by actors. Webpages are an ideal data source for collecting visualizations in their discursive context as they very often consist of both text and visuals.

3.3.1 Data gathering

Two different search strategies were applied to ensure a comprehensive actor list composed of traditional political actors and digital actors. First, an actor analysis was conducted based on descriptions of the evolution of the controversy in academic papers (Andreasson, 2018; Bomberg, 2017a; Cuppen, Pesch, et al., 2016; Dodge & Lee, 2017; Finkeldey, 2018; Metze, 2017). Second, a range of digital methods and tools was used (Rogers, 2013).[14] These two strategies resulted in a list of 98 actors. We then used Google to locate each actor's website (URL).

From the list of websites, we identified webpages with text and visuals that their topic is hydraulic fracturing for shale gas extraction,[15] and we downloaded these webpages.[16] A total of 96 webpages and 205 visualizations on these websites were collected.

3.3.2 Data analysis

The downloaded in-text visualizations were coded in Atlas.ti software, that enables qualitative data analysis of both text and visual content. We first identified frames based on the text. Frames were coded deductively based on existing frame analyses of the shale gas controversy. We also identified themes in previous studies that have the potential to evolve into frames (candidate frames). Candidate frames that reflected 'repeated patterns of meaning' (Braun & Clarke, 2006, p. 86) were defined as frames.[17] An analysis was conducted of the discursive storylines composed of collections of frames. Actors with a similar discursive storyline form a discourse coalition.

14 We used the digital snowballing technique (Rogers, 2013, p. 23) to find internet actors. We used Google scraper with the keywords 'shale gas', 'hydraulic fracturing', and 'fracking' (search terms based on previous studies, see Finkeldey, 2018; Hopke & Simis, 2017; Stoutenborough et al., 2016) to identify the top-ranked URLs discussing shale gas in each internet region according to Google PageRank metrics. These page-rank metrics indicate the most popular online voices. We extracted actors' names (manually and with the help of Aylien Text Analysis API tool) from the results.

15 We used the menu of the website, and when that did not lead to any results we used Google search within a domain with the same keywords that were used to identify actors.

16 We excluded advertisements and other unrelated content on the websites.

17 Frame codes were: Bridge fuel or cleaner energy source (Bomberg, 2017a; Metze, 2017), David v Goliath (Bomberg, 2017a), Delay transition to sustainable energy (Metze, 2017), Drop in the ocean (Metze, 2017), Economic opportunity (Bomberg, 2017a; Dodge & Lee, 2017), Environmental/health risks (Bomberg, 2017a; Dodge & Lee, 2017; Metze, 2017), Geopolitics (Bomberg, 2017a; Cuppen, Pesch, et al., 2016; Dodge & Lee, 2017), Known risks (Weible et al., 2016), Landowner rights (Dodge, 2015; Dodge & Lee, 2017), Technique is safe and nothing new (Metze, 2017), Water scarcity (Andreasson, 2018; Atkinson, 2018).

The next step was to conduct a visual analysis: in each visualization, we identified the type of visualization, for example, map, photograph, diagram, infographic, cartoon. In addition, we used a visual content analysis (Bell, 2001; Rose, 2001) to code what the visualization depicts, for example, natural landscape, industrial site, people, words. We then used the type and content to identify similar visualizations. Finally, in those similar visualizations, we coded the visual storyline by performing a detailed analysis of the key themes and the particular way they are represented in (Rose, 2001, pp. 151–158).

3.4 Empirical examples: visual storylines

To show a possible interplay between the visual and textual storylines and to be able to make 'grounded' claims (meaning, claims that are associated with the controversy in the three locations, see Rogers, 2013), we selected as empirical examples three types of visualization: photographs, maps, and infographics. We ensured that these types of visualization, which occur the most in our dataset, are evenly distributed over the three internet regions. While photographs suggest a seemingly authentic representation of reality, maps and infographics are two types of data visualizations designed to communicate data in a more graphic and easily accessible way. We selected those cases that we believe illustrate in the most interesting way the four dynamics between the discursive storyline and the visual storyline discourse coalitions employ.

3.4.1 Confirmation of one discourse coalition: the example of photographs of flames in the NY controversy

In the NY shale gas controversy, previous research identified the environmental threat discourse coalition (Dodge & Lee, 2017). Actors belonging to this coalition – environmental organizations, members of the public, public officials, and lawmakers – use a discursive storyline that focuses on the undesirable environmental impacts of fracking by casting doubt on existing knowledge and the preparedness of institutions (Dodge & Lee, 2017, p. 21).

Two actors in this coalition, the Natural Resources Defense Council (NRDC) and Sierra Club, both use photographs of flames. NRDC uses a photograph of someone who ignites a flame from a flow of water on the ground and narrates a storyline of

risk to our water sources (see Figure 3.2(a)[18]); Sierra Club's photograph depicts the burning of natural gas from a well near a cornfield and narrates a storyline of risk to agricultural yield (see Figure 3.2(b)[19]).

(a)

(b)

18 See https://www.nrdc.org/stories/delaware-river-basin-partial-fracking-ban-partial-victory. For an archived copy of the webpage visit https://web.archive.org/web/20200718075153/https://www.nrdc.org/stories/delaware-river-basin-partial-fracking-ban-partial-victory.

19 For an archived copy of the webpage visit https://web.archive.org/web/20200818095925/https://www.sierraclub.org/sierra/green-life/life-not-pretty-picture-fracking-epicenter-photography-people.

(c)

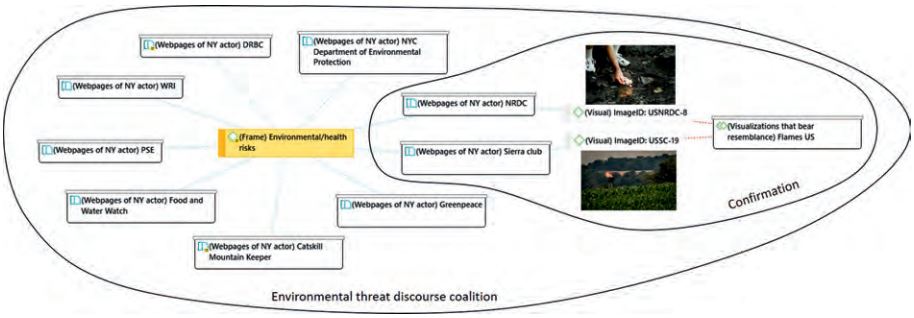

Figure 3.2. (a) NRDC photograph of David Headley igniting a flow of water, shot by director Joshua B. Pribanic of Public Herald Studios for the documentary Triple Divide, licensed under CC BY-NC-ND 2.0 , source: https://tripledividefilm.org. (b) Sierra Club photograph of a gas flare, shot by Karen Kasmauski, source: https://www.sierraclub.org/sierra/green-life/life-not-pretty-picture-fracking-epicenter-photography-people. (c) Discourse coalition and visualizations depicting flames in the NY controversy.

By narrating a storyline of environmental risk in both photographs, these actors contribute to the confirmation of the environmental threat discourse coalition (see Figure 3.2(c)). The risk storyline, which is also part of the textual narrative accompanying the visualizations, is narrated through the photographs in two distinct ways. NRDC narrates a risk storyline by strengthening a connection that has already been made between a threat to drinking water and fracking. Sierra Club narrates a risk storyline by visually focusing on the proximity of an existing well fire to a cornfield. By using photographs that depict flames, members of the coalition repeat the narrative of environmental risk and thus confirm their discourse coalition's discursive storyline.

3.4.2 Disintegration of one discourse coalition: the example of maps in the SA controversy

In the SA controversy, an agnotological coalition can be identified. The name refers to what Proctor (2008) calls agnotology – the production of ignorance, for instance by the publication of inaccurate or misleading data. Actors belonging to this coalition use a discursive storyline that focuses on the unknowns with regard to the technology and claim that more research is needed in the SA context in order to drill for shale gas safely. They do so by utilizing frames that reflect contradicting normative standpoints: the pro-frames – economic opportunity and geopolitics – according to which shale gas provides energy security and/or independence from other countries (see, for example, Andreasson, 2018; Ingle & Atkinson, 2015), and

the anti-frame –environmental/health risks. The Department of Mineral Resources (DMR), a governmental actor, and the Council for Geoscience (CGS), a national science council, are members of the agnotological discourse coalition.

The two actors use similar data visualizations: maps. Such maps have often been used in the shale gas controversy (Metze, 2018b) to communicate (seemingly) neutral information. These maps show the geological underground of the Karoo (see https://www.dmr.gov.za/mineral-policy-promotion/shale-gas[20] and Figure 3.3(a)[21]). However, the CGS adds an area in light blue that represents suggestions about 'sweet spots',[22] the best places for shale gas exploration.

The two maps – one without and one with sweet spots – communicate two different visual storylines. According to the DMR's map, data show that there are geological potentials for shale gas retrieval, with no indication of whether this indeed should be done. The CGS communicates, using the map, data relevant to a successful shale gas retrieval. Two actors belonging to the same discourse coalition use visualizations based on different knowledge bases, thereby leading to different visual storylines and potentially contributing to discourse coalition disintegration (see Figure 3.3(b)).

The fact that the visualizations of the DMR and the CGS are allegedly the same, but actually relate to two ways of interpreting reality, echoes the ambiguity in the way the DMR is acting in the context of SA's shale gas development. According to Atkinson (2018), the DMR is supposed to collaborate with local offices in the provinces but in reality, its approach is rather central. This vague stance might cause the DMR's position within its discourse coalition to be indefinite and the coalition to be less coherent. Visualizations – this example shows – are an important indicator of this lack of coherence within a discourse coalition.

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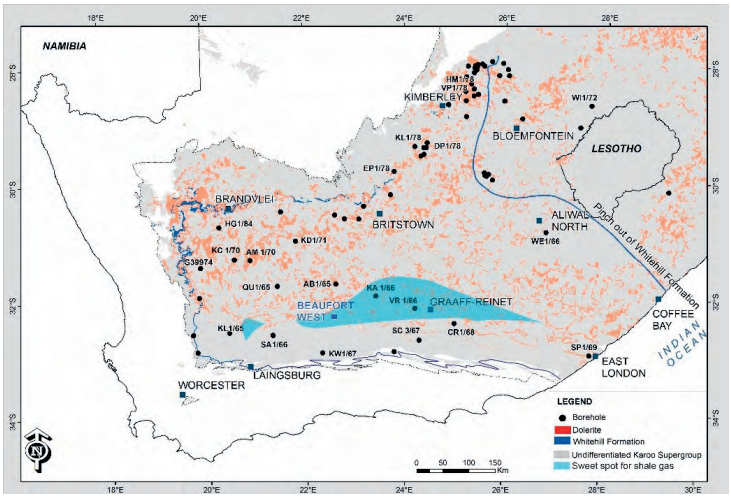
20 For an archived copy of the webpage visit
https://web.archive.org/web/20200614062027/http://www.dmr.gov.za/mineral-policy-promotion/shale-gas.

21 See http://www.geoscience.org.za/index.php/key-projects/754-the-karoo-deep-drilling-project. For an archived copy of the webpage visit
https://web.archive.org/web/20200820185037/https://www.geoscience.org.za/index.php/key-projects/754-the-karoo-deep-drilling-project.

22 According to Schlumberger's Oilfield Glossary, sweet spot is 'a target location or area within a play or a reservoir that represents the best production or potential production [of shale gas]' (https://www.glossary.oilfield.slb.com/en/Terms/s/sweet_spot.aspx, accessed 6 September 2019).

(a)



(b)

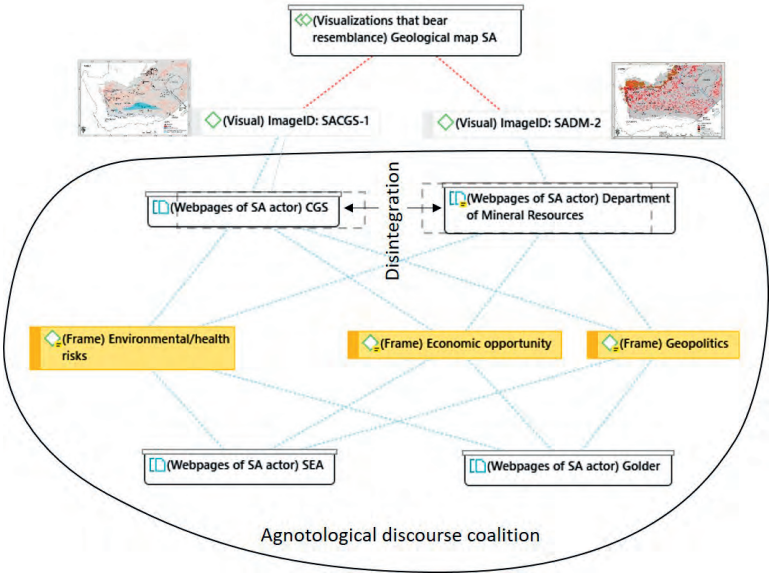


Figure 3.3. (a) CGS map showing the area earmarked as the shale gas sweet spot in Beaufort West, which is a chosen site for the Karoo Deep Drilling Program, source: the Council for Geoscience. (b) Discourse coalition and visualizations depicting maps with geological information in SA.

3.4.3 Integration of two discourse coalitions: the example of landscape photographs in the SA controversy

In the SA controversy, we examined two discourse coalitions: the abovementioned agnotological coalition and the environmental risk coalition. The latter focuses on the potential risks that fracking poses to communities and to the environment,

given the unique characteristics of the Karoo basin (Atkinson, 2018; De Wit, 2011; Tucker & van Tonder, 2015). In our study, we identified three NGOs that belong to this coalition, and this example focuses on one of them: the Treasure Karoo Action Group (TKAG), which aims 'to ensure awareness, advocacy, accountability and fair decision-making around the issue of shale gas mining in South Africa'.[23] The TKAG was the first sign of civil opposition to shale gas and succeeded in mobilizing publics shortly after it was launched (Ingle & Atkinson, 2015, p. 540).

Another member of the agnotological coalition is a team of science councils who is working on a Strategic Environmental Assessment (SEA) for Shale Gas Development. This team consists of members of three science councils (one of them is the aforementioned CGS). The commission was launched in May 2015 by the Minister of Environmental Affairs, joined by other relevant authorities. The project aim was to deliver a scientific assessment of the Karoo region and to use the assessment as the evidence base from which to develop appropriate decision making.[24]

The two discourse coalitions – environmental risk and agnotological – have different discursive storylines, one that focuses on the potential risks to communities and to the environment and another that focuses on the unknowns and claims that more research is needed. However, they communicate a shared visual storyline by using a photograph depicting a water pumping mill, also called a wind pump or steel flowers[25] (see Figure 3.4(a), https://www.treasurethekaroo.co.za[26], and http://seasgd.csir.co.za[27]). This mill symbolizes the identity of the Karoo, and it narrates how locals produce energy to pump up water in this dry area (Jorritsma, 2012; Marais, 2013).

23 Source: https://www.treasurethekaroo.co.za/about, accessed 19 February 2020.
24 Source: http://seasgd.csir.co.za/12-may-2015-project-launc, accessed 19 February 2020.
25 See for example http://karoospace.co.za/windmills-windpumps-or-windpompe, accessed 12 February 2020.
26 For an archived copy of the webpage visit https://web.archive.org/web/20190921084552/https://www.treasurethekaroo.co.za.
27 For an archived copy of the webpage visit https://web.archive.org/web/20200721221919/http://seasgd.csir.co.za.

(a)

(b)

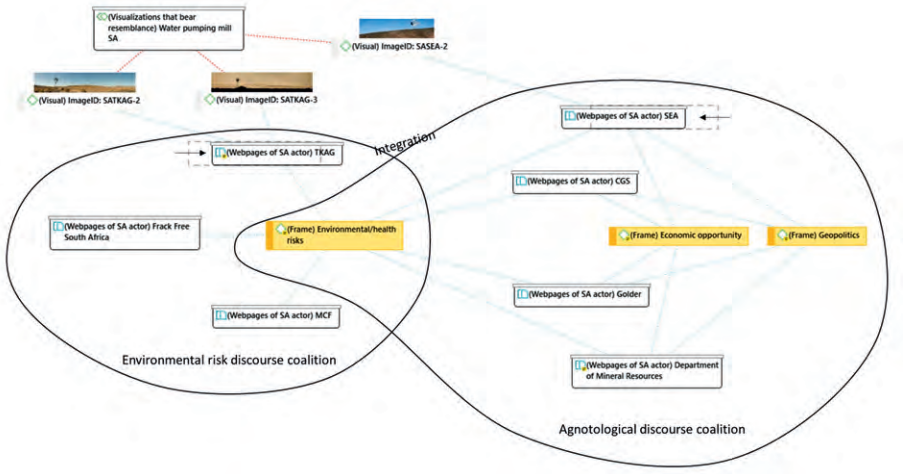


Figure 3.4. (a) Water pumping mill, source: Pxfuel. (b) Discourse coalitions and photographs of wind pumps in the South African controversy.

The use of this similar photograph of the Karoo wind pump narrates the story of energy-independent and dry Karoo. This shared visual storyline might contribute to an integration of two discourse coalitions – environmental risk and agnotological (see Figure 3.4(b)). The textual analysis on the TKAG's webpage supports this finding: the text declares that the TKAG 'stand(s) in opposition to the licencing of shale gas exploration'.[28] Yet, it implies that the TKAG supports the SEA project, perhaps in the hope that it will provide proof that drilling for shale gas is harmful to the environment in the Karoo context.

28 Source: https://www.treasurethekaroo.co.za, accessed 19 February 2020.

3.4.4 Polarization of two discourse coalition

Among the examples that we chose to illustrate how visualization contributes to discourse coalition dynamics, we have three of possible polarization.

Example 1: infographics in the NY controversy

The first example compares two competing discourse coalitions in the NY controversy: the environmental threat discourse coalition (see section 3.4.1) and the gas rush discourse coalition. The latter frames fracking as an economic opportunity for landlords and local governments and consists of oil and gas industry representatives, the staff of the Department of Environmental Conservation in the Division of Mineral Resources, representatives of the Chemung and New York Farm Bureau, landowners, and local officials (Dodge & Lee, 2017, pp. 19–20).

Three actors belonging to these conflicting discourse coalitions depict similar infographics that describe a well construction. One actor is the New York State Water Resources Institute (NYSWRI), which belongs to the environmental threat discourse coalition. From the gas rush discourse coalition, we have the energy company Hess and Marcellus Shale Coalition (MSC) – a coalition that promotes shale gas production in the US.

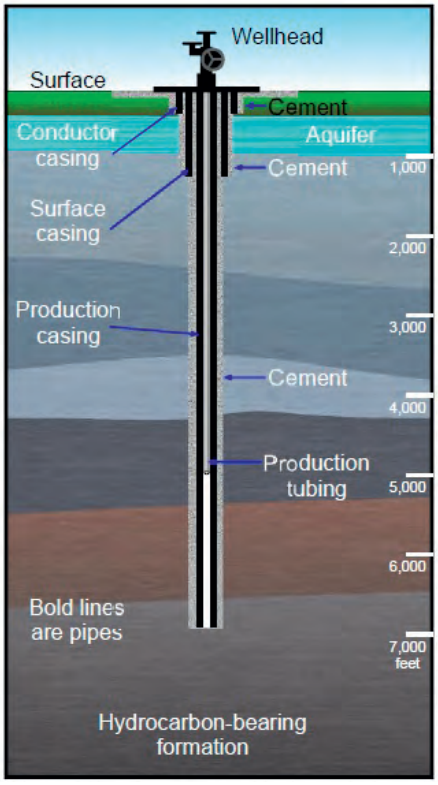
The Hess and the MSC infographics depict the drilling technique. In the visualizations and the accompanying text, the two actors narrate about the safety of the technique and visually showthemultiple casing that makes a shale well safe (see https://www.hess.com/sustainability/environment/shale-energy[29] and https://marcelluscoalition.org/marcellus-shale/production-processes/casing-the-well[30]). By contrast, the NYSWRI infographic shows the multiple casing in context and as part of a complete well, including the subterranean layers through which it drills and the formation that it aims to reach (the hydrocarbon-bearing formation) (see Figure 3.5(a)[31]).

29 For an archived copy of the webpage visit https://web.archive.org/web/20200820185737/https://www.hess.com/sustainability/environment/shale-energy.

30 For an archived copy of the webpage visit https://web.archive.org/web/20200708025845/https://marcelluscoalition.org/marcellus-shale/production-processes/casing-the-well.

31 See https://wri.cals.cornell.edu/research-topics/shale-gas/groundwater-impacts. For an archived copy of the webpage visit https://web.archive.org/web/20190614151951/https://wri.cals.cornell.edu/research-topics/shale-gas/groundwater-impacts.

(a)



(b)

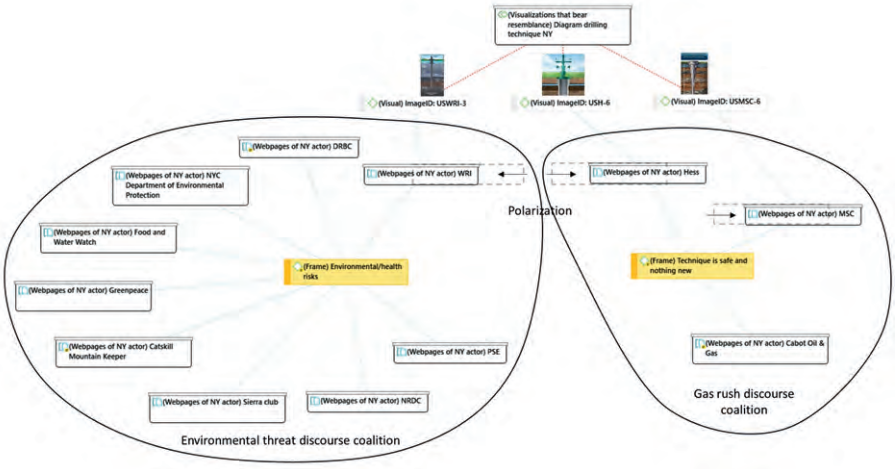


Figure 3.5. (a) NYSWRI's infographic of a drilling well, source: the United States Environmental Protection Agency. (b) Discourse coalitions and visualizations depicting hydraulic fracturing well in infographics in the NY controversy.

The impact of the visual technique of zooming out is twofold: first, it is showing more details about the subject (a well); second, it is informing the audience about the bigger picture, the broader context within which the subject is being used. Zooming out offers the viewer a particular viewing position and is a distinct and powerful visualizing technique (Rose, 2001, pp. 40–44). Through the use of this visual technique, differences between the discursive storylines of the two discourse coalitions are emphasized in the visual storyline; this may contribute to the polarization of the two discourse coalitions (see Figure 3.5(b)).

Example 2: photographs in the Dutch controversy

The second example of discourse coalition polarization comes from the Dutch controversy. We examined two discourse coalitions with conflicting discursive storylines: business-as-usual and environmental risk. While the business-as-usual coalition frames fracking as an economic opportunity, given the long Dutch experience of producing and relying on natural gas, the environmental risk coalition expresses concerns about the negative environmental impact of fracking, mainly based on academic reports and incidents (Metze, 2017).

The actor Cuadrilla Resources, a gas company that received a local permit to test drilling for shale gas, belongs to the business-as-usual discourse coalition, which consists of mainly gas companies, national and local governmental actors, and experts (Metze, 2017, p. 42). The actor Schaliegasvrij Nederland (Shale GasFree Netherlands, an NGO that opposes fracking), belongs to the environmental risk discourse coalition which consists of mainly activists, politicians, and journalists (Metze, 2017, p. 43).

Both actors use in their websites photographs of flames. Schaliegasvrij Nederland uses the well-known photograph of a flaming faucet from *Gasland* (see the second banner image of the website https://www.schaliegasvrij.nl[32]). This photograph goes beyond the simple depiction of what is photographed. It also communicates something intangible and experiential we cannot really see (see Mirzoeff, 1999, p. 5), namely the sensation of risk. It does so by depicting a particular image of flames: big yellow flames in a place where they do not belong. By contrast, Cuadrilla uses a photograph of a gas used for cooking and narrates a different storyline: one of a Dutch routine activity (see https://web.archive.org/web/20161109215926/http://www.cuadrillaresources.nl/boren-naar-schaliegas/film-gasland[33]).

32 For an archived copy of the webpage visit https://web.archive.org/web/20191203151433/https://www.schaliegasvrij.nl.

33 Cuadrilla's Dutch site (www.cuadrillaresources.nl) was accessed in December 2018. The site is no longer available.

The flames depicted in the Caudrilla photograph are coming from an object from which they are supposed to come – a cooking stove (see Figure 3.6(a)). This perhaps also narrates the necessity of having gas and the casual way in which we use flammable gas in our homes.

The two very different visual storylines, of risk and of a routine activity, stand out, given that they both use the same visual element – flames. The unique use of this visual element emphasizes the distance between different ways of interpreting the policy issue. Thus, the visual storyline increases the tension between the two discourse coalitions and may contribute to polarization (see Figure 3.6(b)).

(a)

(b)

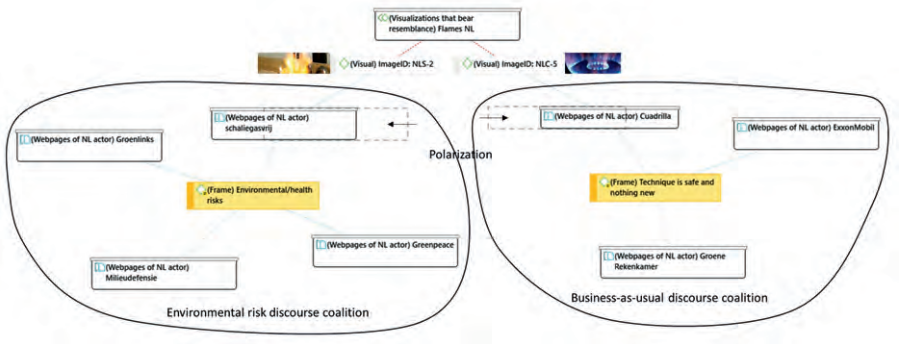


Figure 3.6. (a) Cooking stove flame, source: Pxfuel. (b) Discourse coalitions and photographs depicting flames in the Dutch controversy.

Example 3: use of maps in the Dutch controversy

A last example of polarization also comes from the Dutch controversy. Two discourse coalitions that we examined in this example are the environmental risk coalition and a coalition for which we borrow the term 'agnotological'. Similar

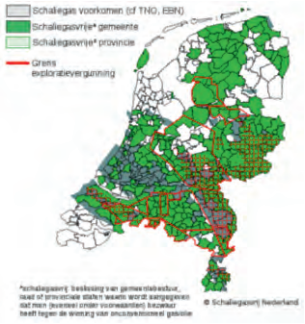
to the SA agnotological discourse coalition, the discursive storyline of the latter coalition reflects a balanced way of interpreting the shale gas issue. It does so by utilizing contradicting normative frames: in this case, the pro-frame – bridge fuel or cleaner energy source – according to which shale gas is relatively 'clean' and therefore a step toward a more sustainable energy future, and the anti-frame – environmental/health risks. From the actors belonging to this coalition, we focus in this example on RIVM, the National Research Institute for Public Health and the Environment.

The actor RIVM from the agnotological discourse coalition and the aforementioned actor Schaliegasvrij Nederland from the environmental risk discourse coalition use maps of shale gas reserves in the Netherlands (see Figure 3.7(a,b)). RIVM uses a map made by TNO, the Netherlands Organisation for Applied Scientific Research. This map shows the geological layers where shale gas may be found in the Netherlands. Schaliegasvrij Nederland uses a similar map. However, on top of the layer showing potential shale gas reserves (in grey), it adds information about the areas in which exploration permits were issued (marked with a red line) and communities that declared themselves shale gas free (in green).

The two Dutch actors communicate two different visual storylines through using these maps. RIVM narrates a storyline of potential, either for an economically prosperous future for the Netherlands or for a future of energy security (or both). Interestingly, the text adjacent to the map points out uncertainties involved in exploiting the potential. But while this text, together with the map, communicates a balanced way of interpreting the shale gas issue, the visual narrates a promise. The other actor, Schaliegasvrij Nederland, narrates a different storyline. By showing three layers of information – the geological data, the drilling permits, and the opposition to shale gas – it narrates a complete story of geological potential, a legal act that follows it, and opposition to this legal act (see also Metze, 2018b). Among these three layers, the visually most distinct one is of the communities that declared themselves shale gas free, making opposition the most dominant narrative of the map.

(a)

(b)



(c)

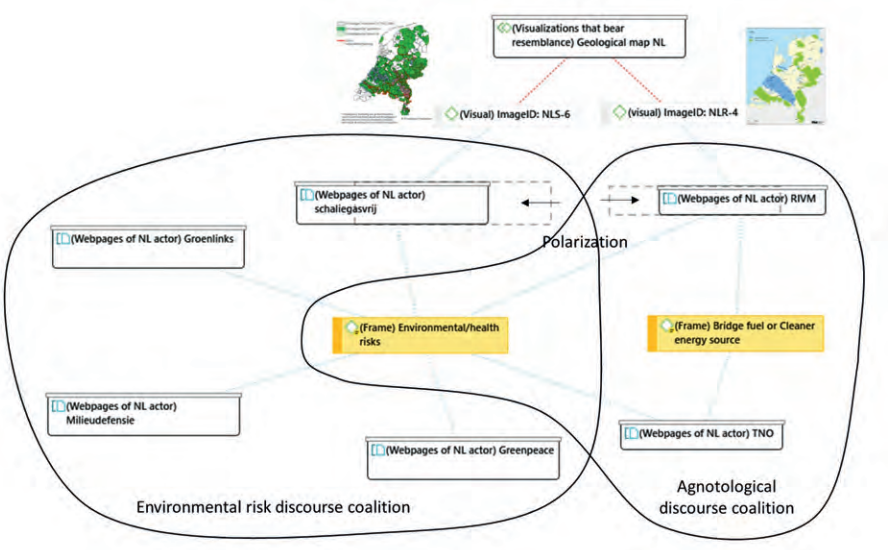


Figure 3.7. (a) RIVM map of shale gas reserves in the Netherlands, source: https://www.rivm.nl/schaliegas/schaliegas-en-winning (b) Schaliegasvrij map of shale gas reserves in the Netherlands and provinces and municipalities that have declared themselves shale gas free, source: https://www.schaliegasvrij.nl (c) Discourse coalitions and maps about shale gas in the Netherlands.

RIVM and Schaliegasvrij Nederland use similar visualizations. Yet, by narrating two conflicting storylines through these visualizations – one of potential, the other of opposition – the two actors are positioned at a distance from each other (see Figure 3.7(c)). This repositioning of actors within their discourse coalition may

contribute to polarization between the two coalitions and to increasing the tension between them.

3.5 Discussion of the visual storylines

The visual and the quality of seeing have been used as a means of engaging in a democracy as noticed, for example, in Rosanvallon's (2008) notion of counter-democracy, Keane's (2009) monitory democracy, and Green's (2010) ocular democracy. These writers emphasize the role of the eye in supervising political acts of governments and other actors. Green (2010), specifically, assigns great importance to the visibility of unplanned occurrences that constitute a politician's everyday life. According to him, these unpredictable events and their uncontrolled visuality are inherently part of politics (Green, 2010, p. 20). What does the study of the degree of coherence between discursive and visual storylines contribute to this notion? The practice of visualizing by a discourse coalition makes the discursive storyline – the collection of ideas, verbal statements, and storylines – visible, perhaps in the same way that spontaneous events reveal something about political leaders. A high degree of coherence between the visual and the discursive storylines, especially when visualizing done unthinkingly, might reflect sincerity and honesty – 'candor', in Green's (2010) words. These qualities are valuable in policy controversies in a democratic society.

Our analysis shows that visual and discursive storylines can create a coherent whole. When this happens within a discourse coalition, actors that use the visual narrative form a visual discourse coalition (VDC), a network of actors that share a similar discursive storyline *and* a similar visual storyline of the controversy. Actors belonging to the same VDC interpret reality in a shared way and may also be connected to one another through shared associations – because visuals have a unique quality of relying on their audience's associative world in their reasoning (Clancy & Clancy, 2016). Thus, in the flammable faucet example, an association between yellow flames coming from a drinking water tap and risk is needed to strengthen a storyline of environmental risk.

Another quality of visualizations stands out due to the fact that they seemingly offer evidence of something that is currently happening or has happened in the past

(Hansen, 2011). Thus, the maps of areas where shale gas could be retrieved suggest some form of ocular proof. At the same time, our map examples show how visual supplements can offer proof of different types of truths which are dependent on interpretation – both of the visualization and of the reality it represents. This makes visualizations a particular type of boundary object (see also An & Powe, 2015; Metze, 2010, 2020; Morseletto, 2017, p. 41). Their evidential nature and their multi-interpretability make them objects that are 'weakly structured in common use, and become strongly structured in individual use' (Star & Griesemer, 1989, p. 393). Our study adds to the study of the concept of boundary object by investigating it in a situation of conflict. As an exploratory study, it lays the foundation for future work that will investigate different meanings that actors assign to a visualization while engaging with it as producers or as viewers.

Discerning the type of visualization may lead to new insights about the contribution of visualizations to the evolution of discourse coalitions. Our empirical examples suggest that photographs and data visualizations (maps, infographics) produce a visual narrative in different ways. Photographs overtly narrate a storyline (of risk or of energy independence in a dry area), whereas data visualizations narrate a storyline more subtly. A careful look at the data visualizations is needed to decode their visual storylines and to reveal differences between them – perhaps because data visualizations commonly represent reality in a more abstract way than photographs. Moreover, in our empirical examples, differences between visual narratives in maps and in infographics are caused by different visual techniques: maps differentiate between two storylines by adding a layer of data; infographics do that by using the technique of zooming out. The zooming technique is acknowledged also in the literature (Schneider & Walsh, 2019) as a means of materializing a politically problematic issue. Further research is needed to better understand the role of the types (infographics, photographs, maps, and so on) of visualizations and their specific characteristics in discourse formation.

Our approach attends to the role visualizations play in creating online publics. Because of their unique characteristics and the affordance of the internet (see Rogers, 2013), online visualizations are capable of mobilizing publics and creating a global community. However, visualizations considered as 'global' to some audiences might narrate a different story to other audiences, as shown by Jasanoff (2004). In addition, studies that use the internet as a source often consider the

online space that is networked around an issue as a locative and demarcated space (Rogers, 2013). Our study uses the notion of differences in interpretations among audiences as a starting point. It does so by selecting different internet regions for studying visualizations employed by discourse coalitions. And indeed, in some of our empirical examples, the analysis reveals a distinct 'local' visual storyline such as an identity of an area or a routine activity. By remaining alert to a possible emergence of both domestic and global storylines, we contribute to a more nuanced understanding of the organization of publics around a controversial issue.

3.6 Conclusion

Visualizations play various roles in discourse coalition formation. Although our approach does not try to detect causal relations between the use of visualizations and the dynamic evolution of discourse coalitions, it does allow for the study of the delicate interplay between visual and textual storylines and reveals how and when visual and discursive storylines overlap and a VDC is formed. The analysis utilizes visual data to contribute to the understanding of the mechanisms shaping policy controversies and the emergence of publics and issues in them. These emerging publics are increasingly important in the governance of controversies. This study also responds to the call for increased attention to the effects framing of an issue has on the organization of publics (Marres & Rogers, 2005; Van Beek et al., 2020), as it casts light on non-linguistic elements that may influence the dynamics of framing and the establishment of discourses.

The VDC concept opens up new ways of research as it integrates discourse analysis with visual analysis. The added visual dimension is not just an extra layer that gets draped over the controversies. By deploying the notion of VDCs and detecting the visual relations in the formation of discourse networks, it becomes possible to identify the visual formation of various coalitions, such as the environmental threat, agnotological, gas rush, business-as-usual, and environmental risk coalitions.

CHAPTER 4

Visual and Textual Framing by Coalitions in a Policy Controversy

Efrat Gommeh, Karin Schroën, Tamara Metze

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Abstract

The framing of processed foods by groups of positive, negative or balanced online actors expresses the public mood about processed food and at the same time influences public views and policy. In this paper, we studied the framing of processed food by *online sentiment coalitions* – groups of online actors that are united by their positive, negative, or balanced stance towards processed food. We innovatively integrated digital methods with textual and visual analyses of 164 webpages and 344 online visualizations published by a total of 89 actors, such as academics, food technologists, journalists, governmental actors, NGOs, industry actors, nutrition specialists. The analysis shows that the online "dream" coalition of processed food framed it in a way to convey the human aspects of food processing: processed food is understood as a way to improve human lives, and photographs of industrially processed food produced by humans show it is not as industrialized as often thought of. The online "nightmare" coalition of processed food framed it primarily as posing health threats and accompanied this with photographs of unhealthy but colourful foods. The balanced coalition gave a balanced description of the benefits and drawbacks of processed food and accompanied this frame with photographs emphasizing the difficulty in making food choices. Extending the knowledge about the ways sentiments about processed food are communicated online is essential as it provides important insights into people's understanding of the notion of "processed food" and the meaning that is given to it by various online interpretive communities.

4.1 Introduction

In everyday talk, "processed food" often has a negative connotation: it is associated with salty, unhealthy, industrially manufactured foods that in the academic literature would be classified as ultra-processed foods (see Text box 1 for explanation). Very often processed foods are opposed to "natural" or "clean" foods (Baker & Walsh, 2020; "clean" food is "unprocessed food considered to be as close to its whole form and natural state as possible", Lupton, 2018, p. 71). However, preparing and cooking foods in our own kitchens – cutting, heating, adding sugar and salt, turning into a puree – is also food processing. Despite this imprecise use of the term processed food in everyday speak, these discursive and visual (mis) representations of processed food in media and new-media are interesting to study as they depict how an online general public is interpreting processed foods. In addition, since the internet is an important source of information for the general public, these (mis)representations are influential on public opinion formation and even political decision-making (Clancy & Clancy, 2016; Rojas-Padilla et al., 2022).

The rapidly growing popularity of food on digital platforms (de Solier, 2018; Lewis, 2018; Lupton, 2020) turned these platforms into key spaces to discuss food-related issues, to the extent that "thinking about food through digitized media has become mainstream" (Rousseau, 2012, p. 92). Digitized information about food is accessed through internet search engines (Lupton, 2018), which present information provided by various actors such as nutrition specialists, policymakers, academics, industry, bloggers, and NGOs. These actors share knowledge and also manifest their views, sometimes by disclosing (visual) information that otherwise remains hidden or inaccessible (Schneider et al., 2018). Online, visualizations are used extensively to represent food (Lupton, 2020); producing visualizations or engaging with them is everyday practice (Lewis, 2018). Online visualizations communicate meanings about food-related issues and may enhance or limit the credibility of the information given about food (Baker & Walsh, 2020).

Text box 1. Processed food: Purposes and Definitions

The availability of sufficient and healthy food has been an issue ever since people started walking the face of the earth. Primitive methods of food processing were necessary, in prehistoric times, for the survival of humans. Later, when humankind has systematically been able to breed improved versions of grains and to farm animals, maintaining the quality of the obtained foods has been an uphill struggle dealt with by applying primary storage methods but also processing techniques such as drying, salting, and fermenting. Food processing allowed to build supplies that sometimes – quite literally – carried communities through the harsh winter. In current times, food processing is much more diverse and industrialized and has become a major market sector that serves various purposes such as extending shelf life, improving nutritional value and safety, and increasing convenience and palatability (Huebbe & Rimbach, 2020). However, the highly mechanized and less traditional manufacturing processes have created a sense of ambivalence towards foods produced in a factory. Complicated facts about foods, which change over time, and the enormous complexity of the food production and consumptions system contribute even more confusion and scepticism to this bewildering situation. In 2009, a group of nutrition and health researchers at the University of São Paulo proposed a new way of categorizing foods that is based on the extent and purpose of the processing and coined a new food category of ultra-processed food (Fraanje & Garnett, 2019). Next to subsequent study that used this categorization system and associated the consumption of ultra-processed foods with chronic non-communicable diseases (e.g., Marrón-Ponce et al., 2019; Martínez Steele et al., 2019), the classification system was also criticized for being impossible to use (Gibney et al., 2017), and there is an ongoing scholarly debate about whether the type and level of processing should be considered as a criterion for food classification and replace a more traditional food categorization that is based on nutrient value and food components (Eicher-miller et al., 2012; Jones, 2019; Poti et al., 2015). Among scientists that categorize foods based on the level of processing, there is no widely accepted categories and definitions, and there are discrepancies between various classification systems (Bleiweiss-Sande et al., 2019). Yoghurt can serve as an example. It is considered unprocessed or minimally processed, according to NOVA classification system (Monteiro et al., 2019); it is considered basic processed, according to a classification system of researchers from University of North Carolina at Chapel Hill (this classification system also has an "unprocessed/minimally processed" food category, Poti et al., 2015); it is considered ready-to-eat, according to the International Food Information Council (IFIC, 2010). In everyday talk the term "processed food" refers to foods belonging to the higher processing-level categories in the various classification systems: those foods that are mass-produced, contain industrially formulated mixtures, and few 'natural' ingredients, e.g. 'ready-to-eat processed foods', 'prepared foods/meals' (Eicher-miller et al., 2012), 'ultra-processed food' (Monteiro et al., 2019), 'highly processed food' (Poti et al., 2015).

However, (visual) information shared on the internet not only gives insights into how a digital public understands food issues but also influences the way people think about food and discuss it (Lupton, 2018). Visual and textual information spread in the digital world shapes public views (Clancy & Clancy, 2016) and policies (Metze, 2020; Wozniak et al., 2017). This digital world is often seen as experimental (Marres, 2017, p. 147), where the boundaries between experts and laypeople are re-defined (Lupton, 2018; Rousseau, 2012), and information is heavily mediated by algorithms (Lewis, 2018; Rogers, 2019). Hence, the diverse interpretations of food online may not only represent expert knowledge and the exiting digital cultures of processed food but it can also affect the societal debate about it, which is related to decision-making, as happened, for example, in the case of genetically modified organisms (GMOs) and other food-related issues (De Cock et al., 2016; Inghelbrecht et al., 2014).

Although framing in text and visuals in newspapers and new media is recognized as influential in various academic studies (Krause & Bucy, 2018; O'Neill, 2013; Redden, 2011), actors' sentiments in combination with these visual and textual framing has not received much scholarly attention. To fill this gap, this paper sets out to further develop the notion of *online sentiment coalition* – a group of actors that predominantly express positive, negative, or balanced sentiment about an issue on their websites – and examines the particular ways in which they frame processed food. This will provide insights into people's understanding of the notion of "processed food" and the meaning that is given to it by various online interpretive communities (see Yanow, 2000).

The research question in this paper is: how do online sentiment coalitions visually and textually frame processed food? To answer this question, we studied (1) which online actors belong to which sentiment coalitions and (2) what discursive and visual framings they use.

4.2 Conceptual framework: Online sentiment coalitions and their textual and visual framing

Inspired by automated sentiment analysis, we categorize online publics (Marres & Rogers, 2005) that form around processed food in three groups: those that express

and share predominantly positive sentiment, negative sentiment, and a more balanced sentiment about processed food. In automated sentiment analysis, sentiments are typically classified as positive (pro-), negative (anti-), or neutral (Kwak & Grable, 2021; Yigitcanlar et al., 2020), and emotion in text is recognized based on positive or negative words (Cambria et al., 2017). Hence, in automated sentiment analysis, a binary classification of emotions is used, which is different from affective analysis that labels a set of emotions. In framing analysis, this binary approach is referred to as **tone-of-voice** which indicates a positive, negative, or neutral stance in media reporting on particular issues (e.g., Baumgartner et al., 2008; Kuttschreuter et al., 2011). In this study, we follow this binary division and study what groups of actors are present on the internet, based on their discursively expressed positive and negative stances towards processed food. As such, we are interested in *online sentiment coalitions* that we labelled "a dream" (positive), "a nightmare" (negative), and a balanced coalition.

Next to their discursively expressed sentiments, these groups of actors can also frame processed food in different ways. Framing can take place discursively but also visually. Framing is a process in which some aspects of reality are selected and given greater emphasis or importance so that the problem is defined, its causes are diagnosed, moral judgements are suggested, and appropriate solutions and actions are proposed (Entman, 1993, p. 52). Stemming from semiotics from Saussure, both discursive and visual framing can take place by use of *denotive signs and connotive signs* (Saussure in Richter, 1998). Denotive signs are those that try and name or depict reality. For example, the word rose is referring to the flower, or a picture of a rose can depict this particular flower. The denotive signs can be studied through content analysis: one can, for example, identify what a word is referring to or what is in the picture: a person, an animal, industry, a landscape, and that refers to a "real" thing (a person, an animal, etc.; Rose, 2016, p. 121). There is, however, a second layer of meaning: the meaning that is carried by *connotive signs* which is the cultural meaning of the words, sentences, or the visuals (Rose, 2016). For example, in the controversy over GMOs, the use of the word biohazard and the use of its symbols in the depiction of GMOs stimulated interpreting those as toxic (Clancy & Clancy, 2016). The metaphor or symbol in words or a picture is then representing an idea or a mental construct – in our words, a particular interpretation, framing, of the issue.

To summarize, online sentiment coalitions are networks of online actors tied together around a sentimental storyline about a particular issue. Online sentiment coalitions visually and textually frame an issue. Both the textual and visual framing can take place through the use of denotive or connotive signs.

4.3 Method

To answer the research question, we followed the steps visualized in Figure 4.1 and elaborated below.

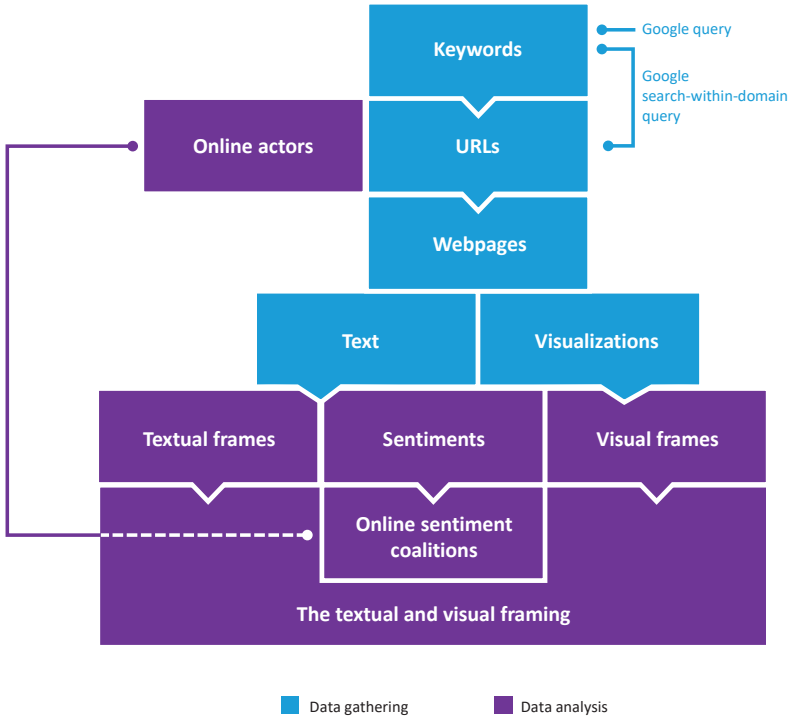


Figure 4.1. Visual of the steps used with the method applied.

4.3.1 Data gathering

To construct a dataset, we queried Google[34] for pages in English containing the terms "processed food" and "food processing", which were identified in preliminary

34 We opted for Google, the dominant web search engine, repurposed by Rogers (2019) as an epistemological machine for conducting social research, and we enclosed queries within double quotation marks ("unambiguous queries", see, Rogers, 2019, pp. 32–22). To mitigate Google's biases, we searched anonymously (logged out of any Google account), using a clean (no cash or cookies) instance of a web browser, with search settings changed from current region (that prioritizes city-level results) to national level.

research as the most prevalent sets of keywords that actors use online when referring to processed food. To include dominant online English-speaking voices, the queries were conducted in the two largest English-speaking nations in the Western world (*List of Countries by English-Speaking Population*, n.d.), namely, the United States and the United Kingdom, and their 50 top-ranked results were integrated. This list was cleaned of duplicates and URLs that were unavailable or URLs that did not include content about processed food. The cleaned URL list was used for search-within-a-domain Google queries with the terms "processed food" and "food processing". The two top-ranked pages from every URL that contained textual information about processed food and visualizations[35] were included in our dataset, which ultimately contained 164 web pages and their 344 visualizations.[36] We downloaded those pages (text + visuals) into Atlas.ti software to further analyse them.

4.3.2 Data analysis

Our unit of analysis was a page (web page) that belongs to a particular actor and communicates a particular sentimental storyline.

We first coded the actor to which every page belonged and categorized the actors. We adapted the categories suggested by Cullerton et al. (2016), acknowledging the emergence of new actor categories through new media (Vaast et al., 2013) (see Supplemental Material, Annex B, Table B1).

In the second step, we coded for the overall sentiment expressed in each page based on a manual analysis of the complete text, which is valuable for revealing the valence of emotions evoked from it (Lappeman et al., 2020), and the reading of the title of the page, which may place the page's audience in a particular relationship with its content (O'Neill, 2013).

Following this manual sentiment analysis, we constructed the online sentiment coalitions: we grouped the actors that shared a predominantly positive, negative or balanced sentiment about processed food.

35 We did not include webpages in a PDF format, as this format contains layouts that are often inappropriate for the type of analysis conducted.

36 To avoid over-representation of a particular actor, we limited the scraping of images from a particular URL to the first 10 images.

The next step was analysing the textual framing. We coded the text of the pages of each sentiment coalition for particular framings of processed food (see supplemental material, Annex B, Table B2). A first set of frames was defined deductively based on academic papers about food technology issues (Aschemann-Witzel et al., 2019; Marks et al., 2007; Nisbet & Huge, 2007; Nisbet & Lewenstein, 2002; Oleschuk, 2020). These frames were: "environmental harm", "environmental opportunity", "health opportunity", "health threat", "home cooking", "many possibilities", and "safety concerns". New frames were added inductively along with the analysis. These were: "food security", "injustice", "nutritional value", "safety standards", and "lack scientific evidence".

Next, we coded for (1) type of visual (e.g. photograph, infographic),[37] (2) the content ("what is depicted?" e.g. people, food),[38] and (3) the visual frame. The visual frames were interpreted inductively based on the reading of denotive and connotive signs. In denotive reading, the visual was interpreted "literally" (see also "denotative content", O'Neill, 2013, p. 13), for example, a visualization portraying happy people involved in food-related activities was coded with the visual frame "food happiness". Frames based on denotive reading were: "abundance", "contemplation", "food classification", "food happiness", "industrial- food-people". In connotive reading, implicit meaning, usually culture-dependent, was revealed (see also "connotative content", O'Neill, 2013, p. 13), for example, a woman who holds her head in a way that implies she has a headache was coded with the visual frame "unpleasantness". Frames based on connotive reading were: "body care", "unpleasantness".

Finally, we analysed the textual and visual framing of the three sentiment coalitions.

4.4 Results: Framing the dream, nightmare, or providing information

4.4.1 Online sentiment coalitions

Overall, the online negative sentiment coalition about processed food was the largest one in our data set (Figure 4.2). We can also see that "journalist" was the

37 Visualization-type codes were adapted from Morseletto (2017) and from a series of project meetings in which the researchers coded images for their type and discussed disagreement until consensus was achieved.

38 For the content analysis method see Bell (2001) and Rose (2016).

most prominent actor category among the negative coalition and constituted more than half of the coalition (58%, Figure 4.2), meaning that a lot of journalists (old-media, new-media, and professional, see Supplemental Material, Annex B, Table B1) were expressing negative sentimental storylines. In the negative coalition, the group "academic and food technologist"[39] was the second-biggest actor category, and "NGO" was the third. The remaining pages in this coalition belonged to "individual", "private sector (nutrition specialist)", "knowledge platform", "private sector (industry)", and "online market place" actors.

In the positive sentiment coalition, two actor categories were the biggest: "journalist", similar to the negative coalition, and "academic and food technologist" (Figure 4.2). These two categories together constituted about half of the coalition. "Private sector (industry)" was the next biggest category, followed by "government" and "online education". The remaining pages belonged to "political sector", "NGO", "private sector (nutrition specialist)", "individual", and "online market place" actors.
In the balanced coalition, again the most prominent actor category was "journalist" (40%), followed by "knowledge platform". The two categories together constituted more than half of the coalition (Figure 4.2). The remaining pages in this coalition belonged to "academic and food technologist", "private sector (nutrition specialist)", "NGO", "government", and "individual" actors.

4.4.2 Textual and visual framing by three online sentiment coalitions

4.4.2.1 Framing the nightmare: Health threats

We identified ten discursive storylines in the pages of this negative sentiment coalition. In this coalition, processed food was most prominently framed as a "health threat" (Figure 4.3), which means that processed food is most of all considered a health threat because there are unhealthy ingredients and that their intake should be limited or avoided. For example, a new-media journalist stated that "all those processed chemicals [that are found in processed foods] can affect mood because the 'foods' aren't actually giving your body any adequate nutrition; you're getting toxic ingredients, instead".[40] This discursive framing also included advice on how to avoid the intake of these "unhealthy processed foods". For example, advice given was to "check the label. The longer the ingredient list, the more processed a food is.

39 Academics and food technologists are grouped together. However, there were no food technologists in our negative coalition.

40 Source: https://www.eatthis.com/stop-eating-processed-foods accessed 15 February 2021.

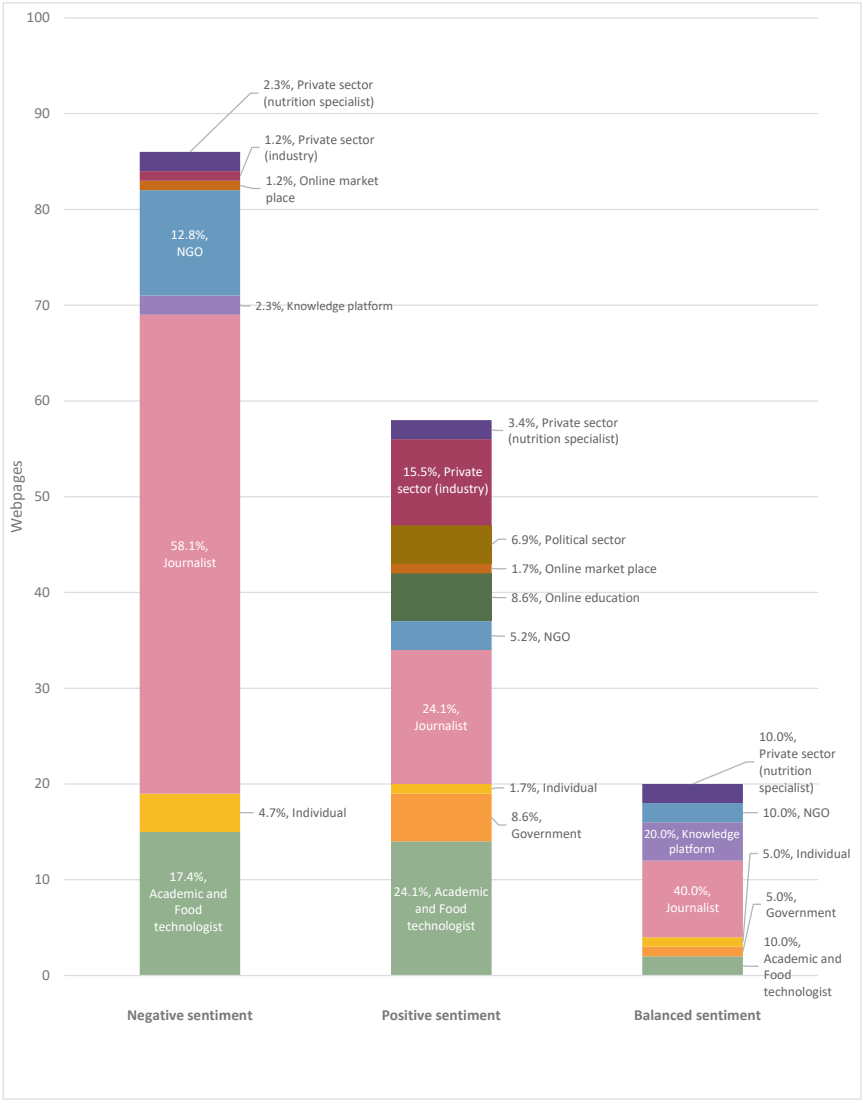


Figure 4.2. Actor analysis of the three online sentiment coalitions.

If most of the ingredients are hard-to-pronounce chemicals instead of actual food, it's a safe bet that food is heavily processed".[41] Some online actors tied the unhealthy frame to the idea of food companies that manipulate consumers and try to increase their intake of unhealthy processed food. For example, an academic actor wondered

41 Source: https://www.lhsfna.org/index.cfm/lifelines/may-2019/the-many-health- risks-of-processed-foods accessed 25 February 2021.

"why then are U.S. food marketing budgets overwhelmingly used to promote sales of nutrient-poor products like sodas and sweetened breakfast cereals?".[42]

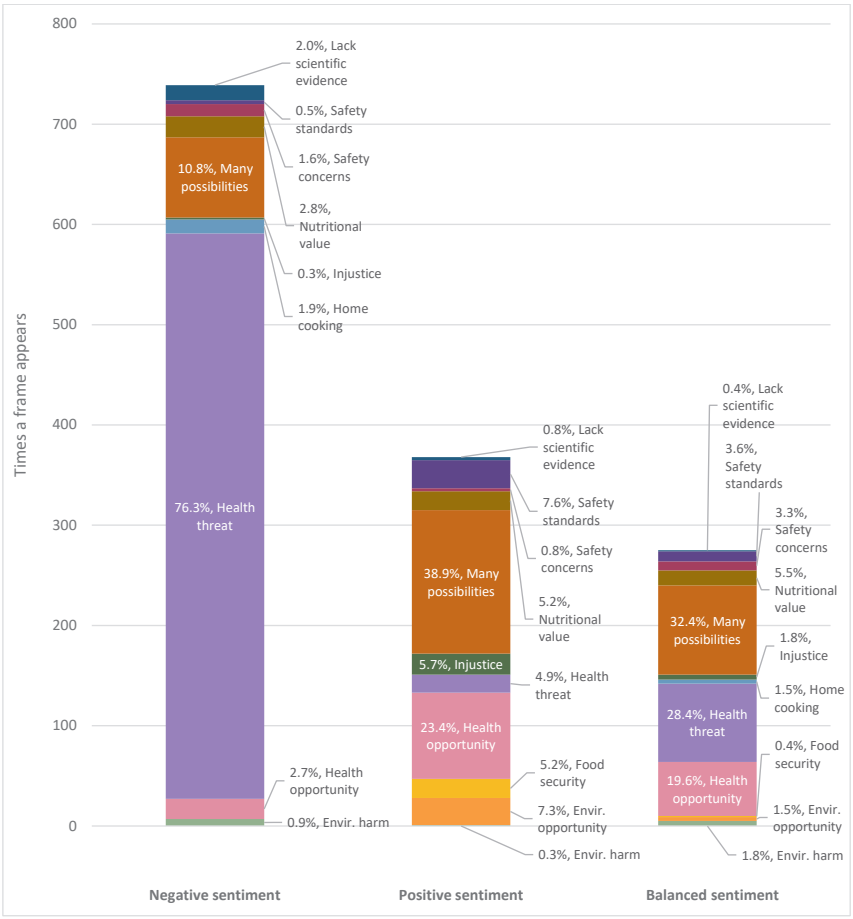


Figure 4.3. The distribution of discursive frames across sentiment coalitions.

In the negative sentiment coalition, which framed processed food as unhealthy, there was extensive use of visualizations with the visual frame of "abundance", followed by the "food classification" frame (see below; Figure 4.4). "Abundance" is a frame of foods that exist in a variety of types and colours. It communicates an idea of countless options when making food choices and can be associated with food security but also with the idea of too much food. In our dataset, the "abundance" visual frame was in photographs portraying food by means of what was seen as staging a scene or choosing a particular angle that emphasized variety. In those

42 Source: http://www.foodsystemprimer.org/food-and-nutrition/food-marketing- and-labeling accessed 15 February 2021.

photographs, foods were neatly organized on a table and captured, mostly, from top-view, or they were in their natural place, filling the whole camera frame, and creating a non-hierarchical frame with many elements (Figure 4.5). In the negative coalition specifically, those photographs were of foods typically considered as processed or even ultra-processed (see, Da Costa Louzada et al., 2017, p. 114), such as packaged foods, pizza, crisps, French-fries, and candies (Figure 4.5, see also the discussion below).

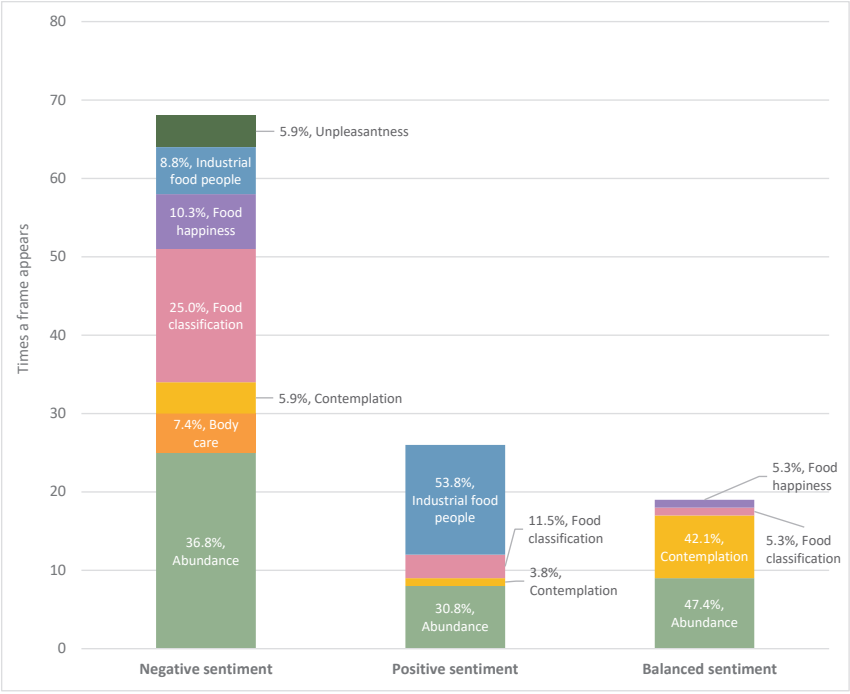


Figure 4.4. The distribution of visual frames across sentiment coalitions.

"Food classification" is a frame of foods that are classified into different groups. In our dataset, the "food classification" visual frame was in visualizations of a specific type, namely, diagrams (Figure 4.5). The use of diagrams is prevalent in scientific publications (Perini, 2005, p. 913), and, therefore, diagrams can be considered as conveying scientific information. Accompanying the unhealthy frame with extensive use of "scientific" visual frame might be a way in which actors of the negative coalition try to gain legitimacy by presenting themselves as capable of producing scientific knowledge (Schwarz, 2013).

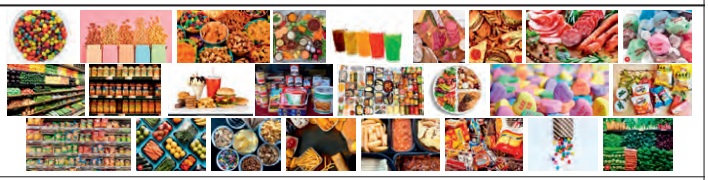
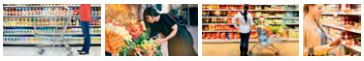
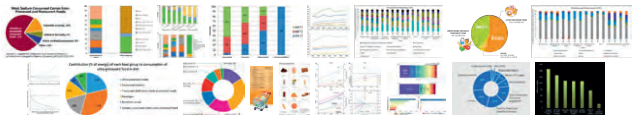
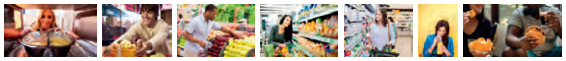
Frames and their definition	Negative
Abundance – Foods exist in a variety of types and colors	
Contemplation – People are planning their food choices or thinking about them carefully	
Food classification – Foods can be classified into different groups	
Food happiness – Eating, preparing, or shopping for food is enjoyable	
Industrial food people – Industrial food is produced by people	

Figure 4.5. Visual frames in the three sentiment coalitions (for the visualizations as they appear in their URLs see supplemental material, Annex B, Figure B1 and Table B3).

4.4.2.2 Framing the dream: Possibilities and health benefits

In the positive sentiment coalition, the framing of processed food was most of all done by emphasizing its "many possibilities" (Figure 4.3). In this framing, it is emphasized that food processing enables various improvements for humans by, for example, improving taste, enhancing convenience for consumers, and allowing for greater food choice and diet diversity. For example, it was expressed that "without processed foods, we would never have the huge variety of foods that we have available to us today".[43]

Next to the new possibilities in creating new (convenient) foods, another quite present framing in the positive coalition was "health opportunity". In this frame, processed food was presented as most of all benefiting human health by, for example, improving nutritional value or by keeping food safe for human

43 Source: https://www.srnutrition.co.uk/2018/10/processed-foods-the-pros-and-cons accessed 10 March 2021.

Positive	Balanced
	
	
	
	
	

consumption (by adding preservatives). For example, in one of the pages it was stated "in most cases, food processing ensures food safety and nutrition".[44]

This positive framing of processed food as providing many opportunities for more safe, convenient, and healthy foods, was commonly accompanied by visuals that were photographs depicting people involved in the preparation of food in a factory, warehouse, or institutional food service in industrial settings (the "industrial food people" frame, see, Figure 4.4). Some of the photographs presented people's faces or upper bodies, whereas others presented only their hands (Figure 4.5). These visuals seemed to frame processed food as less industrial and more human as often depicted; when people are included in photographs of industrial food preparation, it might make the process of industrial food preparation more personal, and therefore easier to relate to.

44 Source: https://www.fooddive.com/spons/the-truth-about-processed-food-1/553052 accessed 10 March 2021.

4.4.2.3 Framing balanced sentiment

In the balanced coalition, the framing of processed food was commonly as providing "many possibilities" (benefits) in combination with the framing of processed food as being a "health threat" (Figure 4.3). For example, it was stated that "tertiary food processing [the commercial production of ready-to-eat or heat-and-serve foods] has been criticized for promoting overnutrition and obesity, containing too much sugar and salt, too little fibre, and otherwise being unhealthful in respect to dietary needs of humans and farm animals", but also that "many forms of processing contribute to improved food safety and longer shelf life before the food spoils".[45] In some pages, this balanced frame was complemented by the "nutritional value" frame, according to which nutritional value or energy density per type of processed food should be assessed in order to be able to judge if the food product is healthy or not. For example, a new-media journalists claimed that "the best way to tell the difference between healthy refined food and not so healthy refined food is by doing a little nutritional sleuthing (as in label reading)".[46]

This textual framing was commonly accompanied by an "abundance" or "contemplation" visual frame. "Abundance" was communicated with a mixture of visualizations – some portray foods perceived as industrial and others portray foods perceived as natural. "Contemplation" was present in photographs portraying people reading food labels, looking at a shopping list while shopping for food, and scrutinizing a food or seeming to be thinking seriously about it when taking it off the shelf (Figure 4.5). Hence, the mixed message about processed food as having benefits but also possible downsides was combined with a visual framing of people trying to make choices and also with having enough food. This visually frames processed food as leading to food-choice hesitancy but also to have enough food, or even abundant food.

The main findings are summarized in Table 4.1.

45 Source: https://en.wikipedia.org/wiki/Food_processing accessed 15 February 2021.

46 Source: https://www.verywellfit.com/are-all-processed-foods-unhealthy-2506393 accessed 15 February 2021.

Table 4.1. Summary of the results

	Main actors	Textual framing	Visual framing	Visualization type	Visual content
Negative (Nightmare), 86 webpages	Journalists (58%)	Processed food poses a health threat (76%); Processed food offers many possibilities (11%)	There is an abundance of food (food security/too much food) (37%)	Photographs	Artificial looking candies, fast food, snacks, packaged foods, and some fruits and vegetables
			Foods can be classified into different groups (25%)	Data visualizations	Diagrams
Positive (Dream), 58 webpages	Journalists (24%); Academics and food technologists (24%)	Processed food offers many possibilities (39%) and health benefits (23%)	Industrial foods are produced by people (54%)	Photographs	People in industrial-food sites
			There is an abundance of food (food security/too much food) (31%)	Photographs	Artificial looking candies, coffee beans, nuts, packaged foods, fruits and vegetables
Balanced, 20 webpages	Journalists (40%); Knowledge platform operators (20%)	Processed food offers many possibilities (32%) and health benefits (20%); Processed food poses a health threat (28%)	There is an abundance of food (food security/too much food) (47%)	Photographs	Artificial looking candies, snacks, jarred pickles, and fruits and vegetables
			Contemplation about food: what to choose? (42%)	Photographs	People hesitating: what foods to buy?

4.5 Discussion

Our results show that the positive, negative, and balanced sentiment coalitions emphasized different aspects of processed food both in their textual and visual framing (Table 4.1).

If we compare the textual framing across the three sentiment coalitions, we see that processed food as providing "many possibilities", the most dominant frame in positive pages, was also used in the other coalitions' pages, even the negative one. Very often in the negative sentiment coalition, possible benefits were also mentioned. That could be related to the fact that this coalition was composed of many journalists. However, various types of actors in the negative coalition framed processed food as also offering many possibilities. For example, a private consultancy mentioned that "while some foods are processed to the point that they're barely recognizable, others are only modified to ensure they are edible, clean, and convenient".[47] Hence, overall, the negative sentiment coalition framed a negative message in a more balanced way than the way the positive coalition framed a positive message. Overall, the positive sentiment coalition framed processed food in optimistic ways and refrained from mentioning possible drawbacks. This might indicate that actors are more cautious when communicating a negative message about processed food than a positive message, and might be related to the fact that in many countries, the dietary share of (ultra-)processed foods is significant (Fiolet et al., 2018; Martínez Steele et al., 2017), and communicating an intolerant negative message about these foods would mean opposing a prevailing eating practice. Further research could investigate the framing of positive and negative messages about food technologies that are not (yet) widespread. In addition, for practitioners in the processed food positive coalition, it could be advised to also show the possible downsides of processed food – textually and visually, to communicate a more balanced frame of it.

If we compare the visual framing, we see that online actors from the negative coalition told a story of being surrounded by unhealthy and visually attractive processed food; online actors from the positive coalition narrated a story of human food industry; online actors from the balanced coalition narrated a story

47 Source: https://nutritionstripped.com/ultra-processed-foods accessed 15 February 2021.

of food-choice hesitancy. In digital food cultures literature, visuals are indeed acknowledged as adding information to the story told in the text (de Solier, 2018), and both textual and visual digital content are considered as meaningful elements in people's reflection on habits and preferences (Lupton, 2018, 2020) and also in the attempt to change those (the so-called "digital food activism", Schneider et al., 2018). In visual framing literature, visuals are considered as powerful framing devices, equally important or even more important than text (Metze, 2018b; Rodriguez & Dimitrova, 2011). Hence, attending to the visual framing when investigating the expression of sentiments, online, facilitates an important extension of the knowledge about the ways sentiments are communicated. This knowledge can lead to insights on how the (online) public understands contested food-related issues and the (dynamic) public mood about them.

Our results also show the benefits of manual sentiment analysis in combination with framing analysis. The two types of analyses together support the study of sentiments while applying a broad definition of sentiment, which entails noticing emotional expressions. Visual framing analysis, specifically, complements well manual sentiment analysis because visual framing is often considered as powerful particularly because of its emotional effect (Rodriguez & Dimitrova, 2011). This is even more true when the framed topic is controversial (Metze, 2018b).

Through the study of the expressed sentiments about processed food and the framing of it on the internet – in so-called "food media" (Goodman et al., 2017), we shed light on the outcome of visual choices made by different actors, deliberately or not, when communicating a message. Food media plays a critical role in the dynamic process of producing food knowledge that in turn influences the understanding of the food system and the perception of specific foods as, for example, healthy or sustainable (Goodman et al., 2017). Therefore, a better understanding of those visual choices can contribute to the understanding of the way in which conflicting knowledges about processed food are spread and gain credit. For example, in our study, the fact that a "scientific" visual frame of "food classification" was used, most of all, in the negative coalition stands out against the fact that this coalition did not have a big share of academics and food technologist. This fact is interesting given visualizations' capacity to affect the perceived credibility of online food information (Baker & Walsh, 2020). This is important especially since, in the digital environment, there is no longer distinguish between a sender and a

receiver: a member of the audience of a visual can become a producer (Van Beek et al., 2020), and the boundaries between experts and laypeople are re-defined (Lupton, 2018; Rousseau, 2012).

The results also indicate that in web searches, the online public is more likely to encounter content about processed food in a negative context than in a positive or balanced context and that this information is provided mostly by journalists. Of course, limiting our data to the top-ranked Google results has limitations because of Google's black-boxed algorithm, which privileges certain pages over others (Rogers, 2019, p. 109). Hence, the fact that among the top-ranked Google results, more pages were communicating negative sentiment than any other sentiment and the fact that "journalist" was the biggest actor category in all coalitions might be an outcome of the tendency to click on results with a negative message or results with information provided by journalists. In further research, better data gathering and data reductions strategies that are less dependent on Google's algorithm would be preferable for this type of research.

Our findings suggest that examining the visual qualities and techniques of visualizations can deepen the understanding of framing processes. Thus, for example, examining the colours used when framing food in a negative way expanded the findings, that is, the complete message revealed was that not only processed food is unhealthy but it also surrounds us and is visually attractive. In addition, the revealing of frames based on both denotive and connotive reading of signs, textual or visual, leads to a rich coding scheme and comprehensive results. Further in-depth studies into the denotive and connotive signs in both text and visuals by, for example, better including the role of specific word or colour used and the role of symbols, metaphors, and cultural interpretations, could further improve our study.

In addition, there might be hidden biases in our dataset that can be overcome by using, for example, our own developed scraper, sentiment and topic analyser. Other methods, such as interviews and surveys, may provide interesting insights into why actors talk about processed food as they do, or why they choose particular visuals with their stories. This study does not give insights into intentions (or a lack of those) when selecting visualizations that frame processed food in a particular way, nor does it examine the awareness of the emotional effect visualizations have (Krause & Bucy, 2018; Lilleker et al., 2019). Last but not least,

the results of this exploratory study are culturally biased since we had to limit our data to English. Further research should construct a broader dataset that includes sources in languages other than English and from non-Western countries.

4.6 Conclusion

In this study, we investigated how "dream", "nightmare" and balanced online sentiment coalitions textually and visually frame processed food. We studied 89 online actors and their 164 webpages. We extracted from the pages text and 344 visualizations about processed food. The results show that the negative coalition was most dominant. This coalition framed processed food as posing health threats due to unhealthy ingredients that their intake should be limited or avoided. In the negative coalition, compared to other coalitions, more online actors supported this framing with data visualizations suggesting that their claims are supported by scientific evidence, and more online actors supported this framing with photographs of visually attractive processed foods. The slightly less dominant positive coalition framed processed food as providing a health opportunity and allowing many possibilities for improvement of taste, greater convenience and food choice for consumers, and diet diversity. In the positive coalition, compared to other coalitions, more online actors supported this framing with photographs that depict humans preparing foods in industrial environments. In the balanced coalition, processed food was framed as providing a health opportunity and allowing many possibilities – as was the case in the positive coalition, but also as posing possible health threats. In the balanced coalition, compared to other coalitions, more online actors supported this framing with visualizations that emphasize the difficulty in making food choices.

The dream and nightmare views of processed food will most likely remain prevailing in society, given that "mass-produced food will remain a powerful part of culture" (Bentley & Figueroa, 2018, p. 93). Hence, investigating the various meanings that are given to processed food by different actors is essential. In addition, this study also adds an investigation of online coalitions and their textual and visual framing to a recent study that sees the way in which the digital is entangled with food as an expression of the complex relationship between the digital and our daily life (Lewis, 2018; Rousseau, 2012).

CHAPTER 5

The Meaning of Circulating Visualisations related to a Policy Controversy

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Abstract

This study explores circulation of digital visualisations of nanotechnology in food and food packaging. We analyse visualisations' textual tone, their image–text storyline, and how these change, over time, across platforms and across topical contexts. By applying interpretive methods, we investigate 90 tweets, their 104 visualisations, and 667 URLs on which these visualisations were found. The findings show that, on Twitter, visualisations and their accompanying text communicate positive storylines about food security, food sustainability, and health benefits, and negative storylines about food contamination and health concerns. When comparing platforms, the message conveyed by visualisations and their accompanying text on the open Web is more complex and nuanced than on Twitter. We suggest that, the connection between multiple topics that use shared visualisations is enriched and worthy of investigation, and the circulation of visualisations across topical contexts allows precise insights to be gained into changes in the meaning of digital visualisations.

5.1 Introduction

Visualisations are commonly used as a non-verbal form of communication in public debates about political issues (Rojas-Padilla et al., 2022). They are 'condensed graphical elements depicting realities, knowledge, ideas, or messages capable of packaging cognitive, normative, and emotional information in non-necessarily verbal form' (Rojas-Padilla et al., 2022, p. 105). Visualisations such as photographs, maps, graphs, and infographics are capable of shifting a debate in a specific direction (Lilleker et al., 2019; Schneider & Nocke, 2014) and influencing decision-making and how an issue is governed (Clancy & Clancy, 2016; Metze, 2017, 2018b). Online, they are often accompanied by text. A growing body of literature aims to include the visual dimension when investigating policy controversies online (Allen, 2021; Gommeh et al., 2021, 2022; Metze, 2018b; Rabello et al., 2021; Rojas-Padilla et al., 2022). This paper adds to this corpus a focus on the circulation of digital visualisations.

Visualisations rarely remain where they were produced; rather, they circulate (Rose, 2016). Various disciplines recognize circulating visualisations as a phenomenon worthy of attention. In cultural studies, circulating a visualisation is considered a means of expressing a user's perception of a politicized issue (Geboers & Van De Wiele, 2020). In policy studies, it is acknowledged that visualisations can circulate and (re)frame a policy topic (Van Beek et al., 2020). Scholars of science and technology studies are concerned with scientific visualisations extracted from their scientific context and used in non-scientific contexts (Burri & Dumit, 2008). This concern is linked with facts packaged in visualisations: visualisations can carry facts when used in a scientific or another specific context, but these facts may change or even not reach the new destination when the visualisation circulates (Merz, 2011; Morgan, 2011).

Specific scholarly attention has been given to visualisations circulated on the internet and social media platforms, where visualisation is an everyday practice (Highfield & Leaver, 2016; Niederer, 2018; Pearce et al., 2020) and circulation is an ever-intensifying process (Rose, 2016, p. 288). Prior research on the circulation of digital visualisations focuses on circulating across platforms (D'Andréa & Mintz, 2019) and countries (McSwiney et al., 2021), circulation of memes (Kligler-Vilenchik & Thorson, 2016; Smits & Ros, 2021) and infographics (Amit-Danhi & Shifman, 2018),

and circulation of specific visualisations in a particular political context (Kasra, 2017; Metze, 2018b). By conceptually developing a particular form of circulation and integrating it with other circulation forms, and by exploring how the meaning of visualisations changes when they circulate, this paper adds to this literature a comprehensive and refined conceptual approach to circulation and an innovative method that leads to rich empirical illustration.

During circulation and over time, a visualisation's meaning may change (Hand, 2016; Niederer & Colombo, 2019; Schneider & Nocke, 2014). The meaning change can be associated with a change in the context in which a visualisation is used (Schneider & Nocke, 2014, p. 17) and is especially important in online interactions about policy issues. In this interaction, a change in a visualisation's meaning can result from a negotiation between actors (Rojas-Padilla et al., 2022), and this calls for an awareness of that change.

This paper focuses on the circulation of digital visualisations of nanotechnology in food and food packaging (referred to here as *nanotechnology in food*). Nanotechnology in food is a debated emerging field that presents promises as well as concerns (Finglas et al., 2014; te Kulve et al., 2013). Current and prospective nanotechnology-based applications are, for example, nanocapsulated active ingredients that remain stable and protected until released in a targeted place in the body, and active and intelligent packaging that, e.g., detects pathogens or improves the packaged food (Handford et al., 2014; Henchion et al., 2019). These innovations and other nanotechnology-based innovations have far-reaching implications for the entire food system (Handford et al., 2014). They can greatly improve food quality, quantity, and safety, and can fundamentally contribute to human health, and more generally to a more efficient and sustainable food system (Chaudhry et al., 2017; Handford et al., 2014; Henchion et al., 2019). However, nanotechnology-based food applications are associated with knowledge gaps, potential risks to human health and the environment, and safety concerns (Chaudhry et al., 2017; Handford et al., 2014; Henchion et al., 2019). This has made the development of nanotechnology-based food applications significantly dependent on the consumer response that has played a key role at least since the mid-2000s (Fischer et al., 2013; Frewer et al., 2014; Steenis & Fischer, 2016). In the study of consumer response to contested technologies, nanotechnology is one of

them, the online environment is a central medium (Cacciatore et al., 2012; Hopke & Simis, 2017).

The research question addressed here is: What meanings, given the visual and its accompanying text, are carried by circulating visualisations about nanotechnology in food, does the meaning change when these visualisations circulate, and, if so, how? To answer the research question, we formulated two research sub-questions. The first sub-question (RSQ1) is: What visualisations about nanotechnology in food circulate on Twitter, with what textual tone, and as part of what storyline? Twitter is suitable for the investigation of circulating visualisations in the context of nanotechnology in food as it is an important source for studying views about emerging technologies in the agri-food sector (Tabei et al., 2020; Waller & Gugganig, 2021). However, to expand our inquiry beyond the boundaries of the nanotechnology-in-food context, we turn to the open Web. The second sub-question (RSQ2) is: Which of the visualisations revealed through RSQ1 circulate frequently on the open Web, in what context, with what textual tone, and as part of what nanotechnology-in-food storyline (if at all)? Answering RSQ2 enables us to reveal more meanings assigned to circulating visualisations and changes in meanings.

5.2 Conceptual framework

5.2.1 Circulating definition

Rose (2016) recognizes the circulating of a visualisation as one of four sites where the meaning of a visualisation is made. For Rose, circulating is the site where a digital visualisation passes from one place to another (e.g., from the TV screen to a mobile phone screen). Unlike Rose, van Beek et al. (2020) consider only two sites where the meaning of a visualisation is made: production and circulation. For van Beek et al., the other two sites that Rose (2016) recognizes – the image itself and audiencing – are elements inherently involved in both the production and the circulation of a visualisation. Like van Beek et al., we see circulation as involving audiencing: during a visualisation's circulation, audiences already interact with it – they perceive, interpret, use, and republish it (Van Beek et al., 2020, p. 499). We, however, aim to reveal changes in meaning that result from the circulation process itself rather than visual modifications made during the process. Hence, we focus

on circulation in which visualisations remain intact and we do not include, as van Beek (2020) do, the image itself as an element in the circulation of a visualisation. We define circulation as the process in which an online visualisation is republished, as is, by its audience.

5.2.2 Forms of circulating

Circulating within a platform

Circulating within a platform, for example by retweeting a tweet containing a visualisation, is often studied using quantitative methods (e.g., counting hashtags, likes, or retweets) that produce network graphs (Niederer, 2018; Rogers, 2021). To study circulating on a specific platform, the platform's affordance should be considered when the research protocol is being designed (McSwiney et al., 2021; Pearce et al., 2020), and the ways the specific digital traces offered by a platform construct the dataset should be acknowledged (Venturini, Bounegru, et al., 2018).

Circulating across platforms

Circulating can also occur across platforms (D'Andréa & Mintz, 2019; Hand, 2016), for example when a Twitter user saves a visualisation to her drive and uses it in a blog post or a website. Unlike circulating within a specific platform that has its designated circulation buttons (e.g., retweet, share), circulating across platforms usually requires more clicks. A cross-platform circulation is challenging to study because of the individual social media platforms' APIs and other data-driven architectures specific to a platform (D'Andréa & Mintz, 2019; Rogers, 2019). Studying cross-platform circulation involves, like cross-platform study in general, balancing the need to design a research protocol specific to a platform with the need to enable comparability between the platforms (Venturini, Bounegru, et al., 2018).

Circulating across topical contexts

Another form of circulation can happen within or across platforms and relates to the context in which the visualisation is used. Regarding the circulation of visualisations, context is acknowledged as important. Visualisations can circulate from one context to another, for example when a visualisation is detached from its original scientific context and used in a non-scientific context (Schneider & Nocke, 2014, p. 17) or when a visualisation circulates from a policy document to a news

website (Van Beek et al., 2020, p. 501). However, context can also be associated with the *topic* discussed. Think, for example, of a photograph of a girl eating ice cream appearing on a webpage discussing ways of cooling down in hot weather. The same photograph will have a very different meaning when appearing on a webpage discussing nano-particles in ice cream. In policy studies, revealing the topic of a text discussing a policy issue is seen as a valuable step prior to revealing actors' ideas of what the issue is about and their way of making sense of it (see, for example, Hjerpe & Buhr, 2014; Metze, 2017). Hence, a topical context is a specific notion of context in which a digital visualisation is used and is significant in communication about a policy issue and therefore worthy of attention in studies on the circulation of digital visualisations.

5.2.3 Meaning of a visualisation

Tone

In revealing a visualisation's meaning, the text accompanying a visualisation often provides a key to selecting one meaning out of several possible meanings of it (Rose, 2016, p. 121). More specifically, the tone of the accompanying text is important. In media coverage, the tone of the text – positive, negative, or neutral – is determined by the dimension of the discussion that is given focus (Baumgartner et al., 2008). Thus, in relation to nanotechnology in food, the previously mentioned photograph of a girl eating ice cream can be embedded in a webpage with positive (e.g., emphasising that nanotechnology can improve a food's quality without influencing its taste) or negative (e.g., emphasising that nano-particles, although invisible, can be dangerous) text about nanotechnology. The specific tone can influence how a visualisation is being 'read' as it colours the context in which the visualisation is used. Hence, depending on the tone of the accompanying text, a visualisation of a girl eating ice cream can be a sign of technological progress or an alert. Especially when a visualisation is about something invisible such as nanotechnology, revealing the topical context in which the visualisation is used and the tone towards the topic provides valuable clues for decoding the meaning carried by the visualisation.

Storyline

A visualisation's meaning is reflected in the story that it 'tells'. Visualisations narrate storylines (Gibson & Zillmann, 2000; Gommeh et al., 2021) that are used

to give meaning to phenomena in the world, to make sense of the world (Hajer, 1995). They are 'condensed statement[s] summarizing complex narratives, used by people as "short-hand" in discussions' (Hajer, 2006, p. 69). Storylines often include written or spoken linguistic elements (Fletcher, 2009; Hajer, 1995) and visual elements (Gommeh et al., 2021; Metze, 2020). The two modes, the verbal and the visual, have different effects (Kress, 2001). However, they do not work independently of each other, as most public communication is, rather, multimodal (Kress & Van Leeuwen, 2021). This is even truer in digital communication, which integrates most forms of cultural expression (Castells, 2010). Hence, to reveal the complete story, the visual and the text should be viewed as contributing together to a coherent whole (Kress, 2001, 2010).

In summary, the circulation of digital visualisations occurs within or across platforms and can be across topical contexts. During circulation, the meaning carried by a visualisation can change. This meaning is reflected in the tone of the text accompanying the visualisation and the image–text storylines narrated.

5.3 Methods

The novel method used in this study reflects the recent scholarly preference to integrate automated quantitative methods with manual qualitative analysis (e.g., Kermani & Tafreshi, 2022; McSwiney et al., 2021). Below, we describe the steps of the method, which are elaborated in detail in Annex C.

To study the circulation of visualisations on Twitter, we gathered, using Twitter API, tweets about nanotechnology in food that contain images (n=4761). In the most retweeted tweets (RT metrics>10; n=90), we analysed, inductively and based on the visual and the text together, the tone towards nanotechnology in food, as conveyed by the tweet's wording and the storylines narrated. Next, to study cross-platform and cross-topical context circulation, we extracted the visualisations (n=104) from the tweets and, using Google reverse image search, we labelled visualisations that had more than 200 Google reverse image search results (n=14) as visualisations circulated frequently on the open Web. The text of all the URLs on which these visualisations appear (n=667) was analysed to reveal the topical context – the page's main topic – and whether nanotechnology in

food was discussed. For a further, in-depth, qualitative analysis of the tone and the storylines and how they change over time, we selected five visualisations for which nanotechnology in food is discussed among the URLs on which they appear. In all the URLs on which these five visualisations appear (n=157), we analysed the tone towards the page's topic and the nanotechnology-in-food storylines. The URLs were sorted based on their publication date to create a timeline showing changes in the tone towards the topic and the nanotechnology-in-food storylines over time. Figure 5.1 shows the dynamic development of our dataset and the specific analysis conducted at each stage.

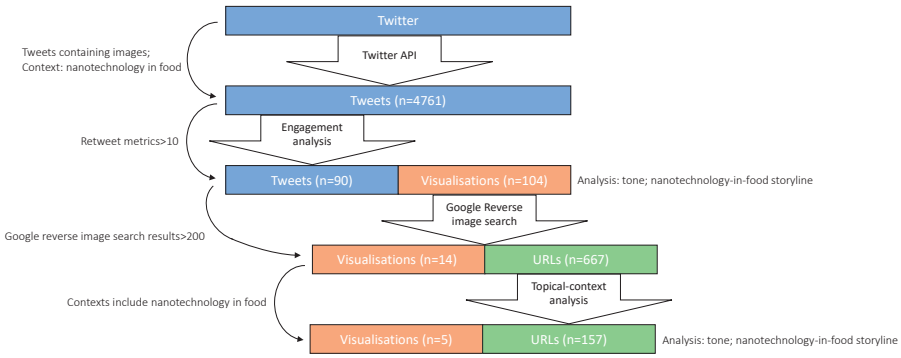


Figure 5.1. Development of the dynamic dataset and the analysis conducted at each stage

5.4 Results

In this section, we first present the results of the analysis of circulating within the Twitter platform: the textual tone that accompanies circulating visualisations about nanotechnology in food and the storyline narrated by the tweets that include those visualisations. Next, we present the results of the analysis of cross-platform circulation and focus first on circulation across topical contexts. Finally, for five selected visualisations that circulated both on Twitter and the open Web in the context of nanotechnology in food, we present the textual tone and the storylines and how the two have changed over time.

5.4.1 Circulating within a platform (Twitter)

Tone

The results of the tweets' tone analysis show that, in the tweets that circulated the most and contained images, tweets with a positive tone are the largest group. Slightly fewer tweets have text with a negative tone. Tweets with a neutral tone are the smallest group (Figure 5.2).

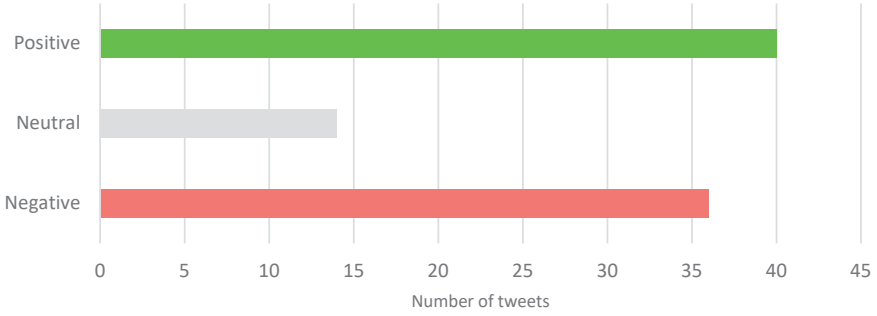


Figure 5.2. Overview of the tone of the text of the most retweeted tweets containing images

Storyline

The results reveal nine image–text storylines in the visualisations and their accompanying text (the text of the tweet in which they were used) (Figure 5.3).

The food-security-and-food-sustainability storyline has the highest number of tweets and is about nanotechnology that advances these conditions or qualities. The tweets' textual tone is always positive. Three tweets with this storyline are also part of the health-benefit storyline, and two tweets are part of the scientific-development storyline. Illustrative tweets of food security and food sustainability contain visualisations of scientific innovations with text describing the innovation and how it benefits society. For example, a visualisation of a cucumber being peeled is accompanied with text explaining that cellulose nano-crystals from cucumber peels are used to create environmentally friendly food-packaging material.

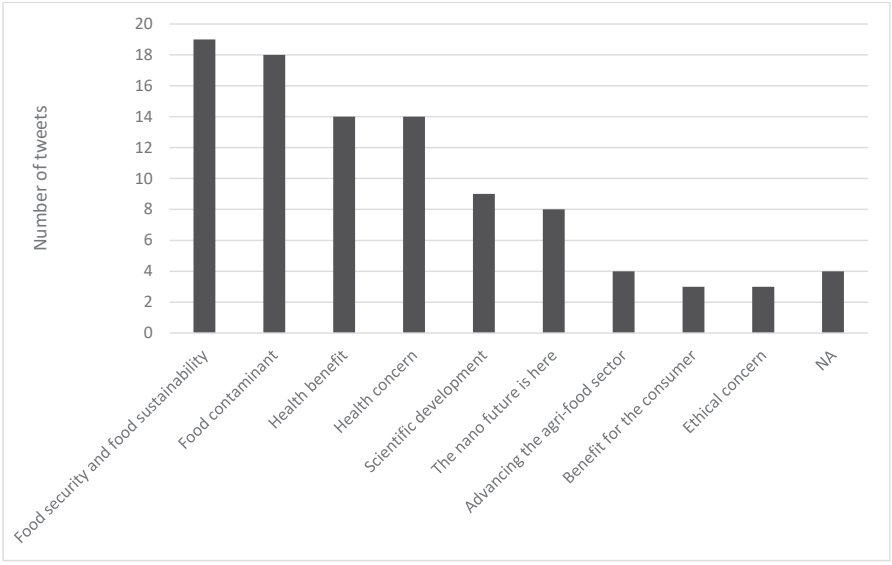


Figure 5.3. Overview of the storylines of the most retweeted tweets and the tweets in which no storyline was revealed (NA)

The food-contaminant storyline is about nano-sized particles that reach our food and contaminate it. The tweets' textual tone is always negative. Some tweets with this storyline communicate the idea of food contamination as a result of using and discarding plastic products. These tweets show small pieces or pellets of plastic, with text describing the phenomenon. Other food-contaminant tweets convey the idea that aircrafts' condensation trails consist of harmful chemicals ('chemtrails') in the form of nano-sized particles. These tweets show mostly photographs of aircraft condensation trails with the text 'Nano Particulates are contaminating everything; food, air, water, DO YOU CARE?'.

Health benefit is another storyline revealed, which is about the health benefits that nanotechnology offers, such as fighting obesity, increasing food safety, and improving nutritional value. The tweets' textual tone is always positive. One tweet with this storyline is also part of the advancing-the-agri-food-sector storyline. In the health-benefit storyline, some tweets visualize nano-structures and accompany the visualisation with text explaining the nano-structures' benefits. Other tweets visualize foods – in a lab, on a counter, in a production line – and textually describe health benefits associated with the food depicted. For example, a visualisation

of boxes of strawberries on a conveyor is accompanied with text about the food industry that uses nanotechnology to improve foods' nutrition and overall quality.

The health-concern storyline is about health concerns, risks, or threats posed by nanotechnology in food. The tweets' textual tone is always negative. Some tweets with this storyline visualize worrisome or alarming charts, lists, or banners and provide more information in the tweet's text. Other tweets show foods or people interacting with foods in what seems to be an ordinary way of interacting. When one reads these tweets' text, it becomes clear that they express health concerns related to the food, or the interaction, that appears in the visualisation. For example, a visualisation of a baby drinking from a bottle is accompanied with text about hazardous nano-ingredients in baby formula. More image–text storylines revealed in tweets are elaborated on in Annex C, Table C1.

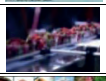
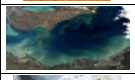
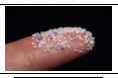
5.4.2 Circulating across platforms

Of the visualisations belonging to the most retweeted tweets about nanotechnology in food, 14 visualisations circulated frequently on the open Web also (Table 5.1). The visualisations depict various objects, mainly foods, plants, people or body parts, and landscapes.

5.4.3 Circulating across topical contexts

The results show that visualisations that circulated on Twitter in the nanotechnology-in-food context circulated on the open Web in various topical contexts. Among 667 URLs containing these visualisations, 39 discussed nanotechnology in food and their main topic is mostly food related (Table 5.1). Among the rest of the URLs, some discussed topics that can be seen as related to nanotechnology in food, such as genetically modified organism (GMO) (Handford et al., 2014; Henchion et al., 2019; Schwarz-Plaschg, 2018). Other URLs discussed topics related to food, for example food production, food vacuum packaging, and the agri-food sector. The remaining URLs discussed topics that are not related in any way to food or nanotechnology in food, for example makeup/beauty/cosmetics or Japan. Visualisations that did circulate on both Twitter and the open Web in the nanotechnology-in-food context (Table 5.1, lines 3, 4, 5, 7, 8, 9, 12) were visualisations of foods, farmers, and landscapes, and visualisations that seem to illustrate a problem (Table 5.1, lines 5 and 12). More observations about the change in the tone of the visualisations' accompanying text, when circulating across topical contexts, are below.

Table 5.1. Visualisations of nanotechnology in food on Twitter found via Google reverse image search circulate frequently on the open Web also

	Visualisation	Tone of accompanying text on Twitter; Nanotechnology-in-food storyline of which the visualisation is part on Twitter	Total English URLs on which the visualisation appears	Topic (number URLs)	Text discussing nanotechnology in food (number URLs)
1		Positive; Health benefit	3	2, 1	0
2		Positive; Food security and food sustainability	38	37, 1	0
3		Positive; Health benefit	83	73, 6, 2, 2	1
4		Positive; The nano future is here	15	15	3
5		Negative; Ethical concern	29	29	15
6		Neutral; The nano future is here	59	55, 4	0
7		Positive; Health benefit	25	17, 5, 3	5
8		Positive; Food security and food sustainability	10	8, 2	2
9		Positive; Food security and food sustainability	116	113, 3	1
10		Positive; Benefit for the consumer	21	14, 3, 2, 2	0
11		Negative; Food contaminant	21	21	0
12		Negative; Food contaminant	76	75, 1	12
13		Negative; Food contaminant	22	19, 2, 1	0
14		Negative; Health concern	147	146, 1	0

Note:

Algae bloom	GMO	Parenting
Climate engineering	Japan (culture/architecture/ geography/tourism/general)	Plastic particles from waste stream
Earth's ozone layer/Pollution/ Human activity influencing Earth	Laboratory/Clinical research or treatment/Chemistry	Shop for Darbha grass
Failure	Makeup/Beauty/Cosmetics	Smart agriculture
Food business/Business management	Milk/Lactose	The agri-food sector
Food production	Nanofood[1]	Water quality or quality management
Food vacuum packaging	Miniature tracking chips in food and elsewhere	Other (when a single topic appears only once)
Food waste	Natural nano-patterns in plants	

[1] Nanofood is "the use of nanotechnology techniques, materials or tools for production, processing, or packaging of food" (Chaudhry et al., 2017, p. 6). This term is used to enable differentiating the topic of nanotechnology-based food applications from the more general idea of nano-sized particles in food (e.g., nano-sized plastic particles from waste stream in our food).

Tone

Regarding the 14 visualisations we focused on in Table 5.1, the tone of the visualisations' accompanying text on Twitter is mostly positive. Fewer visualisations are accompanied with text with a negative tone, and one visualisation is accompanied with text with a neutral tone.

On the open Web (Tables 5.2–5.6), in four of the five visualisations for which nanotechnology in food is discussed among the URLs on which they appear, the tone of the tweet is similar to the tone of most or even all the URLs on which the visualisation appears (Tables 5.2, 5.3, 5.5, 5.6). For example, referring to 'smartdust'[48] (Table 5.3), on both Twitter and most of the URLs, the tone of the text is negative, as the text warns about the ethical problem and the health risks involved in using smartdust. Interestingly, although the smartdust visualisation alone does not communicate any information about any nano measures of smartdust (which, if it exists in nano-size, is not visible to the naked eye), it is used in the context of nano-sized miniature tracking chips in more than half of the URLs on which it appears. On those URLs, it is *always* accompanied with text with a negative tone.

In one of the five selected visualisations, injected tomato, the tone of the tweet containing the visualisation is similar to the tone of only some of the URLs on

48 Smartdust visualization communicates the idea of a miniature tracking device with tiny measures. Smartdust, accordingly, has GPS capabilities and can be sprayed on us or taken in foods, drinks, and even injected.

which the visualisation appears (Table 5.4): the tone is positive when discussing, for example, benefits for society and the individual; it is negative when discussing, for example, health risks; it is neutral when, for example, both benefits and risks are discussed. Injected tomato is used mostly in the context of two topics that are considered related: nanofood and GMO (Handford et al., 2014; Henchion et al., 2019; Schwarz-Plaschg, 2018). Interestingly, when the visualisation is used in the nanofood context, it is often accompanied with positive text and it usually communicates, together with the accompanying text, that we can benefit from manipulating foods at a nano scale. The visualisation contributes to this message by emphasising the novelty of the manipulation. However, when the visualisation is used in the context of GMO, the textual tone is more negative in general. In GMO URLs, the text accompanying the injected tomato visualisation is often about health risks or about reasons to avoid eating GMOs.

Table 5.2. Natural world collection (see the visualisation here: https://ifpnews.com/6-new-nanoproducts-unveiled-iran-agro-food-2016), a collection of photographs of objects from the natural world: plants, a beehive, cereal field, fruits, and vegetables

			Twitter													
Publication date	9/Jun/16	9/Jun/16	9/Jun/16	4/Jul/17	25/Jul/18	15/Nov/18	4/Dec/18	22/Jan/19	6/May/19	6/Nov/20	20/Nov/20	10/Jan/21	19/Apr/21	11/May/21	11/Jul/21	17/Aug/21
URL	ifpnews.com	theiranproject.com		theiranproject.com	openpr.com	en.irna.ir	theiranproject.com	exhibitionmakers.com	theiranproject.com	agroberichtenbuitenland.nl	newtelegraphng.com	newtelegraphng.com	agroberichtenbuitenland.nl	newtelegraphng.com	newtelegraphng.com	impar.in
URL topical context	Agro-food sector															
URL - Nanotech. in food discussed																
Tone																
Storyline	Advnc.; Futur	Advnc.; Futur	Futur	Advnc.; Futur												

Note:

Positive tone-of-voice towards the topic

Neutral tone-of-voice towards the topic

Negative tone-of-voice towards the topic

Abbreviations:
Advnc.=Advancing the agri-food sector; Futur=The nano future is here

Table 5.3. Smartdust (see the visualisation here: https://ancienttimenews.tumblr.com/post/48673351441/smart-dust-are-these-chips-also-being-sprayed), a combination of text, a photograph captured through a magnification device, and a photograph of a human finger with a tiny black dot

											
Publication date	*ND*	*20/Mar/13*	*23/Mar/13*	*21/Apr/13*	*23/Apr/13*	*14/May/13*	*5/May/14 Twitter*	*23/Nov/14*	*18/Apr/15*	*18/Aug/15*	*6/Feb/16*
URL	*earthcoinage.com*	*annlrd.wordpress.com*	*nativeamericanhumorandsomeextrastandups.wordpress.com*	*shanson3871.wordpress.com*	*ancienttimenews.tumblr.com*	*mytaarray.blogspot.com*		*intellicity.wordpress.com*	*buffalohair-jageannsjournalscollection2.weebly.com*	*buffalohair-jageannsjournalscollection2.weebly.com*	*geekfence.com*
URL topical context											
URL - Nanotech. in food discussed											
Tone											
Storyline							*Ethic*		*Ethic*	*Ethic; H.con*	

Note:

Positive tone-of-voice towards the topic
Neutral tone-of-voice towards the topic
Negative tone-of-voice towards the topic

Abbreviations:
Ethic=Ethical concern; H.con=Health concern

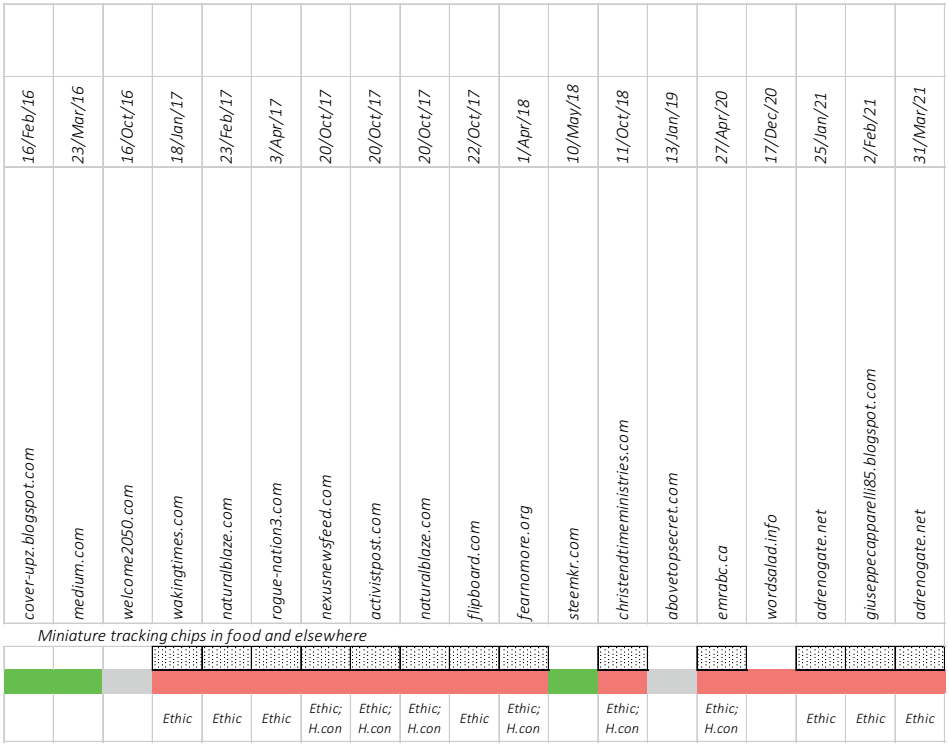

16/Feb/16
23/Mar/16
16/Oct/16
18/Jan/17
23/Feb/17
3/Apr/17
20/Oct/17
20/Oct/17
20/Oct/17
22/Oct/17
1/Apr/18
10/May/18
11/Oct/18
13/Jan/19
27/Apr/20
17/Dec/20
25/Jan/21
2/Feb/21
31/Mar/21
cover-upz.blogspot.com
medium.com
welcome2050.com
wakingtimes.com
naturalblaze.com
rogue-nation3.com
nexusnewsfeed.com
activistpost.com
naturalblaze.com
flipboard.com
fearnomore.org
steemkr.com
christendtimeministries.com
abovetopsecret.com
emrabc.ca
wordsalad.info
adrenogate.net
giuseppecapparelli85.blogspot.com
adrenogate.net
Miniature tracking chips in food and elsewhere
Ethic
Ethic
Ethic
Ethic; H.con
Ethic; H.con
Ethic; H.con
Ethic
Ethic; H.con
Ethic; H.con
Ethic; H.con
Ethic
Ethic
Ethic

Table 5.4. Injected tomato (see the visualisation here: https://www.shutterstock.com/image-photo/injection-into-fresh-red-tomato-61818016), green liquid injected into a red tomato

											
Publication date	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*4/Jul/05*	*2011*	*27/Jun/12*	*20/Aug/12*
URL	*amity.edu*	*thegreatcontroversy.info*	*thesentinellamalaga.com*	*toppr.com*	*slideplayer.com*	*chegg.com*	*plantsoflife.net*	*life.ca*	*life.ca*	*bigthink.com*	*usgreenchamber.com*
URL topical context	*GMO*		*mRNA*	*Nano-food*	*GMO*		*Chem-food*				*GMO*
URL - Nanotech. in food discussed											
Tone											
Storyline				*H.benft*							

Note:

Positive tone-of-voice towards the topic

Neutral tone-of-voice towards the topic

Negative tone-of-voice towards the topic

Abbreviations:

Topical context: GMO=genetically modified organisms; mRNA=mRNA vaccine; Nano-food=Food Nanotechnology; Chem-food=Chemicals in food; Fruits=Misconception with fructose in fruits

Storylines: H.benft.=Health benefit; Advnc.=Advancing the agro-food sector; H.con=Health concern; Unknwm=Some unknowns; C.benft.=Benefit for the consumer; Sci.=Scientific development; Futur=The nano future is here

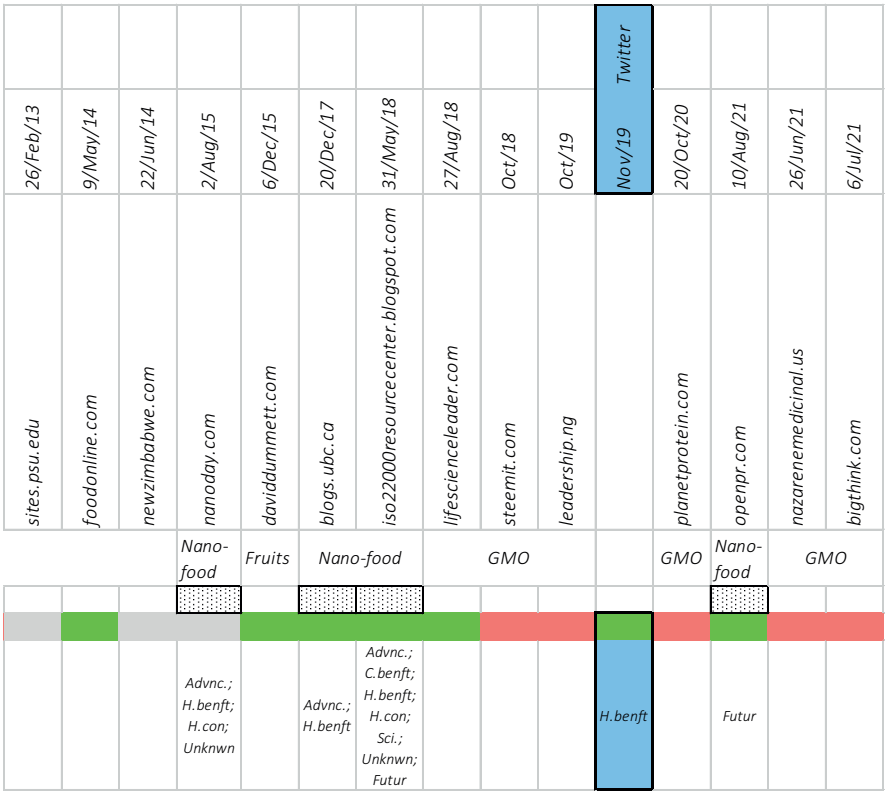

Twitter
26/Feb/13
9/May/14
22/Jun/14
2/Aug/15
6/Dec/15
20/Dec/17
31/May/18
27/Aug/18
Oct/18
Oct/19
Nov/19
20/Oct/20
10/Aug/21
26/Jun/21
6/Jul/21
sites.psu.edu
foodonline.com
newzimbabwe.com
nanoday.com
daviddummett.com
blogs.ubc.ca
iso22000resourcecenter.blogspot.com
lifescienceleader.com
steemit.com
leadership.ng
planetprotein.com
openpr.com
nazarenemedicinal.us
bigthink.com
Nano-food
Fruits
Nano-food
GMO
GMO
Nano-food
GMO
Advnc.; H.benft; H.con; Unknwn
Advnc.; H.benft
Advnc.; C.benft; H.benft; H.con; Sci.; Unknwn; Futur
H.benft
Futur

Table 5.5. Woman farmer in a cereal field (see the visualisation here: https://stock.adobe.com/sk/search/images?k=women+farmer+tractor&asset_id=361525422), a female farmer holding a digital tablet in a cereal field and a harvester at the background

												
Publication date	*ND*	*26/Nov/20*	*5/Feb/21*	*May/21*	*11/May/21*	*24/Jun/21*	*24/Jun/21*	*24/Jun/21*	*26/Jun/21*	*5/Jul/21*	*5/Jul/21*	*11/Jul/21*
URL	*stock.adobe.com*	*blog.trustbix.com/*	*farmersguide.co.uk*	*carolinacountry.com*	*blog.novatex.ag*	*globehealthnews.com*	*news-medical.net*			*euractiv.com*	*injuredly.com*	*digitalseed.eu*
URL topical context	*Smart agriculture*		*Res. Prof*	*Rur. Dev.*	*Smart agriculture*							
URL - Nanotech. in food discussed												
Tone												
Storyline						*Advnc.; Sust.; H.benft.; Sci.*	*Advnc.; Sust.; H.benft.; Sci.*	*Sust.*	*Sust.*			

Note:

Positive tone-of-voice towards the topic

Neutral tone-of-voice towards the topic

Abbreviations:
Topical context: Res.Prof=Respect for professions; Rur.Dev.=Rural areas development
Storylines: Advnc.=Advancing the agro-food sector; Sust.=Food security and food sustainability; H.benft.=Health benefit; Sci.=Scientific development

Storyline

In the 14 visualisations that circulated across platforms, we observe that, on Twitter, these visualisations are part of seven of the nine storylines (there are no visualisations of scientific development or advancing the agri-food sector) (Table 5.1). On the open Web, the five visualisations for which nanotechnology in food is discussed among the URLs on which they appear, are part of all the nine storylines revealed on Twitter. Another storyline appears on the open Web but not on Twitter – some unknowns – according to which nanotechnology's complete effects on health and the environment are still unknown (Tables 5.4 and 5.6).

Other interesting results relate to the storylines narrated in URLs (Tables 5.2–5.6). We observed that, over time, a single visualisation was part of an URL's multiple

storylines. Although these storylines varied among URLs, usually, over time, one storyline was repeated in all URLs. Another observation is that the multiple storylines of a single URL together can communicate some complexity, for example about nano-sized plastic particles contained in food and drinking water and found in human organs, but much is unknown about their harmful effect (Table 5.6).

5.5 Discussion

In this section, we summarize our results (Table 5.7), put them in the wider perspective of our contribution to the literature, and specify the limitations of our study and our recommendations for further research.

On Twitter (Table 5.7), within the boundaries of the nanotechnology-in-food topic, the distribution of the textual tones demonstrates that visualisations belonging to the most retweeted tweets circulate, on Twitter, mostly with text conveying a message with a particular sentiment towards nanotechnology in food. These findings are in line with previous research on policy issues on Twitter, in which tweets are considered strong framing devices (Stevens et al., 2018): given that tweets are effective in framing a topic, it is not surprising that most tweets with visualisations have either a positive or a negative textual tone.

The tone analysis is complemented well by the analysis of image–text storylines when the aim is to reveal the meaning of a visualisation – storylines reveal a more nuanced message conveyed in the accompanying text, and this message can position the visualisation in a specific context that influences its meaning. In our analysis, we see that the image–text storylines varies when either positive, negative, or neutral message is conveyed (Table 5.7). For example, tweets with a positive tone narrated storylines of food security and food sustainability and also of benefit for the consumer. When analysing visualisations embedded in tweets, a storyline analysis is especially valuable in revealing the meaning as the storyline's condensed nature (see Hajer, 2006, p. 69) makes it suitable for a platform with space limits such as Twitter.

Table 5.6. Plastic pellets on a finger (see the visualisation here https://www.shutterstock.com/image-photo/small-plastic-pellets-on-finger-air-1491378407), a photograph of a human finger with small plastic pellets on it

Publication date	ND	3/Mar/19	2/Apr/19	3/Sep/19	6/Oct/19	7/Oct/19	10/Nov/19	2/Jan/20	24/Feb/20	24/Feb/20	26/Feb/20	9/Mar/20	19/Mar/20	3/May/20	20/May/20	13/Jul/20	19/Jul/20	20/Jul/20	4/Aug/20	2/Sep/20	3/Sep/20	28/Sep/20	29/Sep/20	28/Oct/20	Twitter							
URL	shutterstock.com	earth.com	stowa.nl	istockphoto.com	peamun.org	washingtonpost.com	24life.com	sourcingjournal.com	arabnews.com	arabnews.com	forbes.com	ecomogulmagazine.com	cardiffstudentmedia.co.uk	solutions4plastic.co.uk	newsweek.com	veganhkblog.com	nemo.co.nz	zerowastecalifornia.org	heropackaging.com.au	knau.org	geektech.me	innovationnewsnetwork.com	healthiguide.com		vision.org							
URL topical context	Plastic particles from waste stream																														
URL - Nanotech. in food discussed																															
Tone																															
Storyline																	Cntm.; Unknwn						Cntm.	Cntm.	Cntm.; H.con; Unknwn						

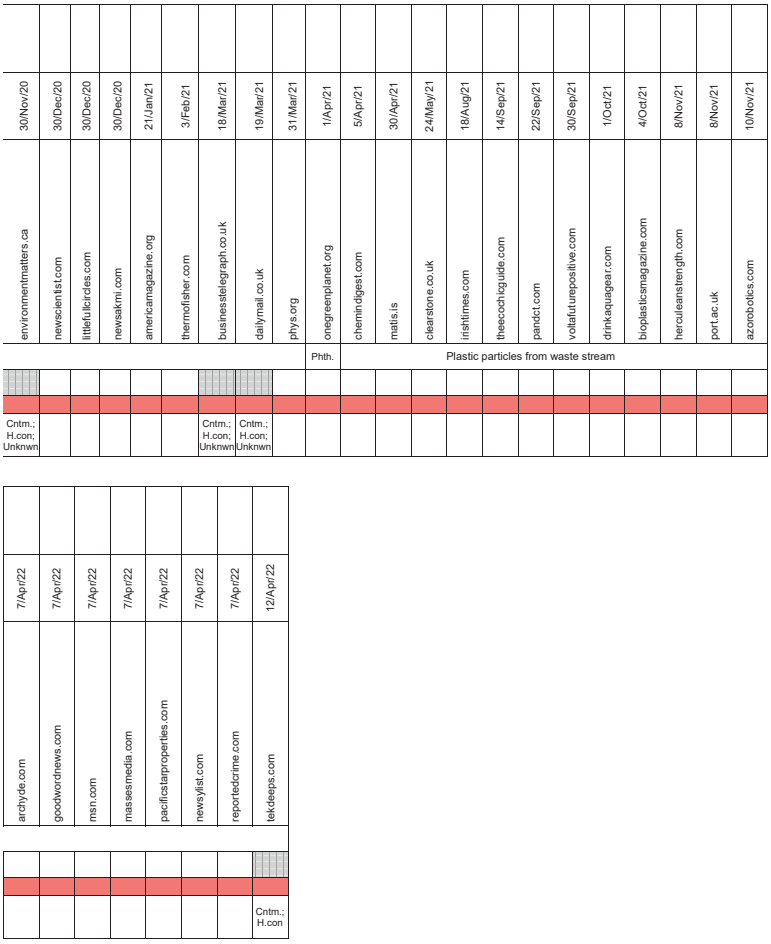
	15/Nov/21	21/Nov/21	23/Nov/21	30/Nov/21	3/Dec/21	27/Dec/21	17/Jan/22	18/Jan/22	20/Jan/22	7/Feb/22	10/Feb/22	10/Feb/22	24/Mar/22	24/Mar/22	27/Mar/22	28/Mar/22	29/Mar/22	30/Mar/22	30/Mar/22	6/Apr/22	6/Apr/22	7/Apr/22										
	sciencenorway.no	theconversation.com	newatlas.com	thenetzeroreport.com	globalwarming-arclein.blogspot.com	hydroviv.com	azonano.com	frb-reporter.com	port.ac.uk	projectebisc.org	reporter.mcgill.ca	community.mcgill.ca	plastics.org.au	fanaticcook.com	thehansindia.com	tikibytes.com	hindustanchronicles.com	edtimes.in	samacharlive.com	mirror.co.uk	gamingdeputy.com	newsweek.com										
	Plastic particles from waste stream																														
							Cntm.; H.con; Unknwn	Cntm.; H.con		Cntm.; H.con	Cntm.; Unknwn	Cntm.; Unknwn																				

Note:

Negative tone-of-voice towards the topic

Abbreviations:
Topical context: Phth.=Phthalates
Storylines: Cntm.=Food contaminant; Unknwm=Some unknowns; H.con=Health concern

Along the storyline analysis and through our study, we encountered visualisations that, together with their accompanying text, seem to indicate some form of misinformation. Some examples are the visualisations of chemtrails and smartdust. Further research could be directed towards the examination of the type of (mis)



information to which the public is exposed in the context of nanotechnology in food, focusing on the use of visuals in communicating both information and misinformation.

The findings of the cross-platform analysis illustrate how the fact that a platform has no space limits enriches the narrative. Whereas most tweets narrated only one storyline, many URLs narrated multiple storylines. When a single tweet/URL was part of multiple storylines, however, only on the open Web did these storylines typically appear with text of different tones (for example, a positive health benefit

Table 5.7. Findings summary. The distribution of tone of accompanying text and nanotechnology-in-food image–text storylines on Twitter and the open Web

Circulation platform	Visualisation(s)	Meaning on Twitter		Meaning on the open Web	
		Tone of accompanying text discussing nanotech. in food	**Nanotechnology-in-food storyline of which the visualisation is part**	**Tone of accompanying text discussing nanotech. in food**	**Nanotechnology-in-food storyline of which the visualisation is part**
On Twitter	Various (46 visualisations)	Positive (40 tweets)	Food security and food sustainability; Health benefit; Scientific development; The nano future is here; Advancing the agri-food sector; Benefit for the consumer		
	Various (46 visualisations)	Negative (36 tweets)	Food contaminant; Health concern; Ethical concern		
	Various (12 visualisations)	Neutral (14 tweets)	Scientific development; The nano future is here; Advancing the agri-food sector		
Across Twitter and the open Web	Natural world collection	Positive (1 tweet)	The nano future is here	Positive (3 URLs)	Advancing the agri-food sector; The nano future is here
	Smartdust	Negative (1 tweet)	Ethical concern	Negative (15 URL)	Ethical concern; Health concern
	Injected tomato	Positive (1 tweet)	Health benefit	Positive (4 URLs); Neutral (1 URL)	Health benefit; Advancing the agri-food sector; Health concern; Some unknowns; Benefit for the consumer; Scientific development; The nano future is here
	Woman farmer in a cereal field	Positive (2 tweets)	Food security and food sustainability	Positive (2 URLs)	Advancing the agri-food sector; Food security and food sustainability; Health benefit; Scientific development
	Plastic pellets on a finger	Negative (1 tweet)	Food contaminant	Negative (12 URLs)	Food contaminant; Some unknowns; Health concern

and negative health concerns, Table 5.4). This conveys a more complex or nuanced message than a single-tone message, for example one about the many benefits of nanotechnology in food but also the risks involved in it. Such a message is perhaps difficult to convey in a compelling way in a tweet's limited space. Embedding visualisations in a tweet is a way of dealing with Twitter's extreme space constraints (Boscarino, 2022). Our findings show that, although visualisations add information to the message conveyed through text (for example, by visually illustrating scientific innovations) or support the text (for example, by providing evidence for a claim made in the text), their capability to help deal with Twitter's space constraints is limited. To gain more insights into the way in which a message is conveyed on various platforms and visualisations' role in it, further research could use other data-gathering strategies and compare storylines narrated on different platforms with and without the use of visualisations.

The findings of the cross-topical context analysis (Table 5.1) show that, on the open Web, visualisations used on Twitter in the context of nanotechnology in food are not unique to the topic and are used in various topical contexts. The topics of URLs discussing nanotechnology in food can be seen as related to nanotechnology in food, directly or indirectly. These topics include, for example, the agri-food sector, miniature tracking chips in food and elsewhere, and GMO. However, visualisations used on Twitter in the context of nanotechnology in food appeared also in URLs that not only do not discuss nanotechnology in food but also whose topic has nothing in common with nanotechnology in food, for example parenting or makeup. Given that an imagery associated with a topic can affect public discourse and contribute to the construction of political narratives (Baker & Walsh, 2020; Pentzold et al., 2019), further research should be directed towards revealing whether there is imagery associated with nanotechnology in food by constructing a visualisations dataset using other methods.

When digital visualisations circulate, online content is networked (Niederer, 2018; Niederer & Colombo, 2019). Thus, the fact that two topics are connected by using a shared visualisation can add another dimension to the connection between the topics. Our findings show that the injected tomato visualisation (Table 5.4) is used in the context of both nanofood and GMO. The literature states that, concerning public acceptance, these two topics are connected: nanofood is often analogized to GMO to communicate a fear that it might arouse controversy similar to that

aroused by GMOs (Handford et al., 2014; Henchion et al., 2019; Schwarz-Plaschg, 2018). In the context of nanofood, this visualisation is (still) used mostly with positive text and as part of positive storylines, whereas, in the context of GMO, the visualisation is often used with negative text. This observation may be relevant to the discussion about the connection between the two topics, nanofood and GMO.

This study suggests, through the in-depth analysis of five selected visualisations, that, although visualisations circulate across topical contexts, within the boundaries of a specific topic their meaning, as reflected in the tone of the text accompanying it, remains mostly stable. Although our number of examples is limited, we still find it worth mentioning that four of the five visualisations, which circulated but stayed mostly within the boundaries of one topical context – natural world collection, smartdust, woman farmer in a cereal field, and plastic pellets on a finger – were mostly accompanied with a single-tone text. Further research could expand the study of meaning and topical-context association by studying more visualisations and more URLs on which they appear.

This paper reports three forms of circulating: within a platform, across platforms, and across topical contexts, and links this to changes in textual tone and image–text storylines, over time. By so doing, the paper refines the notion of circulation, thereby allowing a rich and comprehensive empirical picture to be drawn that is unique in its precise way of describing changes of meaning in the digital world.

Limitations and recommendations for further research

The contribution of the innovative conceptual approach and the original method developed in this study are significant. However, the method also has its limitations. Firstly, the method reveals circulation across topical contexts that occurs across platforms and on the open Web, but it does not reveal any cross-topical context circulation on Twitter, as only tweets about nanotechnology in food were gathered. Further research can use the topical contexts revealed here to study – on Twitter – the circulation across topical contexts of visualisations about nanotechnology in food.

Secondly, the method relies on Google's black-boxed algorithm that dictates, possibly in a biased way, the part of the web that is being indexed, which

information sources are privileged over others, and how results are localized (Allen, 2021; Gerhards & Schäfer, 2010; Rogers, 2019). To address this, further research could use a more transparent research-designated tool.

Other limitations arise from conducting an in-depth analysis of a limited number of visualisations and gathering URLs in English only. Extending the number of visualisations and languages will provide an even richer empirical picture and could identify whether this study's findings are universal, or specific to a language area.

5.6 Conclusion

The paper explores three forms of circulation – within a platform (Twitter), across platforms (Twitter and the open Web), and across topical contexts – by analysing the (dynamic) meaning as reflected in the tone of the visualisations' accompanying text and the image–text storylines. We analysed 90 tweets about nanotechnology in food, their 104 visualisations, and 667 URLs on which these visualisations were found.

The paper demonstrates how, on Twitter, visualisations and their accompanying text narrate opinionated message about nanotechnology in food – either positive, mostly about food security, food sustainability, and health benefits, or negative, mostly about food contamination and health concerns. When circulating on both Twitter and the open Web, the accompanying text on the open Web conveyed a more complex and nuanced message than that on Twitter. The paper also suggests that the connection between multiple topics that use shared visualisations is enriched and worthy of investigation, and that the circulation of visualisations across topical contexts is a specific form of circulation that allows precise insights to be gained into how the meaning of visualisations changes in the digital world. The rich and comprehensive empirical findings, the refined conceptual approach, and this study's innovative method can form the basis for following research that will extend the study of the circulation of digital visualisations of nanotechnology in food and other topics. This would add an important dimension to the understanding of visualisations' role in communications about a contested issue.

CHAPTER 6

Discussion and Conclusions

In this final chapter, I will first show how I addressed the main research question through the sub-questions. This is followed by a discussion, reflection on methods and suggestions for further research. I conclude with recommendations for practice and a final remark.

6.1 Main research question: Answer and Discussion

This thesis investigated the role of visualisations in policy controversies over energy and food technologies. The research aimed to reveal what meanings of contested energy and food technologies are conveyed by visualisations in policy controversies. Hence, the main research question was:

What meanings do visualisations convey in policy controversies over energy and food technologies?

I addressed this question through a conceptual framework of three aspects of visualisations' meaning-making: (1) type and content, (2) narrative and (3) circulation. For each element, I formulated a sub-question that I will answer here. See Annex D for a detailed overview of the results per sub-question.

6.1.1 Type and Content (sub-question 1)

In this section, I discuss my findings of patterns of using visualisations and, in particular, specific visualisation types and content. Hence, I answer the question:

What patterns of type and content can be revealed in an online policy controversy?

In the online controversies I have studied, actors generally give meanings to the contested technology using visualisations of a specific type and content: Often, data-related visualisations are used, and the content of the visuals in the studied controversies is specific to a topic. But there is more to say about these findings.

First pattern: Extensive use of data-related visualisations

Our results indicate that data-related visualisations are used more extensively by opponents than by proponents and mostly are accompanied with a negative

textual message. These visuals are used to frame technologies as both risky and beneficial. In energy controversies, infographics and maps are most often used; in food controversies, these are infographics, charts and diagrams. The fact that opponents use data-related visualisations more than proponents do perhaps reflects the effort of opponents to gain legitimacy and credibility for their claims, which often contradict mainstream claims.

Infographics, maps, charts and diagrams often depict a combination of information and a frame or sentiment, mixing facts with an expression of perspective on the controversial topic. They include selected information that is being used in combination with a particular textual message, thus giving specific meanings – positive, benefits-related or negative, risk-related – to a policy issue. Chapter 3 shows how in energy technology controversies, actors most of all use maps and infographics and select what information to include in them, thus creating distinct meanings: risks-related meaning (for example, of opposition) or benefits-related meaning (for example, of geological potential). Chapter 4 shows how in food technology controversies, many diagrams and charts with information about food classification are used mainly with a negative textual message about processed food being unhealthy, thus creating a distinct risk-related meaning of a group of foods, i.e., processed foods, being unhealthy. The use of 'scientific' visualisations such as infographics, charts and diagrams may be seen as another strategy of framing visuals as endorsed by scientific authority, without actually involving scientists in the generation of these visualisations (e.g., Schwarz, 2013, p. 174).

Second pattern: Content associated with a topic

Actors give meanings by using specific visual content, which is used in a particular way. Patterns of using visual content were present in the two domains, energy and food. Online fracking controversies frequently draw on visuals of natural and industrial landscapes, people (officials, protesters) and flames. Flames were portrayed to give meaning to both risks and benefits. Visualisations which give a risk-meaning show flames where they do not belong, to create a sense of danger, and visualisations which give a benefit-meaning show controlled and routinely-used flames, to create a sense of casualness.

In the online-processed food controversy, less data-related visualisation was used and more photography, much of which is about food abundance. In the

nanotechnology-in-food online controversy, miniature pellets or particles, scientists and scientific activity are often seen. For both processed food and nanotechnology in food, visuals of food and people interacting with it were used. Again, sometimes they communicated the risks or benefits of food technologies. People interacting with food and food abundance were frequently depicted to convey a risk-meaning in the sense of the many temptations; similar visuals conveyed a benefit-meaning when the emphasis was on the variety offered when making food choices.

6.1.2 Narrative (sub-question 2)

In the Introduction chapter, I defined policy controversies as social conflicts in which networks of actors express competing framings of a policy issue. Online, these actor networks compose online publics. In this dissertation, I have studied two types of online publics: online discourse coalitions and online sentiment coalitions. A discourse coalition is 'a loose network of actors who develop a shared way of interpreting a policy issue' (Metze & Dodge, 2016, p. 366). A sentiment coalition is a group of (online) actors that predominantly express positive, negative or balanced sentiments about an issue. In their framing process, online discourse and sentiment coalitions use frames and storylines (referred to together, in this dissertation, as narratives), which are reflected in their text and visualisations. Hence, discourse and sentiment coalitions use, in their framing, word and visual-based narratives. In this section, I discuss the three ways they do so. Hence, I answer the question:

How do coalitions in a policy controversy use visual and textual narratives?

In the controversies I have studied, the narratives most observed are those of risks and benefits of technologies. Risk narratives were often more prevalent than benefit narratives. In all cases, actors use visualisations to make textual narratives more concrete and literally more visible by (1) relating the technology to 'casual', everyday objects or events and (2) isolating objects and magnifying them.

By using visualisations, actors give concrete visual examples of the risks and benefits mentioned in the text. This way of visualising narratives makes abstract risks or benefits concrete. By showing flames coming out of a well or even a kitchen faucet, an abstract risk narrative, expressed through text, becomes tangible. By

visualising people protesting or providing data about communities that declared themselves free of shale gas, the unspecific narrative of opposition to fracking becomes more particular. By showing a local symbol, the general narrative of a negative effect on the environment is associated with particular local and unique characteristics. Similarly, showing natural landscapes makes the generic narrative of protecting the environment specific to a place. The showing of government officials makes the loose narrative of supporting an energy technology factual. The display of a local symbol makes more real the general narrative of benefitting local communities.

In the food controversies studied online, the visualisation of narratives makes the invisible or unnoticed seen. One way of doing so is to *show 'casual' things in combination with a particular text message*. Thus, showing people shopping for food and food abundance next to text about harmful food ingredients or technologies encourages the reader-viewer to rethink the risks involved in these otherwise considered harmless foods or interactions with them. Similarly, the positioning of casual things such as food abundance, people in industrial-food sites and scientific activity next to text describing food security and progress constructs narratives that encourage one to rethink the taken-for-granted objects, situations or activities as reflecting benefits.

Another way to make invisible or unnoticed objects visible is by *visually isolating objects or magnifying them*. This way of visualising makes the reader-viewer aware of things related to these objects – things that are otherwise often overlooked or impossible to see with the naked eye. Thus, the visual isolation of plastic pellets in combination with text describing the health risks posed by plastic residues raises awareness of food contamination as a result of discarding ordinary plastic products. The showing of nanostructures next to textual information about the health benefits of using nanoscale food additives raises awareness of the health benefits offered by adding these invisible ingredients. The technique of magnifying objects is shown to raise awareness of an idea also in a previous study, where a lab-produced image that found its way into popular media is shown to raise awareness of the potential of nanotechnology and the power of science (Merz, 2011, p. 353).

In answering this sub-question in more detail, I found three distinct ways in which coalitions form around frames and storylines: (1) by emphasising different visual or textual aspects, (2) by having different degrees of coherence between the visual and text and (3) by developing an image–text storyline.

First way of using visual and textual narratives: Emphasising different aspects
When looking into the framing processes of online discourse and sentiment coalitions, we found that they visually emphasise different aspects than those emphasised textually. The emphasis of multiple distinct aspects can change the meaning given to the contested issue. For example, Chapter 4 shows that in the online controversy over processed food, in addition to a textual frame of processed food offering many possibilities and health benefits, the fact that processed food is produced by people was visually emphasised. Based solely on the text, the meaning given to processed foods is of something that brings many benefits. On the basis of the visuals, the meaning is of something that is not that different from food prepared at home or in a restaurant. Both meanings convey a positive sentiment, but in two distinct ways.

When looking into the ways coalitions, in their framing, visually emphasise different aspects than those emphasised textually, we found that they portray particular visual content in specific ways (for example, they show foods – in the supermarket, being served, being eaten, etc.) and also use visual qualities such as vivid colours and techniques such as zooming or capturing a scene from a particular angle. Hence, in addition to utilising language in specific manners (e.g., using metaphors) when framing a policy issue (Bulkeley, 2000; Hajer, 1995; Metze & Dodge, 2016), coalitions also employ visual content, qualities and techniques. For example, Chapter 3 shows that a research institute zooms in on an infographic of a well to expose the audience to the subterranean layers through which a well penetrates. The chapter suggests that it is a way of showing the broader context in which drilling is used while textually framing it as potentially risky. Chapter 4 shows that a negative coalition frequently uses photographs of foods taken from a particular angle. The chapter suggests that it is a technique to emphasise the extreme variety of processed foods while textually framing them as unhealthy.

Second way of using visual and textual narratives: Different degrees of coherence
In this study, I also set out to figure to what extent visual and textual narratives are coherent, in the sense that they convey a single frame. In Chapter 3, we found that in their framing process, when coalitions employ visual and textual narratives, there are multiple degrees of coherence between visual and textual narratives. In the Dutch and New York online fracking controversies, flames, for example, when depicted in a particular way, are shown to repeat the textual frame of a coalition of environmental risk. On the contrary, in the South African fracking controversy, a visual symbol of a water-pumping mill constructs a storyline of energy independence that is slightly different from the coalition's textual frame of fracking as potentially risky in specific local circumstances. Both frames, visual and textual, attend to the local context in which the fracking technology should be evaluated, but while the textual frame highlights the unknowns, the visual storyline illuminates what already exists. The different degrees of coherence can cause a strengthening of a textual narrative using visualisations or a weakening of it, to the extent that visualisations can contribute to the breaking apart of a coalition or the uniting of multiple discourse coalitions, thus influencing their formation (see Metze & Dodge, 2016). Chapter 3 gives several examples of this potential in the context of the Dutch, New York and South African online fracking controversies.

Third way of using visual and textual narratives: Composite image–text meaning
The comparison of the use of visual narratives to that of textual narratives, conducted in Chapters 3 and 4, leads to the conclusion that the complete meaning of a contested issue is conveyed by narratives composed of both visualisations and text. The two modes, the visual and textual, commonly coexisting in online communication, construct a single multi-layered meaning. This idea has been further developed in Chapter 5, by coining the concept *image–text storyline*, a storyline that is constructed through the use of visual content, qualities and techniques, in combination with text. Using this concept, we found that on Twitter, in a nanotechnology-in-food context, actors give positive, negative and neutral meanings to the technology by using a variety of image–text storylines. Positive Tweets commonly narrate image–text stories of food security and food sustainability, and negative tweets commonly narrate image–text stories of food contaminants and health concerns. On the open Web, in the same context, visualisations and their accompanying text narrate image–text storylines similar

to those narrated on Twitter, in addition to a new image–text storyline narrated in some URLs, according to which the complete effects of nanotechnology on health and the environment are still unknown.

6.1.3 Circulation (sub-question 3)

My study shows that the meanings of online visualisations of policy controversies over energy and food technologies may change during three processes of circulation: within a platform, across platforms and across topical contexts. In this section, I discuss the findings for change in meaning of circulating visualisations. I first give an overview of the findings; then, I elaborate on the change in meaning in the three processes of circulation. Hence, I answer the question:

(How) does the meaning of visualisations related to a policy controversy change when they circulate?

We found that, over time, visualisations about shale gas and nanotechnology in food circulate on the open Web and Twitter. The text accompanying the visualisations is different and can also be about different topics. For example, in Chapter 5 we show that visualisations used on websites talking about nanotechnology in food were also found to be used within a topical context of GMOs and mRNA-vaccines. Hence, the composite image–text meaning can vary. However, within the context of a single topic, our data shows that meanings of visualisations are multiple but mostly similar. Usually, their meaning remains either risks- or benefits-related. Depending on the platform on which they are used, they communicate a message with different degrees of complexity. More complex meaning is given, not surprisingly, on websites compared to Twitter. An additional finding is that the meanings that visualisations convey also change in co-occurrence with the evolvement of the policy controversy. Both the type and meaning of the visuals used seem to be related to the stance actors have in a controversy.

First type of change in meaning: Within-platform circulation of specific visualisations

In the online controversy over nanotechnology in food (Chapter 5), one group of visualisations we have studied circulated on Twitter (i.e., were used in different Tweets over time) and another group circulated on the open Web (i.e., were used on different URLs over time). Using the concept of an image–text storyline, I found,

both on Twitter and on the open Web, that the meaning of nanotechnology in food, given by visualisations in several tweets or URLs, remains mostly stable. I analysed this meaning based on the tone of voice in the accompanying text and the composite image–text storyline. The findings, for example, were of a visualisation depicting a miniature tracking device with GPS capabilities. This visualisation appears in 29 URLs in our dataset, and in 20 of them the text has a negative tone; when an image–text storyline about the technology is narrated (in 15 URLs), it is always about ethical concerns. The stability of the meaning is also reflected in the image–text storylines narrated when multiple storylines coexist in a single URL. These multiple storylines are often of the same tone – positive or negative. In the example of the miniature tracking device, when two image–text storylines are narrated in a single URL (occurs seven times), they are both negative: One storyline is about an ethical concern, and the other is about a health concern.

Second type of change in meaning: Cross-platform (Twitter and the open Web) circulation of specific visualisations

In the online controversy about nanotechnology in food, a group of visualisations circulated on Twitter and the open Web. I found that, in our dataset, visualisations that give meaning to nanotechnology in food do that, on Twitter, almost always using a single image–text storyline, whereas in the open Web, visualisations give meaning by using multiple image–text storylines, which add dimensions to the meaning and make it more nuanced. One example is on Twitter, where a visualisation of a woman farmer in a cereal field gives smart agriculture a meaning of food security and food sustainability, together with its accompanying text. It does so using a single image–text storyline of food security and food sustainability. The same visualisation gives the smart agriculture technology a more nuanced meaning on the open Web, where several image–text storylines are added to the food-security-and-sustainability storyline, advancing agri-food, health care and scientific development.

Third type of change in meaning: Circulation across topical contexts

Studying visualisations networked to the fracking topic, in Chapter 2, my colleagues and I found that changes occurring, over time, in this visual content create patterns of using visualisations. As the controversy intensified, there is a growing presence of opponents in the visual online controversy, and more data-related visualisations are used in combination with fewer photographs of governmental officials. As

opponents become more dominant, more types of visualisations are used and a greater variety of visual content is included in them. In addition, visualisations of the controversy can change over time in relation to the extent to which the controversy polarises. In Mexico, for example, at an early stage, a considerable amount of visualisations that express the idea of a promising technology were used in the online controversy, but when the controversy intensified, their use decreased and more visualisations with the meaning of environmental risk were used online.

The results in Chapter 5 show that on the open Web, visualisations of nanotechnology in food are also used in the context of food production, food waste, the agri-food sector and GMOs. Limited data suggests that in different topical contexts, the meaning of the same visualisation changes – the same visual can be used both with a positive and negative sentiment when used for different topics.

Overall, the analysis of circulation of visualisations on Twitter and the open Web is a way of studying how policy controversies develop online. The combination of an analysis of the networks of visualisations forming around a topic with the analysis of the stance of the actors using them and an in-depth interpretive analysis of the textual-visual storylines can show how the controversy evolves. This can perhaps indicate when controversies tend to escalate, polarise or calm down.

6.2 Conclusions

I started this research with a puzzle about visualisations as powerful meaning-makers in policy controversies. In this section, using the conceptual framework I developed of three aspects of visualisations' meaning-making, I introduce my conclusions, which try to make this less of a puzzle (see Schwartz-Shea & Yanow, 2012, p. 27).

6.2.1 Type and Content

There are three conclusions to draw on the role of the type and content of visuals in policy controversies. First of all, the fact that in the controversies I have studied, 'scientific' visualisations are used extensively, more by opponents than by

proponents and more with a negative textual message than a positive one, reflects the importance of disseminating information in a 'scientific' manner, especially by opponents, who are typically non-scientists. In a previous study, visualisations have been shown to be effectively used to refute scientific arguments, often through a particular production mode (namely, software that enables the creation of surreal images) (Clancy, 2017; Clancy & Clancy, 2016). This thesis shows visualisations can be used by non-scientists not only to question scientific authority but also to convey a sense of it, by using another production mode (namely, software that enables creating charts and diagrams).

Second, online visual content in policy controversies about contested technologies puts at the centre considerations and concerns that might otherwise remain marginal. Chapter 3 shows that in the South African online fracking controversy, a local visual symbol was used in combination with a textual manifestation of two distinct storylines, one of potential risks and another of potential benefits. Whereas both textual storylines are used in a local context, of South Africa and the Karoo specifically, it is the visual which makes the local circumstances stand out. In doing so, it placed the consideration of the unique characteristics of the Karoo in the foreground. Chapter 4 shows that in the processed food controversy studied online, visualisations of people hesitating about what foods to buy were commonly used, in addition to textual integrated information on both the health-related risks and benefits. Whereas the text mostly only implies that those risks and benefits, coexisting in many foods, might make it harder for consumers to choose which foods to buy, the visualisations make it stick out. In doing so, they put the concern of consumers making the right food choices when shopping for food at the centre.

Third, visualisations play an essential role in policy controversies not only as objects responding to external claims or events, but also in themselves. A previous study shows the successful use of visuals to mobilise the public and influence decision making. A study on Greenpeace's achievement in the Brent Spar case ascribes much of Greenpeace's success to victimising itself, as a representative of public interests, to visualisations – 'without an image of a powerful bully, Greenpeace could not play victim' (Jordan, 2001, p. 123). However, the success is in seizing opportunity, successfully translating actions (the occupation of Brent Spar) into memorable and influential visuals – 'they [Greenpeace] knew that no occupation

could last forever, but, "It is more a case of actions being made into scenes to generate images, which put a dazzlingly bright light on the perpetrator and attack his legitimacy with the public'" (Wolfgang Sachs cited in Jordan, 2001, p. 21). In the above-mentioned study of the GMO controversy, the success of the anti-GMO campaign is attributed to online distributed visualisations, while acknowledging that these visualisations successfully responded to scientific arguments - visualisations were 'able to refute rationalist discourses about the safety of GMOs' (Clancy & Clancy, 2016, p. 279). This thesis suggests that patterns such as extensive use of data-related visualisations and repeatedly using the same content make the visual dimension of an online policy controversy an essential element in its dynamics not only as a response to any claims or events, but also in its own right.

6.2.2 Narrative

There are three conclusions about the role of narratives of online visualisations in policy controversies. First of all, I conclude that in policy controversies about contested technologies, online visualisations try to convince of a framing of a technology as posing risks or offering benefits by giving risks and benefits the meaning of being real. By making discursive risk and benefit-related narratives visible, visualisations make these risks and benefits tangible and hence easy to envision. Through the portrayal of concrete landscapes, real people protesting and maps or symbols of actual places, risks such as environmental risk and benefits such as economic benefit become concrete and easy to perceive as true.

Second, visualisations in online policy controversies also try to convince of framing of a technology as either posing risks or offering benefits by encouraging to rethink these risks and benefits as embedded in routine activities and ordinary objects. By making these narratives visible, visualisations make these risks and benefits part of our daily life. By isolating everyday objects, focussing on everyday activities, using vivid colours or applying other visual techniques, and doing these things in combination with a particular textual message, casual activities (such as shopping for food) and familiar objects (such as a food plastic bag) are encouraged to be considered as involving risks such as health risk or offering benefits such as scientific progress.

Third, the narratives constructed by visualisations add new information or focus, creating a layer of meaning more multifaceted and richer than the one

given to the issue by using text only. As shown in other studies (Kress, 2010; Van Leeuwen, 2001), the visual can reveal an underlying message, often an ideological one, which makes an image–text message multi-layered. In the context of a policy controversy, this multi-layered meaning can reveal something about the perspective on the controversial issue. Thus, when a negative textual message about harmful foods appears alongside visualisations focussing on the attractiveness of these visually appealing foods, it is important to note the visuals' focus on how difficult it is to escape these harmful foods. This particular way of visualising harmful foods perhaps reflects that the surrounding is considered an essential element influencing an individual's food choices and therefore part of the problem. Hence, the specific way chosen, even unconsciously, to visualise a textual message, among endless available ways of doing so, adds new information to the expressed perspective communicated about the controversial issue.

6.2.3 Circulation

There are three main conclusions about the role of the circulation of online visualisations in policy controversies. First of all, I conclude that in online policy controversies about contested technologies, the meaning visualisations convey may change over time, in different ways. When a change takes place in visualisations that circulate within-platform, the composite image–text meaning changes because visualisations are accompanied with various pieces of text that might even be about topics that have nothing in common. For example, in our dataset, a specific visualisation was used on websites in the context of milk/lactose and also parenting.

Second, the meaning of online visuals changes across platforms. The meaning of composite image–text changes because visualisations are accompanied by various pieces of text; additionally, it changes also because platforms vary in their affordances and the ways they encourage interaction. Websites, for example, do not have the same space limitations as Twitter. Hence, visualisations on websites, together with their accompanying text, are often shown, in our dataset, to give more complex meaning to the topic than they give on Twitter. Most studies about cross-platform circulation of visualisations gather big data and make conclusions about the phenomena of circulating across platforms and the characteristics of the platforms on which the visualisations circulate (e.g., D'Andréa & Mintz, 2019; Pearce et al., 2020). This thesis shows the potential of cross-platform analysis to

also lead to insights into the topics visualisations circulating within their context. Thus, Chapter 5 states that the circulation of visualisation can network topics and that observing the nature of this connection can be relevant when investigating the networked topics. The chapter suggests, for example, that the nature of the visual networking of nanotechnology in food and GMOs is worthy of investigation, as it may lead to more knowledge about these two topics.

Third, a change in the meaning of visualisations can take place when a topic connects visualisations together, and over time some visualisations are disconnected from the network while new visualisations are connected to it. The studied online fracking controversies seem to suggest that the meaning of networked visualisations changes over time because different types, content and narratives of visualisations are networked. This type of change in the meaning of visualisations was previously studied in the context of climate change (Niederer, 2018; Niederer & Pearce, 2017), comparing the platforms on which visualisations are networked. This thesis suggests studying this type of change to gain knowledge of the role of visualisations in the dynamics of online policy controversies.

6.3 Reflection on, and discussion of, methods and recommendations for further research

In this dissertation, I took an interpretive approach and further developed it to also include the visual. I chose an interpretive approach as this dissertation focusses on visualisations as objects making meaning, and the interpretive approach aims to understand how different meanings given to human-created artefacts by various (groups of) people exist (Schwartz-Shea & Yanow, 2012, p. 42; see also Yanow, 2007). In this section, I reflect on the methods used for gathering and analysing data and I point out a number of directions for further research.

6.3.1 Limitations to working with digital methods

Throughout the project, I worked with several digital methods tools and each time found that this comes with different limitations. For example, there are limitations to the reliance on commercial companies (Google and Twitter). There are also limitations to automated categorisation software of both visuals (ClarifAI) and text (sentiment analysis as developed by Roel Kuiper, a student in the team

and myself). For almost all of the chapters, I relied on the Google search engine, including Google's reverse image search. Google's results are possibly biased and black-boxed (see Rogers, 2019, p. 109). I tried to mitigate this limitation by conducting anonymous searches, cleaning the search history and checking the searches in other search engines such as Duckduckgo. Additionally, the gathering of data using Google and also Twitter API (special thanks to Prof. dr. Art Dewulf for enabling this) is 'sensitive to keywords' (see Rogers, 2019, p. 37) and therefore has the risk of not being exhaustive, when relevant keywords are not known to the researchers. Limitations that come with the reliance on automated visual categorisation exist in Chapter 2, where we used software (ClarifAI) that labels visual content by categorising it as humans, landscapes, icons, etc. This labelling has limitations; for example, the software does not consider any cultural context when labelling content. Additionally, some visual content may be ambiguous, in terms of labelling. Whereas in manual labelling (often termed coding), ambiguity can be discussed with others until an agreement is reached, the software simply provides its black-boxed verdict.

6.3.2 Limitations to working with interpretive methods

In each of the chapters, I have been working with interpretive methods. The use of interpretive methods comes with limitations: The construction of coalitions can be done in different ways, and the coding of sentiments, narratives and storylines can also be conducted in different ways. In addition, in Chapter 3, the grouping of visuals based on type and content was mainly interpretive and manual and can be done in different ways. To mitigate these limitations of interpretive research, I checked the textual and visual coding with the team of supervisors and a team of students working on similar topics. We also did this for the type of visuals and included a visualisation expert from the Netherlands Environmental Assessment Agency (Filip de Bois), to enable rigorous and relevant coding.

Another difficulty was that there are also visualisations that contain text integrated into them, and I needed to decide how to approach this text: as text belonging to the textual analysis, as an element with only visual qualities (thereby ignoring the readable message) or as an element that has both visual and verbal qualities. I opted for the third option. Selecting any of the other options, obviously, would lead to a different analysis.

Additionally, the analysis of image–text storylines in tweets in Chapter 5 was challenging, especially given the fact that on some occasions, only nuanced details in the text or the visualisation reveal the storyline. The failure to notice these details might have resulted in an inaccurate analysis. For example, one tweet contained the text, 'Do you know which foods contain #nanotechnology? New searchable database: http://ow.ly/T5cNp' and a visualisation of magnified structure with a layer of the text: 'NANOTECHNOLOGY IN OUR FOOD / An Interactive Database Consumer Food Products Containing Nanomaterials'. Whereas the text and the visual could be considered informative, a close reading of them both reveals a warning tone. The text emphasises the surprise element (implying that consumers are not being informed about nanomaterials in their food), the text-layer in the visualisation is in red, and there is a logo in the visualisation of the Center for Food Safety, which implies there is a safety issue with nanomaterials in food. When checking the link in the tweet, the storyline of health concern is confirmed.

6.3.3 Recommendations for further research

Further research can test the research protocols we used and the results in larger datasets and in the context of other controversial technologies or policy controversies, more generally. Such research can use digital tools for the gathering and analysis of data. It should be noted that digital tools, either offered within no particular context (e.g., search engines) or specifically for conducting academic research (e.g., Twitter API for academic researchers), are often black-boxed and are possibly biased. Ideally, future research will use transparent software tools that will be completely independent of any black-boxed algorithms. Further research can also rely on my interpretation as a theoretical starting point when studying visualisations as playing a role in other policy controversies.

6.4 Recommendation for practice

In this section, I make several recommendations for policy controversy analysts and for those who visualise issues which are at the heart of policy controversies.

6.4.1 Recommendations for policy controversy analysts

When studying online visualisations of a policy controversy, it is advisable to alternate between zooming in and out in the analysis of the visuals. Online

visualisations are valuable objects for gaining insights into the controversy. Sometimes it is good to read the image (Kress & Van Leeuwen, 2021). Zooming in on visualisations enables noticing their details – the exact content presented, how it is being represented (e.g., from a low angle or eye-bird view), and what specific qualities visualisations have (e.g., dark or bright colours). However, sometimes the patterns between the visualisations in their context reveal what is at stake in the policy controversy. Zooming out enables identifying patterns – repeated content, dominant means of representation, prevalent qualities – and associating these patterns with other information available on the controversy. Tacking back and forth between noticing the specific elements visualisations employ and acquiring an overview of their use in a controversy ensures that visualisations' full potential as objects offering insights into the controversy is thoroughly explored.

Online visualisations can serve as accessible objects for better understanding of the attitudes and concerns of actors in a policy controversy. Examining a visualisation or a group of visualisations used by actors in a controversy, one can try to infer why a particular way of visualising was chosen, intentionally or not, among endless options of doing so. An answer to this question may provide an extended and more nuanced understanding of the views and concerns of the actors. Trying to infer why a particular way of visualising was chosen can guide controversy analysts in their attempts to understand the controversial issue from an actor's point of view (or a group of actors') point of view and can help virtually elucidate the actors' interpretation of the situation or issue.

6.4.2 Recommendations for visualisers

Actors of all types should consider their visual presence online. This thesis shows that online, especially when the controversy intensifies, anti-actors often have a stronger visual presence. The thesis also shows that the Web is an important field of governance dynamics and that visuals plays a key role in these dynamics. Hence, actors of all types, including people and institutes who typically focus on other means of sharing information than websites and social media, should note their online visibility and visuality.

When noticing online visibility and visuality, actors must be aware of visualisations' 'circulability'. This circulability means that visualisations might find their way to places different from those their authors intended them to be, with text different

from the text originally accompanying them. A visualisation is shown, in this thesis, as capable of circulating across platforms and topics and changing its meaning while circulating. As the text accompanying a visualisation is an important anchor in the decoding of its meaning, one can consider 'securing' the accompanying text to the visualisation by, for example, including it in the image file (as often done in memes and other visualisations on social media).

In addition, visualising can be an opportunity to reflect on own perspectives. When choosing a visualisation to be used online, one can reflect on the meaning conveyed by this visualisation and on whether it corresponds to her or his 'set of values, beliefs, and feelings' (see Yanow, 2000, p. 10). That may lead to a consequent reflection on the own set of values, beliefs and feelings and their relation to the perspective on the controversial issue, along with a possible update of this perspective.

6.5 Concluding remark

'See what I mean?' is an idiom that is 'used to ask if someone understands what you are trying to explain' (Cambridge Dictionary, n.d.). In this idiom, the physical action of the eyes is used in its broader sense to denote perceiving, understanding or comprehending. Similarly, this dissertation broadens the notion of visualising beyond the mere use of visual objects to incorporate the action of giving meaning by using visualisations. This broadened idea of visualisation is applied in the context of online policy controversies over energy and food technologies. However, it can also be applied to democratic life as a whole.

Acknowledging the central role online visualisations play in policy controversies and other polemic situations, while being aware of their framing effect and the various ways they give meanings to events, issues, ideas or policies, makes visualisations too important to be left un(der)studied.

References

Adobe Inc. (2019). Adobe Illustrator. https://www.adobe.com/products/illustrator.html

Aiello, G., & Parry, K. (2020). Visual Communication: Understanding Images in Media Culture. SAGE Publications.

Akrich, M. (1997). The de-scription of technical objects. In W. E. Bijker & J. Law (Eds.), Shapin technology, building society (2nd ed., pp. 205–224). MIT Press.

Allen, W. L. (2021). The conventions and politics of migration data visualizations. New Media and Society, 1–22. https://doi.org/10.1177/14614448211019300

Amit-Danhi, E. R., & Shifman, L. (2018). Digital political infographics: A rhetorical palette of an emergent genre. New Media and Society, 20(10), 3540–3559. https://doi.org/10.1177/1461444817750565

An, K., & Powe, N. A. (2015). Enhancing 'Boundary Work" Through the Use of Virtual Reality: Exploring the Potential within Landscape and Visual Impact Assessment.' Journal of Environmental Policy and Planning, 17(5), 673–690. https://doi.org/10.1080/1523908X.2015.1012757

Andreasson, S. (2018). The bubble that got away? Prospects for shale gas development in South Africa. Extractive Industries and Society, 5(4), 453–460. https://doi.org/10.1016/j.exis.2018.07.004

Appe, S., & Dodge, J. (2022). Interpretive Engagement and the Study of Civil Society Networks: An Illustration of Interpretive Methods. Voluntas, 33(6), 1156–1163. https://doi.org/10.1007/s11266-021-00434-7

Aschemann-Witzel, J., Varela, P., & Peschel, A. O. (2019). Consumers' categorization of food ingredients: Do consumers perceive them as 'clean label' producers expect? An exploration with projective mapping. Food Quality and Preference, 71(June 2018), 117–128. https://doi.org/10.1016/j.foodqual.2018.06.003

Atkinson, D. (2018). Fracking in a fractured environment: Shale gas mining and institutional dynamics in South Africa's young democracy. Extractive Industries and Society, 5(4), 441–452. https://doi.org/10.1016/j.exis.2018.09.013

Baker, S. A., & Walsh, M. J. (2020). You Are What You Instagram: Clean eating and the symbolic representation of food. In D. Lupton & Z. Feldman (Eds.), Digital Food Cultures (pp. 53–67). Routledge.

Barthes, R. (1977). Image, Music, Text. FontanaPress.

Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: an open source software for exploring and manipulating networks. Proceedings of the International AAAI Conference on Web and Social Media, 3(1), 361–362.

Baumgartner, F. R., De Boef, S. L., & Boydstun, A. E. (2008). The decline of the death penalty and the discovery of innocence. Cambridge University Press.

Bell, P. (2001). Content analysis of visual images. In T. Van Leeuwen & C. Jewitt (Eds.), Handbook of Visual Analysis (pp. 10–34). Sage Publications.

Ben-David, A., Amram, A., & Bekkerman, R. (2018). The colors of the national Web: visual data analysis of the historical Yugoslav Web domain. International Journal on Digital Libraries, 19(1), 95–106. https://doi.org/10.1007/s00799-016-0202-6

Bentley, A., & Figueroa, S. L. (2018). A History of Food in Popular Culture Over the Life Span. In K. LeBesco & P. Naccarato (Eds.), The Bloomsbury Handbook of Food and Popular Culture (pp. 83–95). Bloomsbury Publishing.

Biltekoff, C. (2016). The Politics of Food Anti-Politic. Gastronomica, 16(4), 44–57. https://doi.org/10.7551/mitpress/2786.003.0009

Bleiker, R. (2017). In search of thinking space: Reflections on the aesthetic turn in international political theory. Millennium: Journal of International Studies, 45(2), 258–264. https://doi.org/10.1177/0305829816684262

Bleiker, R. (2018). Mapping visual global politics. In R. Bleiker (Ed.), Visual Global Politics (pp. 1–29). Routledge.

Bleiker, R., Campbell, D., Hutchison, E., & Nicholson, X. (2013). The visual dehumanisation of refugees. Australian Journal of Political Science, 48(4), 398–416. https://doi.org/10.1080/10361146.2013.840769

Bleiweiss-Sande, R., Chui, K., Evans, E. W., Goldberg, J., Amin, S., & Sacheck, J. (2019). Robustness of food processing classification systems. Nutrients, 11(6). https://doi.org/10.3390/nu11061344

Bomberg, E. (2017a). Fracking and framing in transatlantic perspective: A comparison of shale politics in the US and European Union. Journal of Transatlantic Studies, 15(2), 101–120. https://doi.org/10.1080/14794012.2016.1268789

Bomberg, E. (2017b). Shale We Drill? Discourse Dynamics in UK Fracking Debates. Journal of Environmental Policy and Planning, 19(1), 72–88. https://doi.org/10.1080/1523908X.2015.1053111

Boscarino, J. E. (2022). Constructing visual policy narratives in new media: the case of the Dakota Access Pipeline. Information, Communication & Society, 25(2), 278–294. https://doi.org/10.1080/1369118X.2020.1787483

Boswell, J., Corbett, J., & Rhodes, R. A. W. (2019). The Art and Craft of Comparison. Cambridge University Press. https://doi.org/10.1017/9781108561563

Boudet, H. S. (2019). Public perceptions of and responses to new energy technologies. Nature Energy, 4(6), 446–455. https://doi.org/10.1038/s41560-019-0399-x

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1128/AAC.03728-14

Bugden, D., Evensen, D., & Stedman, R. (2017). A drill by any other name: Social representations, framing, and legacies of natural resource extraction in the fracking industry. Energy Research and Social Science, 29(May), 62–71. https://doi.org/10.1016/j.erss.2017.05.011

Bulkeley, H. (2000). Discourse coalitions and the Australian climate change policy network. Environment and Planning C: Government and Policy, 18(6), 727–748. https://doi.org/10.1068/c9905j

Burri, V. R., & Dumit, J. (2008). Social Studies of Scientific Imaging and Visualization. In E. J. Hackett, O. Amsterdamska, M. Lynch, & J. Wajcman (Eds.), The handbook of science and technology studies (3rd ed., pp. 297–318). The MIT Press.

Cacciatore, M. A., Anderson, A. A., Choi, D. H., Brossard, D., Scheufele, D. A., Liang, X., Ladwig, P. J., Xenos, M., & Dudo, A. (2012). Coverage of emerging technologies: A comparison between print and online media. New Media and Society, 14(6), 1039–1059. https://doi.org/10.1177/1461444812439061

Camargo, K., & Grant, R. (2015). Public Health, Science, and Policy Debate: Being Right Is Not Enough. American Journal of Public Health, 105(2), 232–235. https://doi.org/10.2105/AJPH.2014.302241

Cambria, E., Das, D., Bandyopadhyay, S., & Feraco, A. (2017). Affective Computing and Sentiment Analysis. In E. Cambria, D. Das, S. Bandyopadhyay, & A. Feraco (Eds.), A Practical Guide to Sentiment Analysis (pp. 1–10). Springer International Publishing.

Cambridge Dictionary. (n.d.). (do you) see what I mean? Retrieved June 6, 2023, from https://dictionary.cambridge.org/dictionary/english/do-you-see-what-i-mean

Campbell, D. (2007). Geopolitics and visuality: Sighting the Darfur conflict. Political Geography, 26(4), 357–382. https://doi.org/10.1016/j.polgeo.2006.11.005

Castells, M. (2008). The new public sphere: Global civil Society, communication networks, and global governance. Annals of the American Academy of Political and Social Science, 616(1), 78–93. https://doi.org/10.1177/0002716207311877

Castells, M. (2010). The Rise of the Network Society: Vol. I: The Ris (2nd ed.). Wiley-Blackwell. https://doi.org/10.1002/9781444318234.ch5

Chaudhry, Q., Watkins, R., & Castle, L. (2017). Nanotechnologies in Food: What, Why and How? In R. Chaudhry, Q Castle, L Watkins (Ed.), Nanotechnologies in Food (pp. 1–19). Royal Society of Chemistry. https://doi.org/10.1039/9781847559883

Clancy, K. A. (2017). The Politics of Genetically Modified Organisms in the United States and Europe. Palgrave Macmillan. https://doi.org/https://doi-org.ezproxy.library.wur.nl/10.1007/978-3-319-33984-9

Clancy, K. A., & Clancy, B. (2016). Growing monstrous organisms: the construction of anti-GMO visual rhetoric through digital media. Critical Studies in Media Communication, 33(3), 279–292. https://doi.org/10.1080/15295036.2016.1193670

Clark, L. F. (2013). Framing the uncertainty of risk: Models of governance for genetically modified foods. Science and Public Policy, 40(4), 479–491. https://doi.org/10.1093/scipol/sct001

Cullerton, K., Donnet, T., Lee, A., & Gallegos, D. (2016). Exploring power and influence in nutrition policy in Australia. Obesity Reviews, 17(12), 1218–1225. https://doi.org/10.1111/obr.12459

Cuppen, E. (2018). The value of social conflicts. Critiquing invited participation in energy projects. Energy Research and Social Science, 38, 28–32. https://doi.org/10.1016/j.erss.2018.01.016

Cuppen, E., Bosch-Rekveldt, M. G. C., Pikaar, E., & Mehos, D. C. (2016). Stakeholder engagement in large-scale energy infrastructure projects: Revealing perspectives using Q methodology. International Journal of Project Management, 34(7), 1347–1359. https://doi.org/10.1016/j.ijproman.2016.01.003

Cuppen, E., Pesch, U., Remmerswaal, S., & Taanman, M. (2016). Normative diversity, conflict and transition: Shale gas in the Netherlands. Technological Forecasting and Social Change. https://doi.org/10.1016/j.techfore.2016.11.004

D'Andréa, C., & Mintz, A. (2019). Studying the live cross-platform circulation of images with computer vision API: An experiment based on a sports media event. International Journal of Communication, 13, 1825–1845.

De Cock, L., Dessein, J., & de Krom, M. P. (2016). Understanding the development of organic agriculture in Flanders (Belgium): A discourse analytical approach. NJAS - Wageningen Journal of Life Sciences, 79, 1–10. https://doi.org/10.1016/j.njas.2016.04.002

de Solier, I. (2018). Tasting the Digital: New Food Media. In K. LeBesco & P. Naccarato (Eds.), The Bloomsbury Handbook of Food and Popular Culture (pp. 54–65). Bloomsbury Publishing.

De Wit, M. J. (2011). The great shale debate in the Karoo. South African Journal of Science, 107(7–8), 1–9. https://doi.org/10.4102/sajs.v107i7/8.791

Devine-Wright, H. (2011). Envisioning public engagement with renewable energy: An empirical analysis of images within the UK national press 2006/2007. In P. Devine-Wright (Ed.), Renewable Energy and the Public: From NIMBY to Participation (pp. 101–113). Earthscan.

Dewulf, A., Craps, M., Bouwen, R., Taillieu, T., & Pahl-Wostl, C. (2005). Integrated management of natural resources: dealing with ambiguous issues, multiple actors and diverging frames. Water Science & Technology, 52(6), 115-124.

Dodge, J. (2015). The deliberative potential of civil society organizations: framing hydraulic fracturing in New York. Policy Studies, 36(3), 249–266. https://doi.org/10.1080/01442872.2015.1065967

Dodge, J., & Lee, J. (2017). Framing Dynamics and Political Gridlock: The Curious Case of Hydraulic Fracturing in New York. Journal of Environmental Policy and Planning, 19(1), 14–34. https://doi.org/10.1080/1523908X.2015.1116378

Dodge, J., & Metze, T. (2017). Hydraulic fracturing as an interpretive policy problem: lessons on energy controversies in Europe and the U.S.A. Journal of Environmental Policy and Planning, 19(1), 1–13. https://doi.org/10.1080/1523908X.2016.1277947

Doerr, N. (2017). Bridging language barriers, bonding against immigrants: A visual case study of transnational network publics created by far-right activists in Europe. Discourse and Society, 28(1), 3–23. https://doi.org/10.1177/0957926516676689

Doerr, N., Mattoni, A., & Teune, S. (2015). Visuals in Social Movements. In D. Della Porta & M. Diani (Eds.), Oxford Handbook of Social Movements. (pp. 557-566). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199678402.013.48

Doerr, N., & Milman, N. (2014). Working with images. In D. Della Porta (Ed.), Methodological Practices in Social Movement Research. (pp. 418-445). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198719571.001.0001

Domke, D., Perlmutter, D., & Spratt, M. (2002). The primes of our times? Journalism: Theory, Practice & Criticism, 3(2), 131–159. https://doi.org/10.1177/146488490200300211

Downs, A. (1972). Up and down with ecology: The issue-attention cycle. The public, 28, 38-50.

Doyle, J. (2014). Picturing the Clima(c)tic: Greenpeace and the Representational Politics of Climate Change Communication. In B. Schneider & T. Nocke (Eds.), Image Politics of Climate Change: Visualizations, Imaginations, Documentations. (pp. 225–247). Transcript Verlag.

Durnová, A. P., & Hejzlarová, E. M. (2022). Navigating the role of emotions in expertise: public framing of expertise in the Czech public controversy on birth care. Policy Sciences. https://doi.org/10.1007/s11077-022-09471-5

EIA. (2011). Annual Energy Outlook 2011 (Vol. 2011, Issue April).

Eicher-miller, H. A., Fulgoni, V. L., & Keast, D. R. (2012). Contributions of Processed Foods to Dietary Intake in the US from 2003 – 2008. Journal of Nutrition, 142, 2065S-2072S. https://doi.org/10.3945/jn.112.164442.for

El Universal. (2018, August 4). Piden a AMLO cancelar proyecto hidráulico en NL. https://horacero.com.mx/nacional/piden-a-amlo-cancelar-proyecto-hidraulico-en-nl/

Entman, R. M. (1993). Framing: Toward clarification of a fractured paradigm. Journal of Communication, 43(4), 51–58.

Feindt, P. H., & Oels, A. (2005). Does discourse matter? Discourse analysis in environmental policy making. Journal of Environmental Policy and Planning, 7(3), 161–173. https://doi.org/10.1080/15239080500339638

Finglas, P. M., Yada, R. Y., & Toldrá, F. (2014). Nanotechnology in foods: Science behind and future perspectives. Trends in Food Science and Technology, 40(2), 125–126. https://doi.org/10.1016/j.tifs.2014.11.001

Finkeldey, J. (2018). Unconventionally contentious: Frack Free South Africa's challenge to the oil and gas industry. Extractive Industries and Society, 5(4), 461–468. https://doi.org/10.1016/j.exis.2018.08.006

Fiolet, T., Srour, B., Sellem, L., Kesse-Guyot, E., Allès, B., Méjean, C., Deschasaux, M., Fassier, P., Latino-Martel, P., Beslay, M., Hercberg, S., Lavalette, C., Monteiro, C. A., Julia, C., & Touvier, M. (2018). Consumption of ultra-processed

foods and cancer risk: Results from NutriNet-Santé prospective cohort. BMJ (Online), 360(8141). https://doi.org/10.1136/bmj.k322

Fischer, A. R. H., van Dijk, H., de Jonge, J., Rowe, G., & Frewer, L. J. (2013). Attitudes and attitudinal ambivalence change towards nanotechnology applied to food production. Public Understanding of Science, 22(7), 817–831. https://doi.org/10.1177/0963662512440220

Fletcher, A. L. (2009). Clearing the air: The contribution of frame analysis to understanding climate policy in the United States. Environmental Politics, 18(5), 800–816. https://doi.org/10.1080/09644010903157123

Floros, J. D., Newsome, R., Fisher, W., Barbosa-Cánovas, G. v., Chen, H., Dunne, C. P., German, J. B., Hall, R. L., Heldman, D. R., Karwe, M. v., Knabel, S. J., Labuza, T. P., Lund, D. B., Newell-McGloughlin, M., Robinson, J. L., Sebranek, J. G., Shewfelt, R. L., Tracy, W. F., Weaver, C. M., & Ziegler, G. R. (2010). Feeding the world today and tomorrow: The importance of food science and technology. Comprehensive Reviews in Food Science and Food Safety, 9(5), 572–599. https://doi.org/10.1111/j.1541-4337.2010.00127.x

Fraanje, W., & Garnett, T. (2019). What is ultra-processed food? And why do people disagree about its utility as a concept? (Foodsource: building blocks). Food Climate Research Network, University of Oxford. https://doi.org/10.56661/ca3e86f2

Frewer, L. J., Gupta, N., George, S., Fischer, A. R. H., Giles, E. L., & Coles, D. (2014). Consumer attitudes towards nanotechnologies applied to food production. Trends in Food Science and Technology, 40(2), 211–225. https://doi.org/10.1016/j.tifs.2014.06.005

Gamson, W., & Modigliani, A. (1989). Media Discourse and Public Opinion on Nuclear Power: A Constructionist Approach. American Journal of Sociology, 95(1), 1–37.

Geboers, M. (2019). 'Writing' oneself into tragedy: visual user practices and spectatorship of the Alan Kurdi images on Instagram. Visual Communication, 0(0). https://doi.org/10.1177/1470357219857118

Geboers, M., & Van De Wiele, C. T. (2020). Regimes of visibility and the affective affordances of Twitter. International Journal of Cultural Studies, 23(5), 745–765. https://doi.org/10.1177/1367877920923676

Gerhards, J., & Schäfer, M. S. (2010). Is the internet a better public sphere? comparing old and new media in the USA and Germany. New Media and Society, 12(1), 143–160. https://doi.org/10.1177/1461444809341444

Gibney, M. J., Forde, C. G., Mullally, D., & Gibney, E. R. (2017). Ultra-processed foods in human health: A critical appraisal. American Journal of Clinical Nutrition, 106(3), 717–724. https://doi.org/10.3945/ajcn.117.160440

Gibson, R., & Zillmann, D. (2000). Influence of Incidental Pictorial Information on Issue Perception. Journalism & Mass Communication Quarterly, 77(2), 355–366.

Gommeh, E., Dijstelbloem, H., & Metze, T. (2021). Visual discourse coalitions: visualization and discourse formation in controversies over shale gas development. Journal of Environmental Policy & Planning, 23(3), 363–380. https://doi.org/10.1080/1523908x.2020.1823208

Gommeh, E., Schroën, K., & Metze, T. (2022). Processed food dream or nightmare? Influential online sentiment coalitions. NJAS: Impact in Agricultural and Life Sciences, 94(1), 80-111. https://doi.org/10.1080/27685241.2022.2108731

Goodman, M. K., Johnston, J., & Cairns, K. (2017). Food, media and space: The mediated biopolitics of eating. Geoforum, 84(August), 161–168. https://doi.org/10.1016/j.geoforum.2017.06.017

Grabe, M. E., & Bucy, E. P. (2009). Image Bite Politics. Oxford University Press.

Green, J. E. (2010). The Eyes of the People. Oxford University Press.

Hajer, M. A. (1995). The Politics of Environmental Discourse: Ecological Modernization and the Policy Process. Oxford University Press.

Hajer, M. A. (2006). Doing discourse analysis: coalitions, practices, meaning. In M. van de Brink & T. Metze (Eds.), Words matter in policy and planning: Discourse theory and method in the social sciences (pp. 65–74). Netherlands Graduate School of Urban and Regional Research.

Hajer, M. A., & Versteeg, W. (2005). A decade of discourse analysis of environmental politics: Achievements, challenges, perspectives. Journal of Environmental Policy and Planning, 7(3), 175–184. https://doi.org/10.1080/15239080500339646

Hall, S. (1980). Encoding/Decoding. In S. Hall, D. Hobson, A. Lowe, & P. Willis (Eds.), Culture, Media, Language (pp. 128–138). Hutchinson.

Hand, M. (2016). Visuality in Social Media: Researching Images, Circulations and Practices. In L. Sloan & A. Quan-Haase (Eds.), The SAGE Handbook of Social Media Research Methods (pp. 215–231). Sage Publications. https://doi.org/https://dx.doi.org/10.4135/9781473983847

Handford, C. E., Dean, M., Henchion, M., Spence, M., Elliott, C. T., & Campbell, K. (2014). Implications of nanotechnology for the agri-food industry: Opportunities, benefits and risks. Trends in Food Science & Technology, 40(2), 226–241. https://doi.org/10.1016/j.tifs.2014.09.007

Hansen, A., & Cox, R. (2015). The Routledge Handbook of Environment and communication. Routledge.

Hansen, A., & Machin, D. (2013). Editors' introduction: Researching visual environmental communication. Journal of Landscape Architecture, 7(2), 151–168. https://doi.org/10.1080/17524032.2013.785441

Hansen, L. (2011). Theorizing the image for security studies: Visual securitization and the Muhammad Cartoon Crisis. European Journal of International Relations, 17(1), 51–74. https://doi.org/10.1177/1354066110388593

Henchion, M., McCarthy, M., Dillon, E. J., Greehy, G., & McCarthy, S. N. (2019). Big issues for a small technology: Consumer trade-offs in acceptance of nanotechnology in food. Innovative Food Science and Emerging Technologies, 58(August). https://doi.org/10.1016/j.ifset.2019.102210

Hendriks, C. M., Duus, S., & Ercan, S. A. (2016). Performing politics on social media: The dramaturgy of an environmental controversy on Facebook. Environmental Politics, 25(6), 1102–1125. https://doi.org/10.1080/09644016.2016.1196967

Hendriks, C. M., Ercan, S. A., & Duus, S. (2017, June 28-30). A picture worth a thousand words? Visuals in public deliberation [Paper presentation]. 3rd International Conference on Public Policy (ICPP3), Singapore.

Highfield, T., & Leaver, T. (2016). Instagrammatics and digital methods: studying visual social media, from selfies and GIFs to memes and emoji. Communication Research and Practice, 2(1), 47–62. https://doi.org/10.1080/22041451.2016.1155332

Hjerpe, M., & Buhr, K. (2014). Frames of Climate Change in Side Events from Kyoto to Durban. Global Environmental Politics, 14(2, May). https://doi.org/10.1162/GLEP_a_00231

Hopke, J. E., & Simis, M. (2017). Discourse over a contested technology on Twitter: A case study of hydraulic fracturing. Public Understanding of Science, 26(1), 105–120. https://doi.org/10.1177/0963662515607725

Howell, E. L., Li, N., Akin, H., Scheufele, D. A., Xenos, M. A., & Brossard, D. (2017). How do U.S. state residents form opinions about 'fracking' in social contexts? A multilevel analysis. Energy Policy, 106(April), 345–355. https://doi.org/10.1016/j.enpol.2017.04.003

Huebbe, P., & Rimbach, G. (2020). Historical reflection of food processing and the role of legumes as part of a healthy balanced diet. Foods, 9(8), 1–16. https://doi.org/10.3390/foods9081056

Hullman, J., & Diakopoulos, N. (2011). Visualization Rhetoric: Framing Effects in Narrative Visualization. IEEE Transactions on Visualization and Computer Graphics, 17(12), 2231–2240. https://doi.org/10.1109/TVCG.2011.255

IFIC. (2010). Understanding Our Food Communications Tool Kit. https://foodinsight.org/wp-content/uploads/2014/07/IFIC_Leader_Guide_high_res.pdf

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2014). The non-GM crop regime in the EU: How do Industries deal with this wicked problem? NJAS - Wageningen Journal of Life Sciences, 70, 103–112. https://doi.org/10.1016/j.njas.2014.02.002

Ingle, M., & Atkinson, D. (2015). Can the circle be squared? An enquiry into shale gas mining in South Africa's Karoo. Development Southern Africa, 32(5), 539–554. https://doi.org/10.1080/0376835X.2015.1044076

Jasanoff, S. (2004). Heaven and earth: The politics of environmental images. In S. Jasanoff & M.L. Martello (Eds), Earthly Politics: Local and Global in Environmental Governance (pp. 31–52). The MIT Press.

Jayachandran, M., Gatla, R. K., Rao, K. P., Rao, G. S., Mohammed, S., Milyani, A. H., Azhari, A. A., Kalaiarasy, C., & Geetha, S. (2022). Challenges in achieving sustainable development goal 7: Affordable and clean energy in light of nascent technologies. Sustainable Energy Technologies and Assessments, 53. https://doi.org/10.1016/j.seta.2022.102692

Jeffares, S. (2014). Interpreting Hashtag Politics Policy Ideas in an Era of Social Media. Palgrave McMillan.

Jones, J. M. (2019). Food processing: Criteria for dietary guidance and public health? Proceedings of the Nutrition Society, 78(1), 4–18. https://doi.org/10.1017/S0029665118002513

Jordan, G. (2001). Shell, Greenpeace and Brent Spar. Palgrave Macmillan.

Jorritsma, M. (2012). "Don't Frack with Our Karoo": Water, Landscape, and Congregational Song in Kroonvale, South Africa. Safundi, 13(3–4), 373–391. https://doi.org/10.1080/17533171.2012.715420

Kasra, M. (2017). Digital-networked images as personal acts of political expression: New categories for meaning formation. Media and Communication, 5(4), 51–64. https://doi.org/10.17645/mac.v5i4.1065

Keane, J. (2009). The Life and Death of Democracy. Simon & Schuster.

Kermani, H., & Tafreshi, A. (2022). Walking with Bourdieu into Twitter communities: an analysis of networked publics struggling on power in Iranian Twittersphere. Information, Communication & Society, 0(0), 1–22. https://doi.org/10.1080/1369118X.2021.2021267

Kligler-Vilenchik, N., & Thorson, K. (2016). Good citizenship as a frame contest: Kony2012, memes, and critiques of the networked citizen. New Media and Society, 18(9), 1993–2011. https://doi.org/10.1177/1461444815575311

Koops, B.-J. (2015). The Concepts, Approaches, and Applications of Responsible Innovation. In B.-J. Koops, I. Oosterlaken, H. Romijn, T. Swierstra, & J. van den Hoven (Eds.), Responsible Innovation 2: Concepts, Approaches, and Applications (pp. 1–15). Springer International Publishing.

Krabbenborg, L. (2019). Emerging technologies and the Problem of Representation. In I. Eisenberger (Ed.), Nanotechnology: Regulation and Public Discourse (pp. 211–226). Rowman & Littlefield.

Krause, A., & Bucy, E. P. (2018). Interpreting Images of Fracking : How Visual Frames and Standing Attitudes Shape Perceptions of Environmental Risk and Economic Benefit. Environmental Communication, 12(3), 322–343. https://doi.org/10.1080/17524032.2017.1412996

Kress, G. (2001). Multimodal discourse analysis. In J. P. Gee & M. Handford (Eds.), The Routledge Handbook of Discourse Analysis. Routledge. https://doi.org/10.4324/9780203809068.ch3

Kress, G. (2010). Multimodality: A Social Semiotic Approach to Contemporary Communication. Routledge.

Kress, G., & Van Leeuwen, T. (2021). Reading Images: The Grammar of Visual Design. Routledge.

Kuttschreuter, M., Gutteling, J. M., & de Hond, M. (2011). Framing and tone-of-voice of disaster media coverage: The aftermath of the Enschede fireworks disaster in the Netherlands. Health, Risk and Society, 13(3), 201–220. https://doi.org/10.1080/13698575.2011.558620

Kwak, E. J., & Grable, J. E. (2021). Conceptualizing the use of the term financial risk by non-academics and academics using twitter messages and ScienceDirect paper abstracts. Social Network Analysis and Mining, 11(1), 1–14. https://doi.org/10.1007/s13278-020-00709-9

Lappeman, J., Clark, R., Evans, J., Sierra-Rubia, L., & Gordon, P. (2020). Studying social media sentiment using human validated analysis. MethodsX, 7, 100867. https://doi.org/10.1016/j.mex.2020.100867

Latour, B. (1986). Visualization and cognition: Drawing things together. In H. Kuklick (Ed.), Knowledge and Society Studies in the Sociology of Culture Past and Present (Vol. 6, pp. 1–40). Jai Press. http://www.bruno-latour.fr/sites/default/files/21-DRAWING-THINGS-TOGETHER-GB.pdf

Latour, B. (1987). Science in action: How to follow scientists and engineers through society. Harvard university press.

Latour, B. (1990). Technology is Society Made Durable. The Sociological Review, 38(1_suppl), 103–131. https://doi.org/10.1111/j.1467-954X.1990.tb03350.x

Latour, B. (2005). Reassembling the Social: An Introduction to Actor-Network-Theory. Oxford University Press.

Latour, B., & Weibe, P. (Eds.). (2005). Making Things Public: Atmospheres of Democracy. ZKM Center for Art and Media Karlsruhe and MIT Press.

Lewis, T. (2018). Digital food: from paddock to platform. Communication Research and Practice, 4(3), 212–228. https://doi.org/10.1080/22041451.2018.1476795

Lilleker, D. G., Veneti, A., & Jackson, D. (2019). Introduction: Visual Political Communication. In A. Veneti, D. Jackson, & D. G. Lilleker (Eds.), Visual Political Communication (pp. 1–13). Palgrave Macmillan.

Lindahl, K. B., Baker, S., Rist, L., & Zachrisson, A. (2016). Theorising pathways to sustainability. International Journal of Sustainable Development & World Ecology, 23(5), 399–411. https://doi.org/10.1080/13504509.2015.1128492

Lis, A., & Stankiewicz, P. (2017). Framing Shale Gas for Policy-Making in Poland. Journal of Environmental Policy and Planning, 19(1), 53–71. https://doi.org/10.1080/1523908X.2016.1143355

Loredo, D. (2018, October 10). Sin fracking, México dejaría de aprovechar casi el 50 por ciento de sus reservas: CNH. https://elfinanciero.com.mx/economia/sin-fracking-mexicodejaria- de-aprovechar-casi-el-50-por-ciento-de-sus-reservas-cnh

Ludes, P., Nöth, W., & Fahlenbrach, K. (2014). Critical visual theory - Introduction. TripleC, 12(1), 202–213.

Lupton, D. (2018). Cooking, Eating, Uploading: Digital Food Cultures. In K. LeBesco & P. Naccarato (Eds.), The Bloomsbury Handbook of Food and Popular Culture (pp. 66–79). Bloomsbury Publishing.

Lupton, D. (2020). Understanding Digital Food Cultures. In D. Lupton & Z. Feldman (Eds.), Digital Food Cultures (pp. 1–16). Routledge.

Macnaghten, P., Davies, S. R., & Kearnes, M. (2015). Understanding Public Responses to Emerging Technologies: A Narrative Approach. Journal of Environmental Policy and Planning, 1–19. https://doi.org/10.1080/1523908X.2015.1053110

Marais, C. (2013). Steel Flowers – Windpumps of the Karoo. Karoo Space. http://karoospace.co.za/steel-flowers-windpumps-of-the-karoo/

Marks, L. A., Kalaitzandonakes, N., Wilkins, L., & Zakharova, L. (2007). Mass media framing of biotechnology news. Public Understanding of Science, 16(2), 183–203. https://doi.org/10.1177/0963662506065054

Marres, N. (2015). Why Map Issues? On Controversy Analysis as a Digital Method. Science Technology and Human Values, 40(5), 655–686. https://doi.org/10.1177/0162243915574602

Marres, N. (2017). Digital Sociology: The Reinvention of Social Research. Polity Press. https://doi.org/10.1017/CBO9781107415324.004

Marres, N., & Moats, D. (2015). Mapping Controversies with Social Media: The Case for Symmetry. Social Media and Society, 1–17. https://doi.org/10.1177/2056305115604176

Marres, N., & Rogers, R. (2005). Recipe for Tracing Issues and Their Publics on the Web. In B. Latour & P. Weibel (Eds.), Making Things Public: Atmospheres of Democracy (pp. 922–935). ZKM Center for Art and Media Karlsruhe and MIT Press.

Marres, N., & Weltevrede, E. (2013). SCRAPING THE SOCIAL? Journal of Cultural Economy, 6(3), 313–335. https://doi.org/10.1080/17530350.2013.772070

Marrón-Ponce, J. A., Flores, M., Cediel, G., Monteiro, C. A., & Batis, C. (2019). Associations between Consumption of Ultra-Processed Foods and Intake of Nutrients Related to Chronic Non-Communicable Diseases in Mexico. Journal of the Academy of Nutrition and Dietetics, 119(11), 1852–1865. https://doi.org/10.1016/j.jand.2019.04.020

Martínez Steele, E., Juul, F., Neri, D., Rauber, F., & Monteiro, C. A. (2019). Dietary share of ultra-processed foods and metabolic syndrome in the US adult population. Preventive Medicine, 125(May), 40–48. https://doi.org/10.1016/j.ypmed.2019.05.004

Martínez Steele, E., Popkin, B. M., Swinburn, B., & Monteiro, C. A. (2017). The share of ultra-processed foods and the overall nutritional quality of diets in the US: Evidence from a nationally representative cross-sectional study. Population Health Metrics, 15(1), 1–11. https://doi.org/10.1186/s12963-017-0119-3

Mattoni, A., & Teune, S. (2014). Visions of Protest. A Media-Historic Perspective on Images in Social Movements. Sociology Compass, 8(6), 876–887. https://doi.org/10.1111/soc4.12173

Mazur, A. (2016). How did the fracking controversy emerge in the period 2010-2012? Public Understanding of Science, 25(2), 207–222. https://doi.org/10.1177/0963662514545311

McSwiney, J., Vaughan, M., Heft, A., & Hoffmann, M. (2021). Sharing the hate? Memes and transnationality in the far right's digital visual culture. Information, Communication & Society, 24(16), 2502–2521. https://doi.org/10.1080/1369118X.2021.1961006

Mensi, A., & Udenigwe, C. C. (2021). Emerging and practical food innovations for achieving the Sustainable Development Goals (SDG) target 2.2. Trends in Food Science and Technology, 111,783–789. https://doi.org/10.1016/j.tifs.2021.01.079

Merz, M. (2011). Designed for Travel: Communicating Facts through Images. In P. Howlett & M. S. Morgan (Eds.), How Well Do Facts Travel? The Dissemination of Reliable Knowledge (pp. 349–375). Cambridge University Press.

Messaris, P., & Abraham, L. (2011). The role of images in framing news stories. In S. D. Reese, O. H. Jr. Gandy, & A. E. Grant (Eds.), public life: Perspectives on media and our understanding of the social world (pp. 215–226). Lawrence Erlbaum Associates. https://doi.org/10.1017/CBO9781107415324.004

Metze, T. (2010). Innovation Ltd. Boundary work in deliberative governance in land use planning. Eburon Academic Publishers.

Metze, T. (2017). Fracking the Debate: Frame Shifts and Boundary Work in Dutch Decision Making on Shale Gas. Journal of Environmental Policy and Planning, 19(1), 35–52. https://doi.org/10.1080/1523908X.2014.941462

Metze, T. (2018a). Framing the future of fracking: Discursive lock-in or energy degrowth in the Netherlands? Journal of Cleaner Production, 197(2), 1737–1745.

Metze, T. (2018b). Visual framing for policy learning: internet as the eye of the public. In N. F. Dotti (Ed.), Knowledge, policymaking and learning for European cities and regions: From Research to Practice (pp. 165–180). Edwar Elgar Publishing.

Metze, T. (2020). Visualization in environmental policy and planning: a systematic review and research agenda. Journal of Environmental Policy and Planning, 22(5). https://doi.org/10.1080/1523908X.2020.1798751

Metze, T., & Dodge, J. (2016). Dynamic Discourse Coalitions on hydro-fracking in Europe and the United States. Environmental Communication, 10(3), 365–379. https://doi.org/10.1080/17524032.2015.1133437

Mirzoeff, N. (1999). An Introduction to Visual Culture. Routledge. https://doi.org/10.1146/annurev.ps.29.020178.000335

Mol, A. P. J. (2006). Environmental Governance in the Information Age: The Emergence of Informational Governance. Environment and Planning C: Government and Policy, 24(4), 497–514. https://doi.org/10.1068/c0508j

Monteiro, C., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L. C., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L. G., & Jaime, P. C. (2019). Ultra-processed foods: What they are and how to identify them. Public Health Nutrition, 22(5), 936–941. https://doi.org/10.1017/S1368980018003762

Monteiro, C., Cannon, G., Moubarac, J. C., Levy, R. B., Louzada, M. L. C., & Jaime, P. C. (2018). The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutrition, 21(1), 5–17. https://doi.org/10.1017/S1368980017000234

Morgan, M. S. (2011). Travelling Facts. In P. Howlett & M. S. Morgan (Eds.), How Well Do Facts Travel? The Dissemination of Reliable Knowledge (pp. 3–39). Cambridge University Press.

Morseletto, P. (2017). Analysing the influence of visualisations in global environmental governance. Environmental Science and Policy, 78(August), 40–48. https://doi.org/10.1016/j.envsci.2017.08.021

Niederer, S. (2018). Networked Images: Visual methodologies for the digital age. Amsterdam University of Applied Sciences.

Niederer, S., & Colombo, G. (2019). Visual Methodologies for Networked Images: Designing Visualizations for Collaborative Research, Cross-platform Analysis, and Public Participation. Diseña, 14, 40–67. https://doi.org/10.7764/disena.14.40-67

Niederer, S., & Pearce, W. (2017). Making Climate Visual Part II: Climate change imagery after Trump announced the US withdrawal from the Paris Agreement. https://wiki.digitalmethods.net/Dmi/ClimateChangeAlpsWikipedia

Nieuwenhuysen, P. (2019, October 23-24). Information discovery using search by image : applications in the humanities [Paper presentation]. Adab-International Conference on Information and Cultural Sciences, Yogyakarta, Indonesia. https://core.ac.uk/download/323362931.pdf

Nisbet, M., & Huge, M. (2007). Where do science debates come from? Understanding attention cycles and framing. In D. Brossard & J. Shanahan (Eds.), The media, the public and agricultural biotechnology (pp. 193–230). https://doi.org/10.1079/9781845932046.0193

Nisbet, M., & Lewenstein, B. (2002). Biotechnology and the American media: The policy process and the elite press, 1970 to 1999. Science Communication, 23(4), 359–391. https://doi.org/10.1177/1075547002023004001

Oleschuk, M. (2020). "in Today's Market, Your Food Chooses You": News Media Constructions of Responsibility for Health through Home Cooking. Social Problems, 67(1), 1–19. https://doi.org/10.1093/socpro/spz006

Omena, J. J. (2019). Métodos Digitais: Teoria-prática-crítica. Instituto de Comunicação da Nova.

O'Neill, S. J. (2013). Image matters: Climate change imagery in US, UK and Australian newspapers. Geoforum, 49, 10–19. https://doi.org/10.1016/j.geoforum.2013.04.030

O'Neill, S. J., & Smith, N. (2014). Climate change and visual imagery. WIREs Climate Change 5,(1), 73–87. https://doi.org/10.1002/wcc.249

Panofsky, E. (1970). Meaning in the Visual Arts. Penguin.

Pearce, W., Niederer, S., Özkula, S. M., & Sánchez Querubín, N. (2019). The social media life of climate change: Platforms, publics, and future imaginaries. Wiley Interdisciplinary Reviews: Climate Change, 10(2), 1–13. https://doi.org/10.1002/wcc.569

Pearce, W., Özkula, S. M., Greene, A. K., Teeling, L., Bansard, S., Omena, J. J., & Rabello, E. T. (2020). Visual cross-platform analysis : digital methods to research social media images. Information, Communication & Society, 23(2), 161–180. https://doi.org/10.1080/1369118X.2018.1486871

Pentzold, C., Brantner, C., & Fölsche, L. (2019). Imagining big data: Illustrations of "big data" in US news articles, 2010–2016. New Media and Society, 21(1), 139–167. https://doi.org/10.1177/1461444818791326

Perini, L. (2005). Visual Representations and Confirmation. Philosophy of Science, 72(5), 913–926. https://doi.org/10.1086/508949

Popkin, B. M., Adair, L. S., & Ng, S. W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. Nutrition Reviews, 70(1), 3–21. https://doi.org/10.1111/j.1753-4887.2011.00456.x

Poti, J. M., Mendez, M. A., Ng, S. W., & Popkin, B. M. (2015). Is the degree of food processing and convenience linked with the nutritional quality of foods purchased by US households? American Journal of Clinical Nutrition, 101(6), 1251–1262. https://doi.org/10.3945/ajcn.114.100925

Powell, T. E., Boomgaarden, H. G., De Swert, K., & de Vreese, C. H. (2015). A Clearer Picture: The Contribution of Visuals and Text to Framing Effects. Journal of Communication, 65(6), 997–1017.

Proctor, R. (2008). Agnotology: A missing term to describe the cultural production of ignorance (and its study). In R. Proctor & L. Schiebinger (Eds.), Agnotology: The Making and Unmaking of Ignorance (pp. 1–33). Stanford University Press.

Rabello, E. T., Gommeh, E., Benedetti, A., Valerio-Ureña, G., & Metze, T. (2021). Mapping online visuals of shale gas controversy: a digital methods approach. Information, Communication & Society. https://doi.org/10.1080/1369118X.2021.1934064

Rabello, E. T., & Gouveia, F. C. (2019). Métodos digitais nos estudos em saúde: Mapeando usos e propondo sentidos. In J. J. Omena (Ed.), Métodos digitais: Teoria-prática-crítica (1st ed., pp. 143–160). Instituto de Comunicação da Nova.

Redden, J. (2011). Poverty in the news: A framing analysis of coverage in Canada and the UK. Information, Communication & Society, 14(6), 820–849. https://doi.org/10.1080/1369118X.2011.586432

Reforma. (2018, October 6). Descarta AMLO fracking. https://www.elfinanciero.com.mx/economia/sin-fracking-mexico-dejaria-de-aprovechar-casi-el-50-por-ciento-de-sus-reservas-cnh/

Richter, D. H. (1998). Saussure, Ferdinand. "Nature of the Linguistic Sign." In D. H. Richter (Ed.), The Critical Tradition: Classic Texts and Contemporary Trends (pp. 832–835). Bedford/St. Martin's Press.

Rip, A. (1986). controversies as informal Technology Assessment. Knowledge: Creation, DiffusIOn, Utilization, 8(2), 349–371.

Rodriguez, L., & Asoro, R. L. (2012). Visual Representations of Genetic Engineering and Genetically Modified Organisms in the Online Media. Visual Communication Quarterly, 19(4), 232–245. https://doi.org/10.1080/15551393.2012.735585

Rodriguez, L., & Dimitrova, D. V. (2011). The levels of visual framing. Journal of Visual Literacy, 30(1), 48–65. https://doi.org/10.1080/23796529.2011.11674684

Rogers, R. (2013). Digital Methods. MIT Press.

Rogers, R. (2015). Digital Methods for Web Research. Emerging Trends in the Social and Behavioral Sciences, 1–22. https://doi.org/10.1002/9781118900772.etrds0076

Rogers, R. (2017). 5. Foundations of Digital Methods: Query Design. In M. T. Schäfer & K. van Es (Eds.), Studying Culture through Data (pp. 75–94). Amsterdam University Press. https://doi.org/doi:10.1515/9789048531011-008

Rogers, R. (2019). Doing digital methods. Sage Publications.

Rogers, R. (2021). Visual media analysis for Instagram and other online platforms. Big Data and Society, 8(1). https://doi.org/10.1177/20539517211022370

Rogers, R., & Marres, N. (2000). Landscaping climate change: A mapping technique for understanding science and technology debates on the world wide web. Public Understanding of Science, 9(2), 141–163. https://doi.org/10.1088/0963-6625/9/2/304

Rojas-Padilla, E., Metze, T., & Termeer, K. (2022). Seeing the Visual: A Literature Review on Why and How Policy Scholars Would Do Well to Study Influential Visualizations. Policy Studies Yearbook, 12(1), 103–136. https://doi.org/10.18278/psy.12.1.5

Rommetveit, K., & Wynne, B. (2017). Technoscience, imagined publics and public imaginations. Public Understanding of Science, 26(2), 133–147. https://doi.org/10.1177/0963662516663057

Rosanvallon, P. (2008). Counter-Democracy, Politics in an Age of Distrust. Cambridge University Press.

Rose, G. (2001). Visual Methodologies. Sage Publications.

Rose, G. (2016). Visual Methodologies: An Introduction to Researching with Visual Materials (4th ed.). Sage Publications.

Rousseau, S. (2012). Food and Social Media: You Are What You Tweet. AltaMira Press.

Sarge, M. A., Vandyke, M. S., King, A. J., & White, S. R. (2015). Selective perceptions of hydraulic fracturing: The role of issue support in the evaluation of visual frames. Politics and the Life Sciences, 34(1), 57–72. https://doi.org/10.1017/pls.2015.6

Schneider, B., & Nocke, T. (2014). Image Politics of Climate Change: Introduction. In B. Schneider & T. Nocke (Eds.), Image Politics of Climate Change: Visualizations, Imaginations, Documentations. (pp. 9–25). Transcript Verlag.

Schneider, B., & Walsh, L. (2019). The politics of zoom: Problems with downscaling climate visualizations. Geo: Geography and Environment, 6(1), 1–11. https://doi.org/10.1002/geo2.70

Schneider, T., Eli, K., Dolan, C., & Ulijaszek, S. (2018). Introduction: Digital food activism - food transparency one byte/bite at a time? In Digital Food Activism (pp. 1–24). Routledge. https://doi.org/10.4324/9781315109930_1

Schön, D. A., & Rein, M. (1994). Frame Reflection. Basic Books.

Schrickel, I. (2014). Images of Feasibility: On the Viscourse of Climate Engineering. In B. Schneider & T. Nock (Eds.), Image Politics of Climate Change: Visualizations, Imaginations, Documentations. Transcript Verlag.

Schwartz-Shea, P., & Yanow, D. (2012). Interpretive Research Design: Concepts and Processes. Routledge.

Schwarz, E. A. G. (2013). Visualizing the chesapeake bay watershed debate. Environmental Communication: A Journal of Nature and Culture, 7(2), 169–190. https://doi.org/10.1080/17524032.2013.781516

Schwarz-Plaschg, C. (2018). The Power of Analogies for Imagining and Governing Emerging Technologies. NanoEthics, 12(2), 139–153. https://doi.org/10.1007/s11569-018-0315-z

Shifman, L. (2014). Memes in Digital Culture. The MIT Press.

Smits, T., & Ros, R. (2021). Distant reading 940,000 online circulations of 26 iconic photographs. New Media and Society. https://doi.org/10.1177/14614448211049459

Sood, G. (2017). clarifai: R Client for the Clarifai API. R Package Version 0.4, 2.

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. Social Studies of Science, 19(3), 387–420.

Steenis, N. D., & Fischer, A. R. (2016). Consumer attitudes towards nanotechnology in food products: an attribute-based analysis. British Food Journal, 118(5). https://doi-org.ezproxy.library.wur.nl/10.1108/BFJ-09-2015-0330

Stevens, T. M., Aarts, N., Termeer, C. J. A. M., & Dewulf, A. (2016). Social media as a new playing field for the governance of agro-food sustainability. Current Opinion in Environmental Sustainability, 18, 99–106. https://doi.org/10.1016/j.cosust.2015.11.010

Stevens, T. M., Aarts, N., Termeer, C. J. A. M., & Dewulf, A. (2018). Social media hypes about agro-food issues: Activism, scandals and conflicts. Food Policy, 79(June), 23–34. https://doi.org/10.1016/j.foodpol.2018.04.009

Stoutenborough, J. W., Robinson, S. E., & Vedlitz, A. (2016). Is "fracking" a new dirty word? the influence of word choice on public views toward natural gas attitudes. Energy Research and Social Science, 17, 52–58. https://doi.org/10.1016/j.erss.2016.04.005

Tabei, Y., Shimura, S., Kwon, Y., Itaka, S., Fukino, N., Wilhelm, R. A., & Kühn-institut, J. (2020). Analyzing Twitter Conversation on Genome-Edited Foods and Their Labeling in Japan. Frontiers in Plant Science, 11(October), 1–10. https://doi.org/10.3389/fpls.2020.535764

te Kulve, H., Konrad, K., Alvial Palavicino, C., & Walhout, B. (2013). Context Matters: Promises and Concerns Regarding Nanotechnologies for Water and Food Applications. NanoEthics, 7(1), 17–27. https://doi.org/10.1007/s11569-013-0168-4

Tucker, A. R., & van Tonder, G. (2015). The Karoo Fracking Debate: A Christian Contribution to the World Communities of Faith. Science and Engineering Ethics, 21(3), 631–653. https://doi.org/10.1007/s11948-014-9563-7

Uggla, Y. (2018). Framing and visualising biodiversity in EU policy. Journal of Integrative Environmental Sciences, 8168, 103–122. https://doi.org/10.1080/1943815X.2018.1455714

United Nations. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. https://sdgs.un.org/2030agenda

Vaast, E., Davidson, E. J., & Mattson, T. (2013). Talking about Technology: The Emergence of a New Actor Category Through New Media. MIS Quarterly, 37(4), 1069–1092.

Valerio-Ureña, G., & Rogers, R. (2019). Characteristics of the Digital Content about Energy-Saving in Different Countries around the World. Sustainability, 11(17). https://doi.org/10.3390/su11174704

Van Beek, L., Metze, T., Kunseler, E., Huitzing, H., de Blois, F., & Wardekker, A. (2020). Environmental visualizations: framing and reframing between science, policy and society. Environmental Science & Policy, 114, 497-505. https://doi.org/10.1016/j.envsci.2020.09.011

Van Leeuwen, T. (2001). Semiotics and Iconography. In T. Van Leeuwen & C. Jewitt (Eds.), Handbook of Visual Analysis (pp. 92–118). Sage Publications.

Venturini, T. (2010). Diving in magma: How to explore controversies with actor-network theory. Public Understanding of Science, 19(3), 258–273. https://doi.org/10.1177/0963662509102694

Venturini, T., Bounegru, L., Gray, J., & Rogers, R. (2018). A reality check(list) for digital methods. New Media and Society, 20(11), 4195–4217. https://doi.org/10.1177/1461444818769236

Venturini, T., Jacomy, M., Bounegru, L., & Gray, J. (2018). Visual Network Exploration for Data Journalists. In S. A. Eldridge II & B. Franklin (Eds.), The Routledge Handbook of Developments in Digital Journalism Studies (pp. 265–283). Routledge. https://doi.org/10.4324/9781315270449-21

Venturini, T., Jacomy, M., & Pereira, D. (2014). Visual network analysis. http://www.tommasoventurini.it/wp/wp-content/uploads/2014/08/Venturini-Jacomy_Visual-Network-Analysis_WorkingPaper.pdf

Verhoeven, I., & Metze, T. (2022). Heated policy: policy actors' emotional storylines and conflict escalation. Policy Sciences, 55(2), 223–237. https://doi.org/10.1007/s11077-022-09459-1

Wagenaar, H. (2015). Meaning in Action: Interpretation and dialogue in policy analysis. Routledge.

Waller, L., & Gugganig, M. (2021). Re-visioning public engagement with emerging technology: A digital methods experiment on 'vertical farming.' Public Understanding of Science, 30(5), 588-604. https://doi.org/10.1177/0963662521990977

Weible, C., Heikkila, T., Ingold, K., & Fischer, M. (2016). Introduction. In C. Weible, T. Heikkila, K. Ingold, & M. Fischer (Eds.), Policy Debates on Hydraulic Fracturing: Comparing Coalition Politics in North America and Europe (pp. 1–28). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-59574-4

Williams, L., Macnaghten, P., Davies, R., & Curtis, S. (2017). Framing 'fracking': Exploring public perceptions of hydraulic fracturing in the United Kingdom. Public Understanding of Science, 26(1), 89–104. https://doi.org/10.1177/0963662515595159

Williams, L., & Sovacool, B. K. (2019). The discursive politics of 'fracking': Frames, storylines, and the anticipatory contestation of shale gas development in the United Kingdom. Global Environmental Change, 58, 101935. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2019.101935

Williams, L., & Sovacool, B. K. (2020). Energy democracy, dissent and discourse in the party politics of shale gas in the United Kingdom. Environmental Politics, 29(7), 1239–1263. https://doi.org/10.1080/09644016.2020.1740555

Wolf, E. E. A., & Dooren, W. Van. (2021). Fatal remedies. How dealing with policy conflict can backfire in a context of trust-erosion. Governance, 34(4), 1097–1114. https://doi.org/10.1111/gove.12630

Wozniak, A., Wessler, H., & Lück, J. (2017). Who Prevails in the Visual Framing Contest about the United Nations Climate Change Conferences? Journalism Studies, 18(11), 1433–1452. https://doi.org/10.1080/1461670X.2015.1131129

Yanow, D. (2000). Conducting Interpretive Policy Analysis. Sage Publications.

Yanow, D. (2007). Qualitative-Interpretive Methods in Policy Research. In F. Fischer, G. J. Miller, & M. S. Sidney (Eds.), Handbook of Public Policy Analysis: Theory, Politics, and Methods (pp. 405–415). CRC Press.

Yigitcanlar, T., Kankanamge, N., Regona, M., Maldonado, A. R., Rowan, B., Ryu, A., Desouza, K. C., Corchado, J. M., Mehmood, R., & Li, R. Y. M. (2020). Artificial intelligence technologies and related urban planning and development concepts: How are they perceived and utilized in Australia? Journal of Open Innovation: Technology, Market, and Complexity, 6(4), 1–21. https://doi.org/10.3390/joitmc6040187

Supplemental Material

Annex A: Supplemental material Chapter 2

Tables A1, A2 and A3 list the top-ranked actors per country. In red, we see the opponents; in black, the neutrals; in green, the proponents. Marked in grey are those who appeared only in one year in our search. Marked in yellow are those that shifted the position from 2018 to 2019.

Table A1. Mexico: Top-ranked actors per country

2018	2019
Alianza Latinoamericana Frente al Fracking	Alianza Mexicana contra el Fracking
Alianza Mexicana Contra el Fracking	Amigos del Río San Rodrigo
Arthur Berman	Asemblea Ciudadana en Defensa del Agua
Caraiva y Asociados	Asociación Interamericana de Derecho Ambiental,
Centro Mario Molina	Autoridad de Petróleo y Gas
Ilustre Colegio de Geólogos de España	Comisión Interamericana de Derechos Humanos
No Fracking Tamaulipas	Ilustre Colegio de Geólogos de España,
S&P Global Platts	Movimiento de Regeneración Nacional (Morena)
Universidad Autónoma Metropolitana	Partido Laborista UK
Universidad Nacional Autónoma de México	S&P Global Platts
	Secretaría de Medio Ambiente y Recursos Naturales
	British Geological Service
	Tyndall Centre for Climate Change Research
	Universidad Nacional Autónoma de México
Agua.org (Fondo para la Comunicación y la Educación Ambiental, A.C.)	Agencia de Protección Medioambiental EPA
Clúster Energía Coahuila	Agencia de Seguridad, Energía y Ambiente
Comisión Nacional de Hidrocarburos	Centro Mario Molina
Consejo de la Judicatura Federal (CJF)	Comisión Nacional de Hidrocarburos
Instituto Nacional de Estadística y Geografía	Comisión Nacional del Agua
Secretaría de Medioambiente y Recursos Naturales	Comisión Reguladora de Energía
Servicio Geológico de Estados Unidos	Jeremy Corbyn
British Geological Service	Petróleos Mexicanos
	Secretaría de Energía
	Sun God Resources
Agencia de Información de la Energía de Estados Unidos	Agencia de Información de la Energía de Estados Unidos
Agencia de Seguridad, Energía y Ambiente	Agencia Internacional de Energía
Agencia Internacional de Energía	Alfa Laval

Altos Hornos de México	Cuadrilla Resources
Asociación Mexicana de Empresas de Hidrocarburos (Amexhi),	IMPLAN
Asociación Mexicana de Ingeniería, Ciencia y Gestión Ambiental	Intertek
Comisión Federal de Mejora Regulatoria (COFEMER),	Universidad Autónoma de Coahuila
Cuadrilla Resources	Wika
Enrique Peña Nieto	
Gobierno de Tamaulipas	
Halliburton	
Partido Revolucionario Institucional	
Petróleos Mexicanos	
Rogelio Montemayor	
Schlumberger	
Secretaría de Energía	
Strata BPS	
Universidad Autónoma de Coahuila	

Table A2. South Africa: Top-ranked actors per country

2018	2019
Agri Eastern Cape	AfriForum
Agri SA	Agri Eastern Cape
Department of Environmental Affairs	Agri SA
Department of Water and Sanitization Affairs	Alliance Earth
Endangered Wildlife Trust	Centre for Environmental Rights
Environmental Protection Agency	Department of Environmental Affairs
FrackFree South Africa	Department of Water and Sanitization Affairs
South African National Biodiversity Institute	Endangered Wildlife Trust
Southern African Faith Communities' Environment Institute	Environmental Protection Agency
Treasure the Karoo Action Group	Friends of the Earth
Un-Earthed (the movie)	Institute for Groundwater Studies
UNESCO	Southern African Faith Communities' Environment Institute
Water Research Commission	Treasure the Karoo Action Group
World Wide Fund for Nature	University of the Free State
	Water Research Commission
	World Wide Fund for Nature

Academy of Science of South Africa	Academy of Science of South Africa
Council for Geosciences	British Geological Survey
Council for Science and Industrial Research	Council for Scientific and Industrial Research
Department of Cooperative Governance and Tradition Affairs	Council for Geosciences
Duke's Center on Global Change	Duke's Center on Global Change
Eastern Cape High Court	Eastern Cape High Court
Global Change Institute	Global Change Institute
National Council of Provinces	Grahamstown High Court
Pietermaritzburg High Court	Parliamentary Monitoring Group
South African Academy of Engineering	Pietermaritzburg High Court
South African Institute of International Affairs (SAIIA)	Pretoria High Court
South African Journal of Science	Support Centre for Land Change
Southern African Legal Information Institute (SAFLII)	Supreme Court of Appeal
University of Cape Town,	US Energy and Information Administration
University of Johannesburg	UK Department for Business, Energy & Industrial Strategy
US Energy and Information Administration	US Geological Survey
Western Cape High Court	University of Johannesburg
	Virginia Polytechnic and State University
Air Liquide Creative Oxygen	Air Liquide Creative Oxygen
American Council on Science & Health	American Council on Science & Health
Bundu Gas and Oil Exploration	Attarat Power Company
Challenger Energy	Britain's Oil and Gas Authority
Chesapeake Energy	Bundu Gas and Oil Exploration
Chevron	China Energy Engineering Group Guangdong Power Engineering,
Department of Energy SA	China's Ministry of Land and Resources
Department of Mineral Resources	China's National Petroleum Corp
Department of Science and Technology	Cuadrilla,
Econometrix (Pty) Ltd	Department of Mineral Resources
Falcon Oil & Gas	Department of Trade and Industry
Frost & Sullivan consultants	Eskom
Golder Associates Africa	Falcon Oil & Gas
Intergovernmental Panel for Climate Change	Intergovernmental Panel on Climate Change
JPMorgan Chase & Co	National Audit Office
Petroleum Agency of South Africa	Petroleum Agency of South Africa
PwC Africa	Practical GeoMechanics
Rhino Oil and Gas Exploration South Africa	Rhino Oil and Gas Exploration South Africa

Rhino Resource Partners	Shell
Shell	Sinopec
South African Oil & Gas Alliance (SAOGA)	South African National Energy Development Institute
Statoil	Veolia Water Technologies
Total SA	
United States Department of Energy	

Table A3. United Kingdom: Top-ranked actors per country

2018	2019
Frack-off	Bath and North East Somerset Council
Friends of the Earth	City of York Council,
Greenpeace	Committee on Climate Change
Labour's party	East Riding of Yorkshire Council
Quacker.org	Frack-off
Scottish Government	Friends of the Earth
	Greenpeace
	Labour's party
	Lancashire County Council
	National Park Authority
	North Yorkshire County Council
	Oil & Gas Authority
	United Nations
	Young People's Trust for Environment
British Geological Survey	British Geological Survey
European Commission	Health and Safety Executive
Health and Safety Executive	National Audit Office
Historic England	Oxford Institute for Energy Studies
Lancashire County Council,	Royal Academy of Engineering
Oil and Gas Authority	Royal Society
US Energy Information Administration	UK conservative party
	UK Government
	US Environmental Protection Agency
Aethon Energy	Aethon Energy,
Alpha Energy	Alpha Energy
Aurora Energy Resources	Aurora Energy Resources,
BJ Services,	BJ Services,

Cuadrilla	Cuadrilla
Department of Energy and Climate Change (DECC)	Department of Energy and Climate Change
Ecopetrol	Ecopetrol
Ecotricity	Ecotricity
Equinor	Equinor
IGas	Exxon Mobil
Ineos	IGas
Kayrros	Ineos
Task Force on Shale Gas	Kayrros
Third Energy	Shell
UK conservative party,	Task Force on Shale Gas
UK Environment Agency	Tendeka
UK Government	Third Energy
UK Onshore Oil and Gas	UK Environmental Agency
York Energy (UK) Holdings	York Energy (UK) Holdings

Annex B: Supplemental material Chapter 4

Table B1. Actor categories

Actor category	Relevant sub-category	Examples
Non-government organization (NGO)	Health association	Heart and Stroke Foundation of Canada (https://www.heartandstroke.ca); Laborers' Health and Safety Fund of North America (https://www.lhsfna.org)
	Consumer organization	Consumer Reports (https://www.consumerreports.org)
	Non-profit working in the private sector	TechnoServe (https://www.technoserve.org)
Academic and Food technologist	Academic research institute	Harvard T.H. Chan School of Public Health (https://www.hsph.harvard.edu); Institute for Food, Nutrition and Health (IFNH), University of Reading (https://research.reading.ac.uk)
	Academic journal(s) publisher	ScienceDirect (https://www.sciencedirect.com); Springer (https://www.springer.com)
	Professionals in food	IFT (https://www.ift.org)
Government	Government service	National Health Service (https://www.nhs.uk); Agricultural Research Service (ARS), USDA (https://www.ars.usda.gov)
Private sector (industry)	Food industry company	Pacmoore (https://www.pacmoore.com); Fusion Tech (https://ftiinc.org)
	Engineering or management consultancy serving industry companies	Ecolab (https://www.ecolab.com); McKinsey & Company (https://www.mckinsey.com)
	Industry association	Michigan Manufacturing Technology Center (https://www.the-center.org)

Private sector (nutrition specialist)	Dietitian or nutritionist who is private consultant	SR Nutrition (https://www.srnutrition.co.uk); Nutrition Stripped (https://nutritionstripped.com)
	Dietitians' or nutritionists' professional network	Academy of Nutrition and Dietetics (https://www.eatright.org)
Political sector	Political advisors	The European Food Information Council (EUFIC) (https://www.eufic.org); EIT Food (https://www.eitfood.eu)
Journalist	(Nutrition and health) old-media journalist	BBC Food (https://www.bbc.co.uk/food); Washington Post (https://www.washingtonpost.com)
	Food, health, and wellness new-media journalist	Cooking light (https://www.cookinglight.com); Active.com (https://www.active.com);
	(Medical or Food technology) professional journalist	News-Medical (https://www.news-medical.net); Food Processing Technology (https://www.foodprocessing-technology.com)
Individual	n/a	Robert Lustig.com (https://robertlustig.com); Plant Based And Broke (https://plantbasedandbroke.com)
Online education	Distance education	ACS Distance Education (https://www.acsedu.co.uk); Future Learn (https://www.futurelearn.com)
	Learning site	Britannica Kids (https://kids.britannica.com)
Knowledge platform	Online encyclopaedia	Wikipedia (https://en.wikipedia.org); New World Encyclopedia (https://www.newworldencyclopedia.org)
	Popular science platform	Medium (https://elemental.medium.com)
Online marketplace	n/a	Amazon (https://www.amazon.co.uk)

Adapted from (Cullerton et al., 2016)

Table B2. Textual (discursive) frames

Frame	Definition	Empirical examples
Environmental harm (adapted from Nisbet & Lewenstein, 2002)	Processed foods and the food industry damage the environment	"Food packaging from processed items ends up in landfills where it can take a long time to breakdown – especially plastic."
Environmental opportunity (adapted from Aschemann-Witzel et al., 2019)	Processed foods and the food industry benefit the environment	"Processed foods keep better, cutting down on food waste"; "technology can create more sustainable alternatives to beef and chicken and pork."
Food security	Food processing is necessary for (future) food security	"Processed food contributes to both food security (ensuring that sufficient food is available) and nutrition security (ensuring that food quality meets human nutrient needs)."
Health opportunity (adapted from Aschemann-Witzel et al., 2019)	Processed foods benefit human health	"Processed food can help you eat more nutrient-dense foods"; "many foods are processed to improve or fortify their health benefits and overall nutritional value."
Health threat (adapted from Nisbet & Lewenstein, 2002)	Processed food poses a health threat	"If you eat a lot of highly processed foods, you risk getting too much sodium, added sugars and unhealthy fats."

Home cooking (adapted from Oleschuk, 2020)	Home cooking is preferable	"Cook more meals at home"; "one major change in dietary patterns in the last 70 years has been the decline of home cooked meals, and the increase in ultra-processed foods. Tip the balance! Cook at home more often, without using ultra-processed ingredients (heating up frozen fried chicken doesn't count)."
Injustice	The food industry and its products are a target of unjustified judgment	"While it is easy to point fingers at profit-hungry food manufacturers as driving the trend toward more highly-processed food, there are a multitude of factors that have determined the path of processed food"; "processed food doesn't deserve its demonized reputation."
Many possibilities (adapted from Nisbet & Huge, 2007)	Processed food enables various improvements for humans	"Foods are also modified for many different reasons, from improving taste and visual appearance to extending shelf life"; "never in human history have we had such high-quality and safe food so abundant, cheap, and readily available."
Nutritional value	Foods should be assessed on the basis of their nutritional value/energy density	"The label "processed foods" covers quite a wide range of consumable items. While pre-cut watermelon technically qualifies as "processed," it doesn't lose any of its nutritional value through being cut and packaged for convenience."
Safety concerns (adapted from Marks et al., 2007)	Safety issues make the food industry dangerous	"Although businesses use food processing techniques to reduce food safety risks, the facilities where foods are processed are sometimes part of the problem."
Safety standards	The food industry meets high safety standards or is strongly regulated	"Increasing regulatory and consumer demands have intensified the pressure on the food industry to implement reliable methods of food inspection to ensure product safety and quality".
Lack scientific evidence	There is not sufficient evidence to prove that (ingredients of) processed foods are bad for health	"large population studies cannot entirely separate the effects of eating ultra-processed foods from other lifestyle factors that influence disease risk."

Figure B1. The visualisations appearing in Figure 4.5

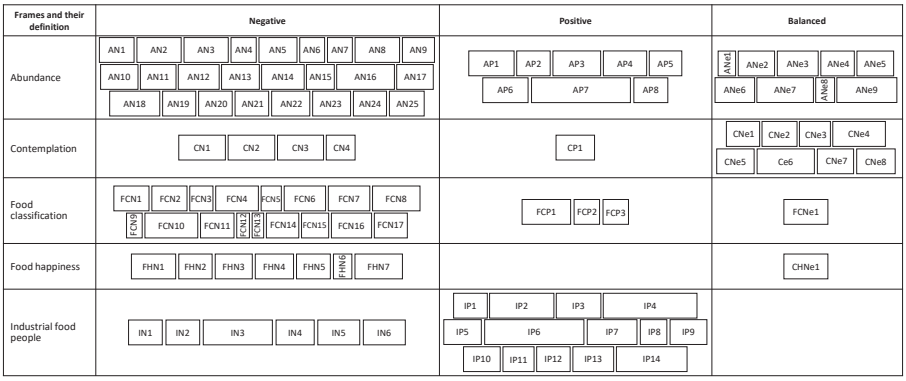
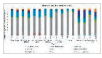
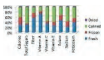


Table B3. URLs of the visualisations appearing in Figure 4.5

Key	Thumbnail	URL (accessed 10 December 2021, unless access date specified)
AN1		https://www.cookinglight.com/eating-smart/smart-choices/what-are-processed-foods
AN2		https://www.bbc.co.uk/food/articles/what_is_ultra-processed_food
AN3		https://www.consumerreports.org/packaged-processed-foods/the-mounting-evidence-against-ultra-processed-foods/
AN4		https://www.bbc.co.uk/food/articles/what_is_ultra-processed_food
AN5		https://www.news-medical.net/health/Why-Should-We-Avoid-Processed-Food.aspx
AN6		https://www.bbc.co.uk/food/articles/what_is_ultra-processed_food
AN7		https://www.runnersworld.com/news/a27761906/processed-foods-bad-for-heart-brain-health/
AN8		https://food.ndtv.com/food-drinks/8-processed-foods-to-avoid-and-why-1669345
AN9		https://thethirty.whowhatwear.com/how-to-read-food-labels/slide11
AN10		https://www.lhsfna.org/index.cfm/lifelines/may-2019/the-many-health-risks-of-processed-foods/ (accessed 10 November 2020)
AN11		https://www.nytimes.com/2016/05/22/upshot/it-isnt-easy-to-figure-out-which-foods-contain-sugar.html?auth=login-email&login=email
AN12		https://food.ndtv.com/news/too-much-of-ultra-processed-food-may-take-toll-on-your-heart-study-2132242
AN13		https://www.lhsfna.org/processed-food-makes-its-case-sort-of/
AN14		https://www.theguardian.com/food/2020/feb/13/how-ultra-processed-food-took-over-your-shopping-basket-brazil-carlos-monteiro
AN15		https://www.heartandstroke.ca/healthy-living/healthy-eating/healthy-eating-basics
AN16		https://www.mcgill.ca/oss/article/food-health/food-additives-and-hyperactivity
AN17		https://www.nytimes.com/2019/05/16/well/eat/why-eating-processed-foods-might-make-you-fat.html
AN18		https://theconversation.com/the-rise-of-ultra-processed-foods-and-why-theyre-really-bad-for-our-health-140537 (accessed 18 November 2020)

AN19		https://thethirty.whowhatwear.com/how-to-read-food-labels
AN20		https://www.heart.org/en/news/2020/01/29/processed-vs-ultra-processed-food-and-why-it-matters-to-your-health
AN21		https://cordis.europa.eu/article/id/125252-trending-science-eating-processed-foods-makes-people-eat-more-and-put-on-weight
AN22		https://www.news-medical.net/news/20190519/Ultra-Processed-foods-delay-satiety-increase-food-intake-and-weight-gain.aspx
AN23		https://www.lhsfna.org/the-many-health-risks-of-processed-foods/
AN24		https://www.cookinglight.com/eating-smart/nutrition-101/which-is-healthier-canned-tuna-or-salmon
AN25		https://thethirty.whowhatwear.com/how-to-read-food-labels/slide2
AP1		https://processedfoodsite.com/2019/06/11/what-makes-a-processed-food-an-ultra-processed-food-how-dangerous-to-our-health-is-ultra-processing/
AP2		https://www.wellandgood.com/what-is-processed-food/
AP3		https://www.newfoodmagazine.com/article/13197/understanding-the-dark-side-of-food-the-analysis-of-processed-food-by-modern-mass-spectrometry/
AP4		https://www.foodprocessing.com/articles/2020/nuts-and-seeds/
AP5		https://www.nutrition.org.uk/nutritionscience/foodfacts/additives.html?start=1 (accessed 1December 2020)
AP6		https://processedfoodsite.com/2019/06/11/what-makes-a-processed-food-an-ultra-processed-food-how-dangerous-to-our-health-is-ultra-processing/
AP7		https://www.auctoresonline.org/journals/nutrition-and-food-processing
AP8		https://www.acsedu.co.uk/Info/Hospitality-and-Tourism/Hospitality/Food-Processing-And-Technology.aspx
ANe1		https://en.wikipedia.org/wiki/Convenience_food
ANe2		https://www.cnet.com/health/nutrition/what-are-processed-foods/
ANe3		https://www.cnet.com/health/nutrition/what-are-processed-foods/
ANe4		https://www.foodsystemprimer.org/food-processing/

ANe5		https://www.hsph.harvard.edu/nutritionsource/processed-foods/
ANe6		https://www.nhs.uk/live-well/eat-well/what-are-processed-foods/
ANe7		https://www.srnutrition.co.uk/2018/10/processed-foods-the-pros-and-cons-part-2/
ANe8		https://www.srnutrition.co.uk/2018/10/processed-foods-the-pros-and-cons-part-2/
ANe9		https://www.sciencefocus.com/science/e-numbers-synthetic-food-dyes-and-the-problem-of-policing-additives/
CN1		https://food.ndtv.com/food-drinks/8-processed-foods-to-avoid-and-why-1669345
CN2		https://www.bbc.com/news/health-48446924
CN3		https://www.webmd.com/diet/news/20190530/highly-processed-food-linked-to-earlier-death#1
CN4		https://www.bbcgoodfood.com/howto/guide/truth-about-low-fat-foods
CP1		https://www.srnutrition.co.uk/2018/10/processed-foods-the-pros-and-cons-part-2/
CNe1		https://www.eatright.org/food/nutrition/nutrition-facts-and-food-labels/processed-foods-whats-ok-and-what-to-avoid
CNe2		https://www.hsph.harvard.edu/nutritionsource/processed-foods/
CNe3		https://www.hsph.harvard.edu/nutritionsource/processed-foods/
CNe4		https://seniorservicesmidland.org/avoiding-processed-food-mean/
CNe5		https://www.verywellfit.com/are-all-processed-foods-unhealthy-2506393
CNe6		https://www.sciencefocus.com/the-human-body/five-things-you-probably-didnt-know-about-processed-food/
CNe7		https://www.srnutrition.co.uk/2018/10/processed-foods-the-pros-and-cons-part-2/
CNe8		https://www.srnutrition.co.uk/2018/10/processed-foods-the-pros-and-cons-part-2/
FCN1		https://www.cdc.gov/salt/food.htm
FCN2		https://www.frontiersin.org/articles/10.3389/fnut.2019.00070/full
FCN3		https://www.frontiersin.org/articles/10.3389/fnut.2019.00070/full

FCN4		https://www.frontiersin.org/articles/10.3389/fnut.2019.00070/full
FCN5		https://www.frontiersin.org/articles/10.3389/fnut.2019.00070/full
FCN6		https://onlinelibrary.wiley.com/doi/full/10.1111/obr.12860
FCN7		https://www.lhsfna.org/the-many-health-risks-of-processed-foods/
FCN8		https://onlinelibrary.wiley.com/doi/full/10.1111/obr.12860
FCN9		https://www.sciencedirect.com/science/article/pii/S0025619619304185
FCN10		https://link.springer.com/article/10.1007/s00394-020-02367-1
FCN11		https://www.bmj.com/content/365/bmj.l1451
FCN12		https://www.cdc.gov/salt/food.htm (accessed 8 December 2020)
FCN13		https://www.bbc.com/news/health-48446924
FCN14		https://www.frontiersin.org/articles/10.3389/fsufs.2018.00088/full
FCN15		https://www.frontiersin.org/articles/10.3389/fsufs.2018.00088/full
FCN16		https://www.bmj.com/content/360/bmj.k322
FCN17		https://www.foodsystemprimer.org/food-and-nutrition/food-marketing-and-labeling/
FCP1		https://pubmed.ncbi.nlm.nih.gov/24760975/
FCP2		https://www.futurelearn.com/info/courses/food-supply-systems/0/steps/53648
FCP3		https://www.futurelearn.com/info/courses/food-supply-systems/0/steps/53648
FCNe1		https://www.washingtonpost.com/news/wonk/wp/2016/05/07/what-life-would-actually-be-like-without-any-processed-food/
FHN1		https://www.medicalnewstoday.com/articles/318630
FHN2		https://www.foodsystemprimer.org/food-and-nutrition/food-marketing-and-labeling/
FHN3		https://www.hsph.harvard.edu/news/press-releases/healthy-vs-unhealthy-diet-costs-1-50-more/

FHN4		https://www.cdc.gov/salt/food.htm (accessed 8 December 2020)
FHN5		https://thethirty.whowhatwear.com/how-to-read-food-labels/slide5
FHN6		https://thethirty.whowhatwear.com/how-to-read-food-labels/slide7
FHN7		https://www.diabetes.co.uk/food/processed-foods.html
CHNe1		https://www.heart.org/en/healthy-living/healthy-eating/eat-smart/nutrition-basics/processed-foods
IN1		https://www.independent.co.uk/news/health/coronavirus-meat-factory-outbreak-why-how-norfolk-suffolk-cornwall-b1230707.html
IN2		https://www.ewg.org/news-insights/news/covid-19-spreading-food-processing-facilities-across-us
IN3		https://ftiinc.org/8-causes-of-costly-injuries-in-food-processing-plants/
IN4		https://www.foodprocessing-technology.com/news/ultra-processed-foods-linked-cancer/
IN5		https://www.theguardian.com/world/2014/dec/21/life-inside-america-food-processing-plants-cheap-meat
IN6		https://www.theguardian.com/world/2014/dec/21/life-inside-america-food-processing-plants-cheap-meat
IP1		https://www.canr.msu.edu/fshn/research/food_processing_and_quality_enhancement
IP2		http://www.invest-in-usa.org/industries/3/food-processing
IP3		https://www.cbc.ca/news/politics/food-security-pandemic-freeland-1.5534372
IP4		https://ag.purdue.edu/foodsci/Pages/food_processing.aspx
IP5		https://www.technoserve.org/blog/fact-versus-fiction-the-role-of-food-processing-in-global-nutrition/
IP6		https://www.auctoresonline.org/journals/nutrition-and-food-processing
IP7		https://theconversation.com/why-forgotten-food-manufacturers-deserve-our-thanks-too-138759
IP8		https://www.pacmoore.com/blog/future-of-food-processing-technology/
IP9		https://www.areadevelopment.com/FoodProcessing/Q4-2015-food-processing-guide/Facility-Engineering-Design-Support-Food-Processing-345522.shtml

IP10		https://kids.britannica.com/students/article/food-processing/274375
IP11		https://www.canr.msu.edu/fshn/research/food_processing_and_quality_enhancement
IP12		https://www.eatright.org/homefoodsafety/safety-tips/food-poisoning/safe-food-processing
IP13		https://www.newfoodmagazine.com/article/125728/food-processing-industry/
IP14		https://www.technoserve.org/our-work/entrepreneurship/food-processing/

Annex C: Supplemental material Chapter 5

C-a. *Steps for answering RSQ1 (what visualisations about nanotechnology in food circulate on Twitter, with what textual tone, and as part of what storyline?)*

1. Constructing the Twitter dataset

Using Twitter API, we retrieved all the original tweets that were in English, were tweeted between 2007[49] and 2021,[50] contained images, and contained – as text or as a hashtag – either nanofood or the combination of nano/nanotech/nanotechnology together with food.[51] Because of its API, Twitter is an ideal platform for collecting visualisations used in a particular topical context, together with their accompanying text (which is the tweet's text). Hence, we used the search string: '((#nanotech #food) OR (#nanotechnology #food) OR (#nano #food) OR (#nanotech #foodpackaging) OR (#nanotechnology #foodpackaging) OR (#nano #foodpackaging) OR #nanofood OR #foodnanotechnology OR (nanotech food) OR (nanotechnology food) OR (nano food) OR nanofood) -is:retweet lang:en has:images', 'start_time': '2007-01-01T00:00:00Z', 'end_time': '2021-07-01T00:00:00Z'.

2. Analysing tweets

The tweet list consisted of 4761 tweets. From this list, we selected the tweets that circulated the most frequently: tweets that were retweeted at least 10 times.

49 2007 is the earliest complete year for which historical tweets are available.
50 The retrieval of tweets was conducted on 14 July 2021.
51 These words were revealed in preliminary research as relevant. We included different variants of the same word (i.e., nano, nanotech, nanotechnology) as Twitter API returns results that match full words only.

Retweet (RT) is the most relevant engagement metric for studying circulating visualisations on Twitter, considering Twitter's affordance (Amit-Danhi & Shifman, 2018): they are not a mere reflection of exposure or attention, but rather an indication of an active engagement that influences a visualisation's online presence (Boscarino, 2022; Geboers & Van De Wiele, 2020). The selection of tweets with high RT metrics left us with a list of 214 tweets. We manually cleaned this list of irrelevant tweets (tweets that are not about nanotechnology in food, e.g., tweets about food and Nano cryptocurrency; tweets about food and things that have nano in their name; tweets that are about nanotechnology AND food but not IN food). We also manually removed one tweet from a suspended account, and we merged tweets that were repeated with bot-like behaviour (multiple times, usually with small intervals, by a single user, and with the same text and visuals).
Our clean dataset consisted of 90 tweets that contained 104 unique visualisations. Some tweets included more than one visualisation; some of the visualisations were repeated in multiple tweets. The visualisations were downloaded; the tweets and their visualisations were put in an Excel file for further analysis of the tone (of the text) towards nanotechnology in food and the storylines (of the visualisations and their accompanying text) narrated.

The tone was coded as typically done in the analysis of media coverage (e.g., Baumgartner et al., 2008; Kuttschreuter et al., 2011). A tweet with positive wording regarding nanotechnology in food, such as 'prevent food spoilage', was coded as positive; a tweet with negative wording, such as 'infecting the public', was coded as negative; a tweet with wording that does not express any valence, such as 'discussing the impact nanotechnology will have on the food chain', was coded as neutral. The results of the tone coding were compared with the results of automated sentiment analysis. When there was a difference between the manual and the automated results, the manual analysis was discussed by the authors until agreement was reached.

The storylines were coded inductively, drawing on Hajer's (1995, p. 56, 2006, p. 71) definition of storyline. This notion of storyline is shown to be effective in analysing tweets with opinions about a policy issue (Jeffares, 2014, p. 144). Following Kress's (2001, 2010) approach, each visualisation and the text accompanying it (its tweet's text) were analysed together to reveal repeated narratives that give meaning to the topic of nanotechnology in food (Table C1). Coding disagreements were discussed by the authors, and storylines were merged and divided, until

agreement was reached. Tweets in which no storyline was revealed were labelled as not applicable (NA).

C-b. *Steps for answering RSQ2 (which of the visualisations revealed through RSQ1 circulate frequently on the open Web, in what topical context, with what textual tone, and as part of what nanotechnology-in-food storyline (if at all)?)*

1. Narrowing the dataset: cross-platform circulating

Using a Google reverse image search (Rogers, 2019, p. 19, 2021, p. 13) and the 104 visualisations extracted from the tweet list, we revealed the frequency of the visualisations' circulation on the open Web. Google reverse image search is a black-boxed algorithm (Rogers, 2019, p. 19) that returns results of a source visualisation as well as modified versions of it (e.g., a version with different colours, a version that is a fragment of the source visualisation, Nieuwenhuysen, 2019). To include only those visualisations that circulated frequently on the open Web, we selected the visualisations whose Google reverse image search returned at least 200 results.[52] The narrowed dataset consisted of 14 visualisations.

2. Analysing URLs

In all the English URLs on which the 14 visualisations appeared,[53] the visualisation was compared with the source visualisation. When there was a visual match (n=667 URLs), the text was coded for its main topical context. For this analysis, the complete text of the URL was analysed, unless the URL contained several distinct sections (e.g., several blog posts). In that case, the section containing the visualisation was analysed. Applying the same strategy as applied to clean the tweet dataset (Step 1 above), we indicated when an URL text discusses nanotechnology in food.

3. Narrowing the visualisations dataset; Adding URLs

52 This number includes URLs that were repeated multiple times, URLs that were unavailable ('broken links'), URLs that although appearing in the result list did not include the visualization, and URLs that included a visualization that was a modified version of the source visualization. These 'false results' were filtered in the next step.

53 We analysed only the URL results in English on each of the first 20 pages. Results in English were generally followed by results in another language. In 13 of the 14 visualizations, all results in English seemed to appear on pages 1 to 20.

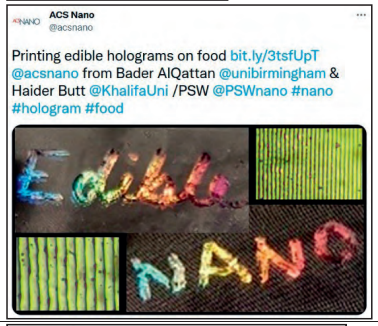
In preparation for an in-depth analysis, from the 14 visualisations that circulated frequently on the open Web, we selected visualisations whose accompanying text was (also) about nanotechnology in food. To limit the data included in the in-depth analysis, we excluded visualisations used only once in the context of nanotechnology in food. Five visualisations were selected. All the URLs on which the five selected visualisations appeared, namely, 157 URLs, were included in the next step of the in-depth analysis.

4. In-depth analyses: publication date, tone, storyline

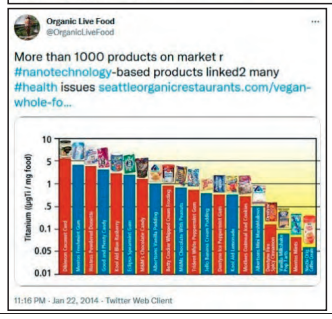
The internet enables, to some extent, access to the historical use of a visualisation, because some of its previous uses may still be online (see "digital history" Rogers, 2019, p. 89). Hence, to have an overview of changes in tone and storyline over time, to answer our main research question (what meanings, given the visual and its accompanying text, are carried by circulating visualisations about nanotechnology in food, does the meaning change when these visualisations circulate, and, if so, how?), for each URL included in the in-depth analysis we determined the publication date, based on the text of the page when a publication date was available, and, when a publication date was not available, we used the publication date that appeared in the page source meta tags or the date registered at the XML sitemap (when a publication date did not appear in the page source or the XML sitemap but an update date was available, we used the latter). For some URLs, no publication/update date was determined.

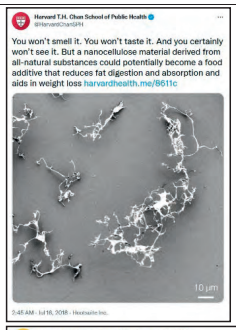
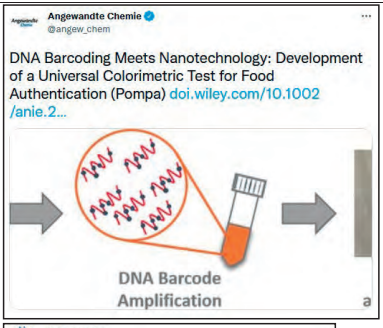
In all the URLs included in the in-depth analysis, we coded the URL's tone towards the topic of the webpage as positive, negative, or neutral. Using ATLAS.ti, we coded the nanotechnology-in-food storyline of the visualisation and its accompanying text. We did so based on the same codebook used for analysing the tweets (Table C1), and also inductively, similar to how we coded the tweets' storyline (step 2 in section c-a above).

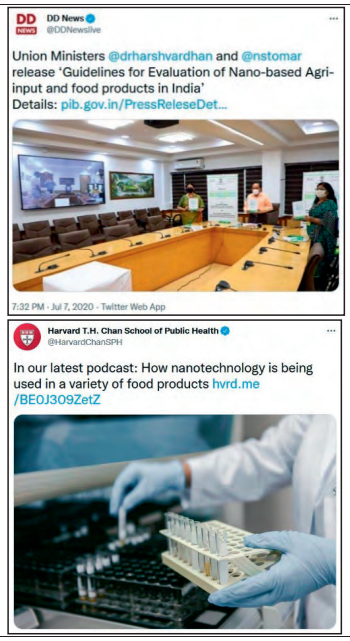
Table C1. *Nanotechnology-in-food storylines*

Storyline	Definition	Examples from tweets or URLs
Advancing the agri-food sector	Nanotechnology in food advances the agri-food sector by enabling the food industry to do exclusive things (e.g., produce foods with specific texture)	 
Benefit for the consumer	Nanotechnology offers food products with added value for the consumer	 

Ethical concern	Nano-sized chips/bots in food are part of a plan to control the public in an unethical manner	 
Food contaminant	Nano-sized particles originating elsewhere reach our food and contaminate it	 

Food security and food sustainability	Nanotechnology advances food security and food sustainability	 
Health concern	Nanotechnology in food poses health concerns/risks/threats	 

Health benefit	Nanotechnology in food offers health benefits	 
Scientific development	Nanotechnology in food is a scientific development	 
Some unknowns	The complete effects of nanotechnology on health and the environment are still unknown	 ‘We need to be cautious when using it until we know its full implications.’

The nano future is here	Nanotechnology in food is part of the future or is already in use	

Annex D: Supplemental material Chapter 6

Table D1. The findings of the empirical chapters with respect to the aspects of visualisation meaning-making introduced as a conceptual framework.

Aspect(s) of meaning-making	Sub-question(s)	Chapter(s)	Findings
Type and content	1	2, 3 and 4	● Extensive use of photographs and data-related visualisations (in energy controversies: infographics and maps; in food controversies: infographics, charts and diagrams) ● Opponents' distinct use of 'scientific' visualisations ● Repeated content (in energy controversies: natural and industrial landscapes, people, flames; in food controversies: people interacting with food, miniature pellets or particles, abundance of food and scientists or scientific activity) ● Proponents' use of visualisations of officials (energy) and people producing food (food) ● Opponents' use of visualisations of landscape and protesters (energy)
Type and content; Circulation	1 and 3	2 and 5	● Association between visualisation type and content and actors' stance in the controversy: o More types of visualisations and content are used as opponents became more dominant (energy) ● Association between visualisation type and content and the evolution of the controversy: o Increased use of data visualisations as the controversy intensified (energy) o Decreased use of visualisations of officials as the controversy intensified (energy)
Type and content; Narrative	1 and 2	3	● Photographs overtly narrating a storyline and data visualisations narrating a storyline more subtly (energy) ● Maps differentiating between two storylines by adding a layer of data; infographics doing the same by using a visual technique (energy)

Narrative	2	3, 4 and 5	● Visualisations that make a discursive storyline or a sentiment visible, using specific content, qualities and techniques ● Visual narratives that add new information or focus on an aspect that exists or does not exist in the text, possibly changing the valence of the message: o A balanced textual storyline accompanied by a positively valenced visual storyline (energy) o Using frames, positive, negative and balanced coalitions, emphasising in visualisations different aspects than those discussed in text (food) ● Different degrees of coherence between visual and textual storylines: o Within a discourse coalition, visual storylines confirming a textual storyline (energy) o Within a discourse coalition, visual storylines contributing to the breaking apart of a coalition into different ways of interpreting a policy issue (energy) o Among discourse coalitions, visual storylines confirming textual storylines, thereby increasing the tension between them (energy) o Among discourse coalitions, visual storylines contributing to the connecting of different ways of interpreting a policy issue (energy). ● Visualisations and their accompanying text that create a range of composite image–text storylines (food).
Narrative; Circulation	2 and 3	5	● As visualisations circulate and stay within the boundaries of the topic, a single image–text storyline is repeated and other storylines are added (food).
Circulation	3	5	● Circulation influencing the meaning conveyed by visualisations (food). ● Visualisations used within various contexts, while circulating (food). ● Visualisations used within the context of already connected topics, enriching the connection (food). ● Possibly, based on one empirical example, a visualisation's meaning changes more often when crossing topical context borders (food).

English Summary

In policy controversies, the meaning-making by visualisations on the Internet and social media is increasingly influential. Visualisations shape the perception of a policy problem and solutions and influences public opinion and governance. The phenomenon of giving meaning to a policy issue by (using) visualisations remains understudied. This dissertation fills this gap by investigating online visualisations in controversies over energy and food technologies. These controversies are particularly noteworthy because innovation in the energy and food domains can contribute to sustainable development. Despite this promise, innovative technologies may spark controversies. In this dissertation the following question is answered: What meanings do visualisations convey in policy controversies over energy and food technologies?

An interpretive approach is taken to answer the research question. Three aspects of meaning-making by visualizations in a policy controversy were further conceptualized and empirically studied: (1) *Visualization type and content,* (2) *Narrative* and (3) *Circulation*. The visualisation *type* (map, cartoon, photo) raises specific expectations and hence contributes to the effect it has. The *content* of the visual (what is in the visual: trees, cars) can be studied to reveal what meaning is addressed to the policy controversy through the visual. When studying *narratives* of the visualizations, we studied their connotative level. This process of meaning-making is about the visual signs – the ideas, concepts and metaphors – that are attached to them. These can be studied and compared to widely accepted conventions. As objects constructing narratives, similar to text, visualisations can form online publics in the form of discourse and sentiment coalitions. When conceptualizing *circulation*, I studied how visualisations, especially digital ones, can be used at different sites (Internet, Twitter) by different accounts or actors. Circulation can change the meaning that specific visualisations or a visual network give to an issue.

The empirical chapters of this thesis study multiple cases: the controversies about hydraulic fracturing for shale gas extraction ('fracking'), food processing and nanotechnology in food and food packaging. The data in each chapter consists of text and visualisations found on webpages or tweets and the research protocol is specified for each empirical chapter.

Chapter 2 employs digital methods to reveal the actors involved in the online fracking controversy in South Africa, Mexico and the United Kingdom. The chapter applies textual content analysis to label actors' stances and analyses the evolution of type and content of the visuals which are networked to the fracking topic at two points in time, 2018 and 2019.

Chapter 3 recognizes online publics of the fracking controversy in the Netherlands, New York State and South Africa. The chapter analyses visuals and text on websites of these online publics to reveal the degree of coherence between the visual and the text and the ways visualisations can contribute to discourse formation.

Chapter 4 uses Google queries to construct a dataset of the online processed food controversy. The chapter uncovers the positive, negative and balanced sentiment coalitions and applies textual and visual analyses of frames. It studies people's understanding of the notion of 'processed food' and reveals how sentiments about processed food are communicated, online.

Chapter 5 uses Twitter API and Google reverse image search to construct datasets and analyses visualisations of nanotechnology in food and food packaging and their accompanying text. The chapter detects changes, over time, in the text's tone and the image–text storyline during visualisations' circulation within a platform, across platforms and across topical contexts.

The chapters together gave the following results. First of all, considering *type*: often, data-related visualisations were used. This type of visualisation (infographics, maps, charts and diagrams) mix facts with an interpretation of the controversial topic. Data-related visualisations were used more extensively by opponents than by proponents and mostly were accompanied with a negative textual message. Related to the *content*, the visualizations in the online fracking controversies frequently drew on visuals of natural and industrial landscapes, people (officials, protesters) and flames. In the online-processed food controversy, many photographs were about food abundance. In the nanotechnology-in-food online controversy, miniature pellets or particles, scientists and scientific activity were often seen. For both processed food and nanotechnology in food, visuals of food and people interacting with it were used.

Second, when looking into the *narratives,* the most observed were those of risks and benefits of technologies. Risk narratives were often more prevalent than benefit narratives. Actors used visualisations to make textual narratives more concrete and visible by relating the technology to 'casual' objects or events, by isolating objects or by magnifying objects that are impossible to see with the naked eye. Three ways of using visual and textual narratives were revealed: (1) Online coalitions visually emphasise different aspects than those emphasised textually; (2) Visualisations strengthen or weaken a textual narrative, to the extent that visualisations can contribute to the breaking apart of a coalition or the uniting of multiple discourse coalitions; (3) Actors give positive, negative and neutral meanings to the technology by using a variety of image–text storylines.

Third, with respect to *circulation*, we found three processes of circulation: (1) Circulation within a platform, in which visualisations are accompanied with different pieces of text; (2) Circulation across platforms, in which visualisations on Twitter give meaning almost always using a single image–text storyline, but on the open Web, they give meaning by using multiple image–text storylines; (3) Circulation across topical contexts, in which visualisations are used in different contexts or they are networked to a topic and the network changes with the evolvement of the controversy.

Based on these findings, I conclude that in online policy controversies actors most of all disseminate information in a 'scientific' manner. This is based on the findings that data visualizations are used extensively, more by opponents than by proponents and more with a negative textual message than a positive one. A second conclusion is that visualisations play an essential role in policy controversies about contested technologies not only as objects responding to external claims or events, but also in themselves. Their content puts at the centre considerations and concerns that might otherwise remain marginal. The narratives constructed by visual content and techniques add new information or focus, creating a layer of meaning more multifaceted and richer than the one given to the issue by using text only. A third conclusion is that online visualisations often frame a technology as posing risks or offering benefits. They do so by making more concrete and visible these risks and benefits and by encouraging to rethink these risks and benefits as embedded in routine activities and ordinary objects. Finally, in online policy controversies, the meaning visualisations convey may change over time.

When visualizations circulate, the composite image–text meaning changes. On websites, together with their accompanying text, visualisations can give more complex meaning to the topic than they do on Twitter. Change in meaning occurs also when visualisation of different types, content and narratives are networked to a topic, as the controversy intensifies.

These conclusions lead to the following recommendations for practice. First of all, policy controversy analysts need to ensure that visualisations' full potential as objects offering insights into the controversy is thoroughly explored. I advise alternating between zooming in and out in the analysis of the visuals. Another piece of advice for analysts would be to try to infer why a particular way of visualising was chosen among endless options for doing so. This attempt can lead to a better understanding of actors' attitudes and concerns. For all actors who visualize issues which are at the heart of policy controversies, I propose to consider their visual presence online. While doing so, actors should be aware that visualisations might find their way to places different from those their authors intended them to be, with text different from the text originally accompanying them, and may consider 'securing' the accompanying text to the visualisation. Additionally, when choosing a visualisation to be used online, a reflection on the multiple meaning conveyed by this visualisation is advisable. Such reflection may help to be aware of the own set of values, beliefs and feelings in relation to the controversial issue, along with a possible change of this perspective.

Nederlandse samenvatting

In beleidscontroverses wordt de betekenisgeving door visualisaties op internet en sociale media steeds invloedrijker. Visualisaties beïnvloeden de perceptie van een beleidsprobleem en oplossingen, en beïnvloeden de publieke opinie en het bestuur. Het fenomeen van betekenis geven aan een beleidsvraagstuk door (gebruik te maken van) visualisaties blijft onderbelicht. Dit proefschrift vult deze leemte op door online visualisaties te onderzoeken in controverses over energie- en voedseltechnologieën. Deze controverses zijn vooral opmerkelijk omdat innovatie op het gebied van energie en voedsel kan bijdragen aan duurzame ontwikkeling. Ondanks deze belofte kunnen innovatieve technologieën tot controverses leiden. In dit proefschrift wordt de vraag beantwoord: Welke betekenissen geven visualisaties aan beleidscontroverses over energie- en voedseltechnologieën?

Een interpretatieve benadering is gekozen om de onderzoeksvraag te beantwoorden. Drie aspecten van betekenisgeving door visualisaties in een beleidscontroverse werden verder geconceptualiseerd en empirisch bestudeerd: (1) Visualisatietype en inhoud (2) Narratief. (3) Circulatie. Het type verbeelding (bijvoorbeeld kaart, cartoon, foto) en de inhoud (wat staat op het plaatje: bomen, auto's) kunnen worden bestudeerd om te onthullen welke betekenis aan de beleidscontroverse wordt gegeven. Bij het bestuderen van het narratief van de visualisaties, bestuderen we hun connotatieve niveau. Dit proces van betekenisgeving gaat over de visuele symbolen - de ideeën of concepten en metaforen - die eraan verbonden zijn. Visualisaties construeren verhalen die door groepen van actoren verteld worden. Dit zijn visuele discours- en sentimentcoalities. Bij het conceptualiseren van circulatie heb ik onderzocht hoe dezelfde digitale visualisaties op verschillende sites (internet, twitter) door verschillende accounts of actoren worden gebruikt.

De empirische hoofdstukken van dit proefschrift bestuderen meerdere cases: de controverses over hydraulische fracking voor schaliegaswinning ('fracking'), voedselverwerking en nanotechnologie in voedsel en voedselverpakkingen. De gegevens in elk hoofdstuk bestaan uit tekst en visualisaties op webpagina's of tweets en het onderzoeksprotocol wordt gespecificeerd voor elk empirisch hoofdstuk.

Hoofdstuk 2 maakt gebruik van digitale methoden om de actoren en visuals te onthullen die betrokken zijn bij de online fracking-controverse in Zuid-Afrika,

Mexico en het Verenigd Koninkrijk. Het hoofdstuk past tekstuele inhoudsanalyse toe om de standpunten van acteurs te labelen en analyseert de evolutie van het type en de inhoud van de visuals die op twee tijdstippen, 2018 en 2019, zijn gekoppeld aan het fracking-onderwerp.

Hoofdstuk 3 laat zien dat er online publieken zijn rondom de fracking controverse in Nederland, New York State en Zuid-Afrika. Het hoofdstuk analyseert visuals en tekst op websites van deze online publieken om de mate van samenhang tussen het visuele en de tekst te onthullen en de manieren waarop visualisaties kunnen bijdragen aan discoursvorming.

Hoofdstuk 4 gebruikt Google-zoekopdrachten om een dataset van de online controverse over verwerkte voedingsmiddelen samen te stellen. Het hoofdstuk legt de positieve, negatieve en evenwichtige sentimentscoalities bloot en past tekstuele en visuele analyses van frames toe. Het bestudeert het begrip van mensen van het begrip 'verwerkt voedsel' en onthult hoe sentimenten over verwerkt voedsel online worden gecommuniceerd.

Hoofdstuk 5 maakt gebruik van Twitter API en Google reverse image search om datasets te construeren en visualisaties van nanotechnologie in voedsel en voedselverpakkingen en de bijbehorende tekst te analyseren. Het hoofdstuk detecteert veranderingen, in de loop van de tijd, in de toon van de tekst en de beeld-tekst verhaallijn tijdens de circulatie van visualisaties binnen een platform, op verschillende platforms en in actuele contexten.

De hoofdstukken samen gaven de volgende resultaten. Allereerst het *type*: vaak werden dat gerelateerde visualisaties gebruikt. Dit soort visualisaties (infographics, kaarten, grafieken en diagrammen) vermengen feiten met een interpretatie van het controversiële onderwerp. Data-gerelateerde visualisaties werden uitgebreider gebruikt door tegenstanders dan door voorstanders en gingen meestal gepaard met een negatieve tekstuele boodschap. Met betrekking tot de *inhoud* waren de visualisaties in de online fracking-controverses vaak gebaseerd op beelden van natuurlijke en industriële landschappen, mensen (ambtenaren, demonstranten) en vlammen. In de online verwerkte voedselcontroverse gingen veel foto's over voedselrijkdom. In de online controverse over nanotechnologie-in-voedsel werden vaak miniatuurpellets of -deeltjes, wetenschappers en wetenschappelijke

activiteit gezien. Voor zowel verwerkt voedsel als nanotechnologie in voedsel werden beelden van voedsel en mensen die ermee omgaan gebruikt.

Ten tweede, bij het bekijken van de narratieven, waren de meest waargenomen die van risico's en voordelen van technologieën. Risicoverhalen kwamen vaak vaker voor dan uitkeringsverhalen. Acteurs gebruikten visualisaties om tekstuele verhalen concreter en zichtbaarder te maken door de technologie te relateren aan 'toevallige' objecten of gebeurtenissen, door objecten te isoleren of door objecten uit te vergroten die met het blote oog onmogelijk te zien zijn. Er werden drie manieren onthuld om visuele en tekstuele verhalen te gebruiken: (1) Online coalities benadrukken visueel andere aspecten dan die tekstueel worden benadrukt; (2) Visualisaties versterken of verzwakken een tekstueel verhaal, en kunnen op die manier bijdragen aan het uiteenvallen van een coalitie of het verenigen van meerdere discourscoalities; (3) Actoren geven positieve, negatieve en neutrale betekenissen aan de technologie door gebruik te maken van een verscheidenheid aan beeld-tekst verhaallijnen.

Ten derde, met betrekking tot circulatie, vonden we drie processen: (1) Circulatie binnen een platform, waarbij visualisaties vergezeld gaan met verschillende narratieven; (2) Circulatie tussen social media platform en internet, waarbij visualisaties op Twitter bijna altijd betekenis geven met behulp van een simpel beeld-tekst verhaallijn, maar op het open web worden meer complexe beeld-tekst verhaallijnen gebruikt; (3) Circulatie tussen contexten, waarin visualisaties in verschillende onderwerpen worden gebruikt (over nano, en GMO), en hetzelfde beeld wordt door een ander netwerk van actoren gebruikt in de loop van de controverse.

Op basis van deze bevindingen concludeer ik ten eerste dat in online beleidscontroverses actoren vooral informatie op een 'wetenschappelijke' manier verspreiden. Vooral datavisualisaties worden gebruikt, meer door tegenstanders dan door voorstanders en meer met een negatieve tekstuele boodschap dan een positieve. Een tweede conclusie is dat visualisaties een essentiële rol spelen in beleidscontroverses over omstreden technologieën, niet alleen als objecten die verschillende interpretaties representeren, maar ook als objecten met invloed: hun inhoud en verhaal laat overwegingen en zorgen zien die anders marginaal zouden blijven. De verhalen geconstrueerd door visuele inhoud en technieken

voegen nieuwe informatie of focus toe aan de beleidscontroverse, waardoor een betekenislaag ontstaat die veelzijdiger en rijker is dan degene die aan het probleem wordt gegeven door alleen tekst te gebruiken. Een derde conclusie is dat online visualisaties een technologie vaak framen als risicovol of juist voordelig: ze doen dit door deze risico's en voordelen concreter en zichtbaarder te maken. Daarmee moedigen ze de 'gebruiker' aan deze risico's en voordelen te heroverwegen. Ze laten vaak de technologieën zien tijdens routinematige activiteiten en als gewone objecten. Tot slot, de vierde conclusie is dat in online beleidscontroverses de betekenis die visualisaties overbrengen in de loop van de tijd kan veranderen. Wanneer visualisaties circuleren, verandert de betekenis van de samengestelde afbeelding-tekst. Op websites geven visualisaties een complexere betekenis aan het controversiële onderwerp dan op Twitter. Verandering in betekenis treedt ook op tijdens het verloop van de controverse: dezelfde visualisatie kan door andere hashtags of groepen van actoren gebruikt worden en een nieuw verhaal gaan vertellen.

Deze conclusies leiden tot de volgende aanbevelingen voor de praktijk. Allereerst moeten analisten van beleidscontroverses ervoor zorgen dat het volledige potentieel van visualisaties als objecten die inzicht bieden in de controverse grondig wordt onderzocht. Ik adviseer om afwisselend in en uit te zoomen op de afbeeldingen. Een ander advies voor analisten zou zijn om te proberen af te leiden waarom een bepaalde manier van visualiseren is gekozen uit eindeloze opties om dit te doen. Deze poging kan leiden tot een beter begrip van de houding en zorgen van actoren. Ten tweede, voor alle actoren die kwesties visualiseren die de kern vormen van beleidscontroverses, raad ik aan dit bewuster te doen. Visualisaties kunnen hun weg vinden naar andere plaatsen dan hun makers of plaatsers hebben bedoeld, met een tekst die verschilt van de tekst die hen oorspronkelijk vergezelde, en kunnen daardoor bijdragen aan betekenisgeving over de controverse die niet bedoeld was. Tot slot dit advies: bij het kiezen van een visualisatie is het goed te reflecteren op de meervoudige betekenis die deze visualisatie overbrengt. Een dergelijke reflectie kan helpen om je bewust te zijn van de eigen set van waarden, overtuigingen en gevoelens met betrekking tot de controversiële kwestie. Dit kan aanleiding geven om de interpretatie van het probleem bij te stellen.

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Pursuing a PhD can be a lonely process. With a non-typical PAP educational background and exploring a topic that is unconventional for the field ("you're studying WHAT in controversies?"), the process can feel even lonelier. Fortunately, there were some precious people along the way who made it feel less solitary.

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About the author

Efrat Gommeh is a social scientist and industrial designer, passionate about bridging the two disciplines. She was born in Holon, Israel, and holds a Bachelor's degree in Industrial Design (2002) as well as a Master's degree in Design Management, graduated cum laude (2008). After a decade of providing design services for companies and individuals, initiating design projects, exhibiting her designs worldwide, teaching design, and managing design processes, Efrat redirected her focus to Academia. This time, her interest led her to study Science, Technology, and Society (STS), culminating in a Master's thesis on crowd participation in product design processes, for which she graduated magna cum laude (2015).

Throughout her career and personal life, Efrat has had several extended stays in foreign countries. She spent approximately a year travelling in Asia, mostly in India; she resided in Eindhoven, the Netherlands, for several months as an exchange student, and later lived and worked in Biel/Bienne, Switzerland, for six months as part of an art residency. In 2017, Efrat combined her wanderlust and intellectual curiosity by pursuing a doctoral degree abroad. She returned to the Netherlands, this time for an extended period, accompanied by her life partner and their son. Efrat joined the Public Administration and Policy Group at Wageningen University and became a leading researcher in the NWO-funded project 'Travelling of Framed Facts and Uncertainties'. The project aimed to enhance responsible research and innovation through the study of contested technology images that circulate on the Internet and social media.

Next to her academic pursuits, Efrat engages in physical and mental practices such as Partner Acrobatics, Yoga, and Mindfulness Meditation. She also periodically contributes to an online magazine for the Israeli community in the Netherlands. Efrat and her family currently reside in Wageningen, the Netherlands.

List of publications

- Efrat Gommeh, Karin Schroën & Tamara Metze (2022) Processed food dream or nightmare? Influential online sentiment coalitions, *NJAS: Impact in Agricultural and Life Sciences*, 94:1, 80-111, DOI:10.1080/27685241.2022.2108731

- Ivanna Colijn, Fabrice Fraiture, Efrat Gommeh, Karin Schroën & Tamara Metze (2022) Science and media framing of the future of plastics in relation to transitioning to a circular economy, *Journal of Cleaner Production*, 370, 133472, DOI:10.1016/j.jclepro.2022.133472

- Elaine Teixeira Rabello, Efrat Gommeh, Andrea Benedetti, Gabriel Valerio-Ureña & Tamara Metze (2022) Mapping online visuals of shale gas controversy: a digital methods approach, *Information, Communication & Society*, 25:15, 2264-2281, DOI:10.1080/1369118X.2021.1934064

- Efrat Gommeh, Huub Dijstelbloem & Tamara Metze (2021) Visual discourse coalitions: visualization and discourse formation in controversies over shale gas development, *Journal of Environmental Policy & Planning*, 23:3, 363-380, DOI:10.1080/1523908X.2020.1823208

- Efrat Gommeh (2016) Crowd Participation in Product Design Processes, *Bezalel Journal of Visual & Material Culture* (8), https://journal.bezalel.ac.il/he/article/3711

Education certificate graduate school

Efrat Gommeh
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
A1 Managing a research project			
WASS Introduction	WASS	2018	1
'The Role of Visualizations in Public Debates over Technological Developments'	ECPR conference	2018	1
'The Role of Visualization in Controversies over Technological Developments'	The international conference in ideology and discourse analysis	2019	1
'Dream or nightmare? Discursive and visual storylines of online sentiment coalitions on processed food'	The 13th interpretive policy analysis conference	2021	1
'Circulating visualizations of nanotechnology in food and food packaging'	The 8th CSSI online symposium	2022	1
The essentials of scientific writing	Wageningen in'to Languages	2018	1.2
Writing the research proposal	WUR	2018	3
Scientific writing	Wageningen in'to Languages	2020	1.8
TOFU Consortium member meetings		2019-2022	2
A2 Integrating research in the corresponding discipline			
Interpretive Policy Analysis Summer School	WASS	2018	4
Research Methodology: From topic to proposal	WASS	2018	4
Policy Agenda Setting and Issue Framing, PAP-52306	WUR	2019	6
Masterclass Social Network Analysis	WASS	2019	0.3
B) General research related competences			
B1 Placing research in a broader scientific context			
Visual Social Sciences and Digital Media Politics	University of Copenhagen	2018	2
Philosophy of Responsible Innovation	TU Delft/WUR	2018	5
B2 Placing research in a societal context			
Co-organization of International Seminar Visual Framing of Food Technologies		2019	4
C) Career related competences/personal development			
C1 Employing transferable skills in different domains/careers			
Brain Training	WGS	2018	0.3
PhD Workshop Carousel	WGS	2018	0.3
Supervising Bsc and Msc thesis students	Education Support Centre	2019	0.64
Supervising BSc and MSc students	WUR	2020-2022	1.5
Career Orientation	WGS	2022	1.5
Total			**42.54**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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