Seeing the Visual: A Literature Review on Why and How Policy Scholars Would Do Well to Study Influential Visualizations

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Visualizations are important for policy debates. In a single image, visuals convey information, values, and emotions. Think of the shocking image of Alan Kurdi's drowning and the abrupt shift in immigration policy debates in Europe. Visualizations influence policy and politics, but how? This article presents a detailed and analytic overview of the state-of-the-art research on visualizations from the policy and political sciences and suggests a research agenda. We identified five explanatory roles for how visualizations influence policy and policy debates as: 1) sense-making devices for interpreting complex information; 2) emotional triggers to strategically manipulate the viewers' sentiments for political gains; 3) objects of political meaning making; 4) icons that convey social and cultural norms; and 5) portrayals of the underlying values that matter when representing situations in society. We applied our findings to a visualization of the controversial gene-editing technology CRISPR-Cas applied to food. We claim that these five roles need to be combined to better understand how visualizations are influential over time and for different policy actors. We argue for studying visualizations as boundary objects whose meaning is negotiated between (groups of) policy actors and that can change over time.

Keywords: Visualizations, Policy Diffusion, Policy Influence, Political Behavior, Framing, Meaning in Policy Making, Social Network Analysis, Media and Policy, Embracing the Visual Turn in Policy Research.

Ver lo visual: una revisión de la literatura sobre por qué y cómo los académicos de políticas harían bien en estudiar visualizaciones influyentes

Las visualizaciones son importantes para los debates sobre políticas. En una sola imagen, las imágenes transmiten información, valores y emociones. Piense en la impactante imagen del ahogamiento de Alan Kurdi y el cambio abrupto en los debates sobre políticas de inmigración en Europa. Las visualizaciones influyen en la política y la política, pero ¿cómo? Este artículo presenta una descripción detallada y analítica de la investigación de vanguardia sobre visualizaciones de las ciencias políticas y políticas y sugiere una agenda de investigación. Identificamos cinco roles explicativos de cómo las visualizaciones influyen en las políticas y los debates de políticas como: 1) dispositivos de creación de sentido para interpretar información compleja; 2) disparadores emocionales para manipular estratégicamente los sentimientos de los espectadores en busca de ganancias políticas; 3) objetos de creación de significado político: 4) iconos que transmiten normas sociales y culturales, y 5) representaciones de los valores subyacentes que importan al representar situaciones en la sociedad. Aplicamos nuestros hallazgos a una visualización de la controvertida tecnología de edición de genes CRISPR-Cas aplicada a los alimentos. Afirmamos que estos cinco roles deben combinarse para comprender mejor cómo las visualizaciones son influyentes a lo largo del tiempo y para los diferentes actores políticos. Abogamos por estudiar las visualizaciones como objetos de frontera cuyo significado se negocia entre (grupos de) actores políticos y que pueden cambiar con el tiempo.

Palabras Clave: Visualizaciones, Políticas, Comportamiento político, Encuadre, Significado en la formulación De Políticas, Análisis de redes sociales.

看到視覺：關於政策學者為什麼以及如何做好研究有影響力的視覺效果的文獻綜述

可視化對於政策辯論很重要。在單個圖像中，視覺傳達信息、價值觀和情感。想想艾倫·庫爾迪 (Alan Kurdi) 溺水的令人震驚的畫面以及歐洲移民政策辯論的突然轉變。可視化影響政策和政治，但如何影響？本文對來自政策和政治科學的可視化的最新研究進行了詳細和分析性的概述，並提出

了研究議程。我們確定了可視化如何影響政策和政策辯論的五個解釋性角色：1）解釋複雜信息的意義製造設備； 2）為了政治利益，戰略性地操縱觀眾情緒的情緒觸發器； 3） 產生政治意義的對象：4） 傳達社會和文化規範的圖標，以及5） 描繪在代表社會情況時重要的潛在價值。我們將我們的發現應用於有爭議的基因編輯技術 CRISPR-Cas 應用於食品的可視化。我們聲稱需要將這五個角色結合起來，以更好地了解可視化如何隨著時間的推移以及對不同政策參與者的影響。我們主張將可視化研究為邊界對象，其含義是在（組）政策參與者之間協商的，並且會隨著時間而改變。

關鍵詞：可視化、政策、政治行為、框架、決策意義、社會網絡分析。

The use of visuals in policy and political issues is omnipresent in public debates: a flaming faucet in the shale gas controversy (Gommeh, Dijstelbloem, and Metze 2020; Metze 2018b); a toddler's body on the seashore in the immigrant crisis (Adler-Nissen, Andersen, and Hansen 2020; Prøitz 2018; Farida and Olga 2015); polar bears adrift on a tiny ice sheet in the Arctic; the burning embers in the climate change debates (Born 2019; see also Metze 2020 on Schellnhuber's diagram); the visual campaign against GMOs (Clancy and Clancy 2016; Clancy 2016); or the pair of scissors precisely cutting out a fragment of DNA, visualizing the potential genome editing capabilities of CRISPR-Cas technology (Hurtley 2013).

We define visualizations as condensed graphical elements depicting realities, knowledge, ideas, or messages capable of packaging cognitive, normative, and emotional information in non-necessarily verbal form. All sorts of actors in policies and politics use visualizations to represent particular views on policy issues, spread (framed) information, and influence the general public and decision makers (Adams and Albin 1980; Jenner 2012). Visualizations are studied increasingly in policy and political studies. For example, in studies on framing in political campaigns (Grabe and Bucy 2009; Rosenberg, Kahn, and Tran 1991), or studies into discourse coalitions and policy learning (Gommeh, Dijstelbloem, and Metze 2020; Metze 2018b). Additionally, there is influential work on the role of visualizations on culture and democracy—for instance, Hariman and Lucaites (2007), and Zelizer (2010) take a cultural perspective to study visual icons. Moreover, the works of Morseletto (2017), Mendonça, Ercan, and Asenbaum (2020), Metze (2018b, 2020), Moody and Bekkers (2018), Hill and Helmers (2012), Stocchetti (2014), Gommeh, Dijstelbloem, and Metze (2020), and van Beek and others (2020) point out an undertheorized, intricate, and nuanced role of visualizations in policy and political sciences.

Across the policy and political sciences, much is to gain by embracing the visual turn that Mitchell (1994) argued for and focusing on understanding how the visual influences social and political life in modern societies (Green 2010; Mendonça, Ercan, and Asenbaum 2020). In the context of a fast-changing online media landscape, the role of visualization takes a different dimension for political and policy research. For example, Kasra (2017) described how digital-networked images facilitated a new means for underrepresented minorities to reappropriate the political and cultural construction of (Egyptian) women as political agents, both in the Arab world and beyond, from studying female nude selfies as personal acts of political expression during the 2011 uprisings in Egypt. In comparison, Doerr (2017) exposed how far-right groups used visualizations strategically to forge cross-linguistic transnational alliances against immigration to Europe. These examples illustrate an understudied dimension of nonverbal forms of communication, political participation, and framing in and through the use of visualizations in modern networked societies.

Although there exist theoretical limitations surrounding the systematic research of visualizations in policy science, there is empirical literature highlighting the influence of visuals in framing and reframing policies (van Beek *et al.* 2020), fueling controversies online (Rabello *et al.* 2021), unifying debates (Born 2019), or giving gravitas to environmental governance (Morseletto 2017).

Empirical evidence indicates an intricate role for visualizations across the policy sciences. For example, in the interplay between science, policy, and society, Clancy (2016) dissects the role of visualizations in the Genetically Modified Organisms (GMO) controversy in Europe and the United States at multiple levels. The central point is that visualizations function as a resistance mechanism, expanding on different ways their influence reached policy framing and decisions. The research further explains how an international coalition of actors used visuals to contest dominant views about agrobiotechnology. By visualizing GMO crops as "Frankenfoods," GMO technology became visible to the public and *different* from regular crops, sedimenting a debate that would shape and reframe public and regulatory policy on GMO technology on both sides of the Atlantic (Clancy 2016).

Additionally, anti-GMO campaigners' use of "visual events" proved to be an instrumental strategy for constructing visual rhetorics through digital media that hindered policy framing and influenced policy decisions in the UK. The most iconic was the image of a Greenpeace truck in 1999, dumping four tons of soybeans outside No. 10, Downing Street with a sign that read "Tony, don't swallow Bill's seed." Weeks later, Prime Minister Tony Blair backtracked standing public policy on agrobiotechnology, electing to implement a five-year moratorium on GM crops in the UK instead (Clancy and Clancy 2016; Durant and Lindsey 1999).

Academic attention toward visualizations also showcases recent examples of how a better understanding of visualizations can help policies. Wardekker and Lorenz (2019) analyzed the visualizations of an Intergovernmental Panel on Cli-

mate Change (IPCC) report to show that the IPPC's visual framing focused on the (science-oriented) existence of climate impacts, hindering attention to adaptation policies to climate change. Their research suggests that IPCC reports pay more attention to adopting a visual framing from a solution-oriented perspective while researching better ways to visualize adaptation. Metze (2018b) makes a similar call for analyzing visual framing for policy learning and policy making. Notably, the urge to theorize better the role of visualizations also comes from those natural scientists who are increasingly aware of the relevance of visuals in communicating information for science and policy (McInerny *et al.* 2014).

Overall, these points indicate that scholarship in the policy sciences would therefore benefit greatly from a better understanding of visualizations as influential elements in negotiating and framing policy in modern society. This article aims to give a systematic overview of the current state of the research into influential visualizations and use that as a starting point for a research agenda and conceptual framework that better take into account the challenges of studying influential visualizations in a networked, globalized, and mediatized world.

We innovatively combined a quantitative and qualitative Social Network Analysis (SNA) to study the most referred literature about visualizations within a selection of policy studies and political science journals. We analyzed the concepts, methods, and explanations they use to study influential visualizations. We then argue that visuals should be studied as boundary objects whose meaning is negotiated between (groups of) policy actors. This meaning differs between groups of actors and changes over time. Moreover, visual boundary objects travel easily, and their traveling and influence on policy and politics should be further conceptualized. The article is structured as follows: we first explain our methods, then the results, and develop a research agenda in the discussion and conclusion. Since our analysis concerns the theoretical starting points, methods, and empirics of a broad range of literature on visualizations, we will not develop a theoretical framework at this point.

Methods

We created a dataset of relevant papers and conducted a two-step social network analysis. In the first, we performed a social network analysis based on co-citations. Co-citation analyses map the connection of ideas in academic knowledge evolution in literature clusters (Boyack and Klavans 2010; Baker 1990). This approach allowed clustering of the literature by affinity. In the second step, we analyzed those clusters manually to understand their ontological, epistemological, methodological, and empirical similarities and differences.

Dataset

To retrieve our raw data, we conducted a Boolean search of the Web of Science (WoS) repository comprised of the terms Poli* AND Visual,* followed by a

refined inclusion/seclusion criteria of research topics using indexation topics. The inclusion criteria focused on political sciences and multidisciplinary sciences, including communication, social sciences, or experimental psychology. We excluded areas like ophthalmology or engineering (see Appendix 1).

A raw dataset of 1,500 papers was collected from WoS on June 25, 2020, spanning from 1945 to the collection date. Equivalent searches were run on Scopus. We compared both datasets for indexation of accessions and journals to prevent overlapping data. The comparison showed that WoS had 2.7 times more relevant journals than Scopus; Scopus also had a 49.4-percent overlap data with WoS. We thus chose to work with the WoS dataset.

The raw data consisted of 1,500 accessions of peer-reviewed papers and academic books. We ran a first co-citation analysis (see below) and decided to include only papers and books that were co-cited at least ten times in order to be able to identify the most important papers and clusters. The final dataset consisted of 77 accessions, of which 43 were articles and 34 books.

Step 1: Quantitative Social Network Analysis

In the first step, we applied a quantitative SNA and established networks between publications based on bibliometrics—more specifically, the number of co-citation incidences (Aria and Cuccurullo (2017); Cowhitt, Butler, and Wilson (2020). We ran co-citation network analyses to our corpus data using the R-package bibliometrix (Aria and Cuccurullo 2017) and used VOSViewer and Gephi to map the network and analyze statistics (Van Eck and Waltman 2010; Bastian Mathieu 2009) (see Appendix 2).

We then organized our corpus data by degree centrality and betweenness centrality of each network node[1] based on co-citations[2] parameters. Degree centrality analysis identifies the principal works of reference spearheading academic literature on visualizations in the political and policy sciences. The betweenness centrality analysis allowed us to identify references bridging literature clusters but not as co-cited as the literature analyzed by degree centrality is. However, they are not mutually exclusive, and some works can have a high degree and high betweenness centrality values. Our next step was to identify the conceptual characteristics that gave each cluster their affinity in our qualitative social network analysis.

Step 2: Qualitative Social Network Analysis

In this step, we analyzed the conceptual, methodological, and empirical similarities and differences in the literature in each of the five clusters. Based on

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1 We set the threshold for the minimal node size at ten co-citations for degree centrality and four co-citations for betweenness centrality. These thresholds were identified in a sequence of try-outs to find a point of workable clustering in the network.

2 We used fractional counting to account for the differences in number of total citations between articles, and between articles and books.

a 10-percent sample from each cluster (about ten papers in total), we inductively built a codebook to analyze which concepts, methods, and objects of study were applied in the literature. The codebook was tested and refined by applying it to a manual selection of the ten papers that varied from older books, papers, and more recent publications.

We coded publications at (1) a *conceptual* level: 1a. What are visualizations (definition)? 1b. What is the nature of visualizations (ontology)? 1c. What is the subject matter studied in visualizations (epistemology)? and 1d. Theoretical relationships between visualizations and text. At (2) an empirical level, we coded for 2a. the type of visualizations (inter alia, photos, data visualizations, or cartoons), and 2b. methods used. We also coded (3) *explanatory level*: What roles are addressed to visualizations in policy or political processes (see Appendix 3)? We coded the five clusters separately until extracting no new data from the literature. We reached this saturation point at around 2/3s of the entries per cluster.

Results: Seeing the Visual in Policy and Politics

Quantitative Review: Mapping Research on Visualizations in the Political and Policy Sciences

The quantitative SNA resulted in 95 nodes, of which 49 were articles and 46 books. We identified five clusters of literature in the network structure (Figure 1). We labeled them as visual framing as sense making *(VAS)* (in red), visual framing as politics *(VAP)* (in green), discourse as visual language *(VAD)* (in yellow), cultural imagery as representation *(CIR)* (in blue), and aesthetics as representation *(AR)* (in purple). Below we describe each cluster more extensively, but we first present each cluster's makeup: the crucial authors, books, and papers. When presenting the qualitative analysis results, we will describe how visualizations and their role in policy and politics are studied in each cluster.

Composition of Clusters: Primary References and Affinities

VAS is the cluster with the highest number of publications in the network, with 27 entries, of which 19 are articles, and eight are books. The most co-cited works within this cluster are Entman (1993), Griffin (2004), and Messaris and Abraham (2001) (Table 1). Publications, such as Geise and Baden (2015), Gitlin (1980), Coleman (2010), and Graber (1990), suggest that the literature found in this cluster shares a similar theoretical and methodological research approach from a framing perspective. Research in this cluster is oriented to study visualizations in processes of sense making of policy or political issues. In other words, how the use of (passive or active) visual framing enables individuals and groups to process and make sense of the issues at hand.

The next larger cluster in the network is *VAP*, consisting of 16 articles and four books. The most co-cited publications are Grabe (2009), Schill (2012), and

Nagel, Maurer, and Reinemann (2012) (Table 1). These works and the work of authors like Shawn Rosenberg (1986, 1987, 1991), Alexander Todorov and others (2005), or Rein Vliegenthart (2012) suggest this cluster conglomerates research on visualizations and framing for persuasion in political events, campaigns, and electoral purposes. Quantitatively, the cluster *VAP* is the closest to the cluster *VAS*.[3] The two distinct clusters suggest differences in approaches to research visualizations between those intended for political and electoral purposes and framing as a sense-making process in general. In the *VAP* cluster, researchers consider visual framing to be intentional. Visual framing is used strategically to persuade and attract viewers/voters, whereas, in *VAS*, visual framing could be passive, not necessarily strategic.

The *VAD* cluster consists of 18 books and one journal article. The most relevant works are Kress and van Leeuwen (1996), Barthes (1977), and Kress (2001) (Table 1), who suggest that visualizations—just like text—are forms of semiology that function to communicate explicit and implicit messages. However, culture and history are essential to decoding those messages. The authors argue that the meaning of visualizations is embedded in history, culture, and "rhetoric threads" from specific social groups, and as such, there are multiple ways to interpret visualizations. Additionally, the authors in this cluster expand the notion of visualization beyond the mere image, and they draw from works by, for example, Anderson (1983), Lakoff (1980), and Foucault (1977) to include discursive imaginaries, metaphors, or visions, as part of their study of discourses. The use of visual language influences forms of thinking and how actors negotiate policy and political issues. Authors in this cluster understand visualizations as discursive, meaning as part of the language used in political and policy interactions—hence as part of larger discourses.

The *CIR* cluster contains 15 books and five articles, and Hariman and Lucaites (2007), Rose (2018), and Mitchell (1994) are its principal works (Table 1). These authors approach visualizations as devices that convey meanings through visual elements and symbols, and these visuals are of cultural importance in political and policy sciences. Other relevant authors are Sontag (1977, 2003), Zelizer (2010), and Ahmed (2004). They emphasize the use of (iconic) visualizations as communicational resources in the (re)production of culture and social practices, ideology, power of representations, and the shaping of collective memories and identities through the media.

AR is the smallest cluster and consists of eight articles and one book. Its main works are Hansen (2015), Campbell (2007), and Williams (2003) (Table 1). They all write about visuals' essential role (particularly photojournalism) in representing conflicts in international relations and their influence in subsequent foreign policy decisions. Moreover, Bleiker (2001, 2015) and Heck and Schlag

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3   This differentiation is visible in our network due to the threshold established as the minimum node size. With node size parameters higher than ten, these two clusters tend to aggregate.

(2013) focus on power dynamics in representing people and issues through photojournalism. Authors in this cluster emphasize aesthetic values' power to underpin people's representations and understandings of (international) issues through visualizations. Table 1 gives an overview of the top three most cited works per cluster.
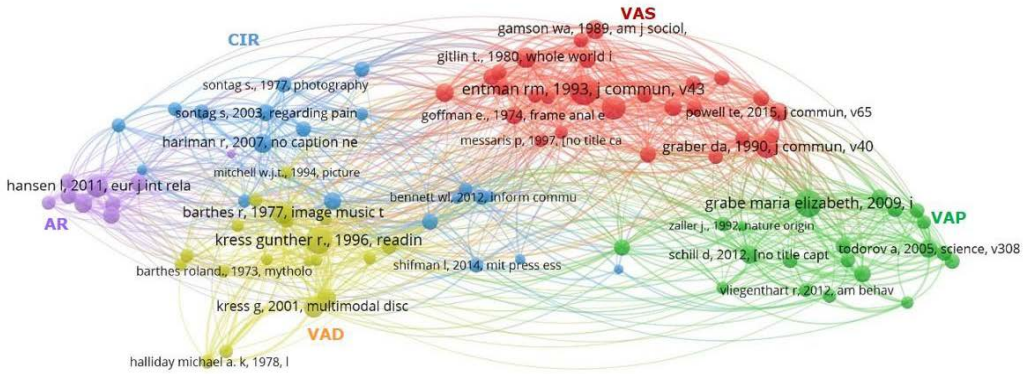

Figure 1. Five Clusters on the Study of Visualizations in the Political and Policy Science Literature

Table 1. Top Three Literature Works per Cluster

Authors	Title	Year	Literature Cluster	Degree centrality value	Total links weight
Entman	Framing: Toward Clarification of a Fractured Paradigm	1993	VAS	53	46
Griffin	Picturing America's War on Terrorism in Afghanistan and Iraq	2004	VAS	53	17
Messaris & Abraham	The Role of Images in Framing News Stories	2001	VAS	52	31
Grabe	Image Bite Politics: News and the Visual Framing of Elections	2009	VAP	51	37
Schill	The Visual Image and the Political Image: A Review of Visual Communication Research in the Field of Political Communication	2012	VAP	40	18
Nagel	Is There a Visual Dominance in Political Communication? How Verbal, Visual, and Vocal Communication Shape Viewers' Impressions of Political Candidates	2012	VAP	38	11

Kress & van Leeuwen	Reading Images: The Grammar of Visual Design	1996	VAD	60	38
Barthes	Image, Music Text	1997	VAD	53	25
Kress	Multimodal Discourse Analysis	2001	VAD	39	22
Hariman	No Caption Needed	2007	CIR	41	19
Rose	Visual Methodologies	2012	CIR	41	16
Mitchell	Picture Theory	1994	CIR	36	7
Hansen	How Images Make World Politics: International Icons and the Case of Abu Ghraib	2011	AR	38	27
Campbell	Geopolitics and Visuality: Sighting the Darfur Conflict	2007	AR	26	15
Williams	Words, Images, Enemies: Securitization and International Politics	2003	AR	26	14

Qualitative Analysis: An In-depth Look into Visualizations in the Political and Policy Sciences

This section describes the (1) theoretical starting points, (2) empirical focus, (3) the role in policy and politics for each cluster, and we illustrate the differences and similarities between the five clusters with the empirical example of a visualization of CRISPR-Cas applications in foods, which is known as "This not a GMO." "This is not a GMO" is a visualization featuring corn (see Figure 2) and was circulated online, for example, by European Greens (the coalition of green parties in the European Parliament) and the Synbiowatch Initiative.

Visual Framing as Sense Making (VAS)

Overall, *VAS* cluster literature understands visuals as framing devices that evoke and reinforce social and cultural schemata in an audience, leading to priming audiences to understand textual messages in a particular way. Authors in this cluster describe their approaches to visualizations on political issues as framing effects (Arpan *et al.* 2006; Fahmy 2004; Zillmann, Knobloch, and Yu 2001), news framing (Entman 1993, 2004; Gamson and Modigliani 1989), visual framing (Powell *et al.* 2015; Rodriguez and Dimitrova 2011; Messaris and Abraham 2001), and visual framing effects (Druckman 2003; Brantner, Lobinger, and Wetzstein 2011).

Theoretical Starting Point

Most authors in the cluster describe their ontological position as social constructivists, in which visualizations are constructed understandings of reality (Entman 1993; Arpan *et al.* 2006; Gamson and Modigliani 1989; Rodriguez and

Figure 2. Example of a Visualization Used in the Debate about CRISPR
Technology in Europe to Oppose the Technology

Dimitrova 2011; Messaris and Abraham 2001; Powell *et al.* 2015; Griffin 2004).
We identified three epistemic approaches based on the relation between text and
visual. 1) Reinforcing: text leads the visual (Entman 1993; Arpan *et al.* 2006; Fah-
my 2004); 2) Priming: visual leads the text (Griffin 2004; Gamson and Modigliani
1989; Zillmann, Knobloch, and Yu 2001; Domke, Perlmutter, and Spratt 2002);
and 3) Multimodal: text and visuals as a single package (Brantner, Lobinger, and
Wetzstein 2011; Gibson and Zillmann 2000; Powell *et al.* 2015; Rodriguez and
Dimitrova 2011; Messaris and Abraham 2001; Entman 2004).

a) *The text leads the visual (reinforcing):* visualizations are framing devices
   competing for the reader's attention. Visual framing focuses on the visual
   itself as a selected fragment illustrating a reality. Authors such as Arpan and
   others (2006), Griffin (2004), Brantner, Lobinger, and Wetzstein (2011), and
   Gibson and Zillmann (2000) emphasize the role of journalists and media
   outlets in constructing part of the interpretive schemata of the public by
   selecting and repeating particular textual framings, and the visualizations
   used to illustrate them.

b) *Visual leads the text (priming):* visualizations evoke previous social and cul-
   tural schemata and set the context for processing new textual information.
   In this way, visualizations become the easiest route to process and inter-
   pret frames from a cultural reference framework. Visualizations then "set
   a frame" (Brantner, Lobinger, and Wetzstein 2011) for meaning-making of
   the textual frames. In framing effects, visualizations are the most effective
   way to associate information to previous knowledge (Griffin 2004; Dom-
   ke, Perlmutter, and Spratt 2002; Gamson and Modigliani 1989; Zillmann,

Knobloch, and Yu 2001). Hence, visualizations can be used as references to make sense of new issues by framing emotions, values, and political positions associated with previous events to process the new information and attract members of the public (Gamson and Modigliani 1989; Zillmann, Knobloch, and Yu 2001).

c) *Visual and the text as a single package (Multimodal)*: visual framing is an analytical differentiation of the textual framing process. In practice, their framing effects cannot be disentangled (Geise and Baden 2015; Powell *et al.* 2015; Rodriguez and Dimitrova 2011). The bimodal (textual and visual) framing message triggers a cognitive and emotional response that influences public opinion formation. Over time, these influences create a public schema to process new issues and controversies in which visualizations have denotative meanings, framing capacity, connotative potential, and ideological representation (Rodriguez and Dimitrova 2011). Authors like Fahmy (2004), Gamson and Modigliani (1989), Powell and others (2015), and Rodriguez and Dimitrova (2011) suggest that the fusion of visualizations and storytelling, discourses, and congruence between text and visuals leads to passive stereotyping, cultural resonance, and ideological representation that can confer visualizations symbol status which, in turn, can trigger political mobilization.

In the *VAS* cluster, authors adopt a cognitive approach and consider frames to be schemata: a pre-existing set of experiences, emotions, values, and ideas that work as general cognitive mental plans, as abstract structures for interpreting information that serves as guides for action (Griffin 2004; Gamson and Modigliani 1989; Geise and Baden 2015). The authors focus on different aspects from schema theory to describe how visuals frame policy issues. For example, the relevance of emotions (Gamson and Modigliani 1989; Fahmy 2004; Brantner, Lobinger, and Wetzstein 2011); previous experiences (Domke, Perlmutter, and Spratt 2002; Gamson and Modigliani 1989; Rodriguez and Dimitrova 2011); or priming audiences (Domke, Perlmutter, and Spratt (2002). In our CRISPR-Cas example, the visualization would prime the viewer to make sense of CRISPR-Cas technology in terms of the GMO debate, emphasizing the (negative) emotions triggered by CRISPR-Cas food applications and drawing on previous experiences with genomic technologies in food crops like GMO crops.

Empirical Focus

The type of empirical visual most studied in the cluster is news photographs and TV images (Arpan *et al.* 2006; Griffin 2004; Fahmy 2004; Gibson and Zillmann 2000; Powell *et al.* 2015; Zillmann, Knobloch, and Yu 2001; Messaris and Abraham 2001). The type of visualization is relevant because photographs are associated with closer representations of reality (Rodriguez and Dimitrova 2011; Powell *et*

al. 2015; Gibson and Zillmann 2000; Gamson and Modigliani 1989). Most authors relied on quantitative content analysis and experimental methods settings to implement their methods. However, authors like Griffin (2004), Gamson and Modigliani (1989), Rodriguez and Dimitrova, and Messaris and Abraham (2001) advocate adopting qualitative and interpretive methods to research visualizations. Lastly, Entman (2004) suggests a mixed-method (quantitative and qualitative) approach to visualizations in framing research.

Explanatory: Role of Visuals in Policy and Politics

The *VAS* cluster contributes in two ways to analyzing visualizations in the political and policy sciences.

1) Visuals are attention-grabber symbols (Arpan *et al.* 2006; Zillmann, Knobloch, and Yu 2001; Gibson and Zillmann 2000) associated with an individual's or social schemas and are used to prime readers/watchers of visualizations (Entman 1993; Barthes 1977; Fahmy 2004; Gamson and Modigliani 1989; Rodriguez and Dimitrova 2011; Messaris and Abraham 2001). In our example, this means CRISPR-Cas technology is framed in the context of the debate as indistinguishable from GMO technology. The reference primes viewers to make sense of novel CRISPR-Cas applications in terms of the older GMO technology, drawing from the highly contested topic of producing and consuming GMO crops in Europe.

2) Visuals are devices for influencing public opinion and gathering support on a policy issue (Brantner, Lobinger, and Wetzstein 2011; Domke, Perlmutter, and Spratt 2002; Powell *et al.* 2015; Entman 2004). For the CRISPR-Cas example, the corn cob and the referencing to the GMO technology draws from the highly effective campaign to mobilize the public opinion against GMO crops' approval in Europe during the 1990s and early 2000s. This campaign made the GMO technology visible in the public debate by using corn as a symbol in different visualizations intended to frame GMO technology as undesirable, dangerous, or unnatural (see Clancy and Clancy 2016; Clancy 2016).

Visual Framing as Politics (VAP)

The fundamental ideas behind the *VAP* cluster are similar to the concepts of *VAS*. The main difference is that authors in this cluster understand actors to deploy framing strategies in intentionally strategic ways. Policy actors visually select elements of a policy or political issue to seduce others to support a particular political stance.

Theoretical Starting Point

Grabe and Bucy (2009), whose groundbreaking research describes the process of visual communication in the viewer's brain, is the most central work in the cluster. Visuals first trigger the more primitive brain areas associated with emotion-

al responses before activating the more recent cognitive areas in the frontal lobe. The cluster's central tenet is that emotions mediate visual communication, and emotional responses influence cognitive political behavior (Grabe and Bucy 2009; Valentino *et al.* 2011). Similarly, political communication and political psychology research indicate that visualizations also work for emotional communication to persuade voters, build the candidate's impression, or picture abstract scenarios like climate change impacts (Caprara *et al.* 2006; Nagel, Maurer, and Reinemann 2012; Nicholson-Cole 2005; Rosenberg, Kahn, and Tran 1991; Rosenberg *et al.* 1986; Schill 2012; Todorov *et al.* 2005; Vliegenthart 2012). In our CRISPR-Cas case, this cluster suggests the strategic use of corn and GMO to visualize CRISPR-Cas technology as a persuasive communication strategy to stock rejection to CRISPR-Cas amongst the public based on fears or negative emotions associated with GMOs, drawing on the 20-year-long controversy about that technology.

Empirical Focus

Most authors in this cluster focus on the effect of images on the public when used in political communication and campaigning. Images in these studies are considered in their literal form as TV images or images in campaign posters. Moreover, the effect of those images is studied in the construction of networks of politically engaged people.

Visualizations research in this cluster pays attention to online images that connect people and promote political engagement. Researchers like Bennett and Segerberg (2012) and Loader, Vromen, and Xenos (2014) apply digital research methods and engagement metrics to explore the construction of political imaginaries (Prior 2014), political identities, engagement in political action, and the dissemination of visual political information in social media and epistemic networks.

Explanatory: Role of Visuals in Policy and Politics

The role—and deliberate manipulation—of emotions in visualizations is a strategy for political actors to influence the public's cognitive behavior. The dissemination of visuals in new media like social networks allows for personalized information and networks of engaged people in organized political actions. These strategic uses have implications for research on political and policy issues. In the CRISPR-Cas visualization case, the strategic use of corn and GMO references plays to the emotions elicited by the visualization to mobilize viewers in actively opposing CRISPR-Cas technology in food crops applications.

Discourse as Visual Language (VAD)

In this cluster, visualizations are understood and researched to study social problems through visual language. Visualizations—as in language—are structures of symbols and signifiers. They are (incomplete) representations, materializations,

or constructions of (social) phenomena, such as nationalism, identity, migration, class relations, culture, knowledge, and gender. Authors in this cluster share semiology as a common ground to study the role of visualizations in political and policy issues (Kress 2001, 2010; Kress and Van Leeuwen 1996; Blair 2004; Billig 1995). Most authors distinguish between denotation and connotation (following Barthes 1977) in which denotation is the technical process of production of the image and the description of what is on the image, its literal meaning. Moreover, the connotation is the encoded second meaning of the image, its figurative meaning.

Theoretical Starting Point

In the *VAD* cluster, authors introduce their approach as (poststructuralist) semiotics: the study of signs and symbols. In this cluster, most authors aim to understand what (political) messages are conveyed using visuals and how these visuals resonate with broader social and cultural discourses. A distinction in this cluster's evolution is made between: 1) semiotics, and 2) social semiotics.

1. *Semiotics:* The main contributors are Kress and Van Leeuwen (1996) with Reading Images: The Grammar of Visual Design. In this book, Kress introduces the baseline for a standard grammar in designing images in Western-like cultures.

2. *Social semiotics:* the critical difference between social semiotics and semiotics lies in the use of cultural resources (icons, symbols, stories, mythologies, popular culture, among others.) rather than structuralist "codes" (color, framing, zooming) for producing and taking up visualizations in communication (Kress 2001, 135-6). Visual language is not considered universally understood; but rather culturally specific.

The CRISPR-Cas visualization case, depicting CRISPR-Cas using GMO and corn in allusion to Magritte's painting *The Treachery of Images*, is culturally specific for European and Westernized cultures. The corn symbol used to illustrate CRISPR-Cas as a GMO reinforces broader discourses against genomic biotechnologies in food crops (e.g., health risks, cultural and environmental threats, unnatural scientific interventions, or corporate overreach). Ultimately, the visual language used in the visualization draws from the negative GMO rhetoric to portray CRISPR-Cas technology as an extension of the same issue.

Empirical Focus

In this cluster, authors adopt a broad scope to approach the empirics of visualizations. Kress and Van Leeuwen (1996) take photographs in the media, textbook illustrations, art photographs, and technical schematics as the basis for their "visual grammar." They propose a way to study visualizations based on their formal elements and design structures—color, perspective, framing, and image

composition. Barthes (1977) uses press photographs to add additional layers of meaning to the visual: it is the structure of the image (what is in it, color, among other components) as well as their interactions with written text which allows for a visual syntax that can be studied. Authors like Anderson (1983), Billig (1995), Hill and Helmers (2012), and Lakoff and Johnson (1980) take the interactions between socially relevant images and image objects (like flags, banners, artisan crafts, works of art, among others) and political behaviors (such as revolutions, uprisings, protest movements, wars, nationalism) to develop a discursive understanding of visual narratives, visual metaphors, and visual rhetoric.

Finally, Kress (2001, 2010) studies pictures of parking instructions at British supermarkets, children's drawings at Museum visits, textbook images, art photos, and commercial products' photographs to develop his social semiotics epistemology and multimodality in discourse analysis, implying that the visual and the textual are social and cultural meaning structures.

Explanatory: Role of Visuals in Policy and Politics

Visualizations in this cluster are considered objects of political meaning making and thus intrinsic parts of larger discourses. A vital aspect of the evolution of discourse literature on visualizations is power relations in and through the structural components of visualizations, namely connotative messages, culturally dependent signs and signifiers, and other graphic features (colors, forms, text) that function as rhetorical visual resources. These visual resources are part of the struggle of groups of (policy and political) actors to establish them as dominant discourses in public debates. In our CRISPR-Cas example, the symbolic use of corn and the text's connotative use create a visual rhetoric that CRISPR-Cas technology is indistinguishable from GMO technology; hence, it should be treated as a GMO. Moreover, a differentiation between the two is artificial and deceptive (like in *The Treachery of Images*). This use of "visual language" provides a plasticity to the visualization that allows connection with other groups opposed to GMO and/ or CRISPR-Cas technology in non-European contexts.

Cultural Imagery as Representation (CIR)

In this cluster, visuals are icons that convey social norms. Exposure to those icons shapes the sentiments of groups of people. Overall, this cluster's studies understand and research visuals to comprehend how emotions encoded in visualizations become salient sociological phenomena. And, how this may lead to action by individuals or groups. The studies explore the persuasive effects of sentiment-laden visualizations of the media in society. They also analyze representation in visualizations and social order construction, for example, the representation of power relations and discourses about race in media visualizations.

Theoretical Starting Point

Researchers in this cluster consider highly recognizable visualizations (mostly photographs and film) as constructed icons and symbols that become cultural resources that represent social and political life (i.e., protests photographs, coverage of asylum seekers, or political ads (see Hariman and Lucaites 2007; Thompson 2005; Zelizer 2010; Hariman and Lucaites 2002). In these studies, the authors understand visualizations from a constructivist perspective.

Culture is shaped over time in this cluster by visualizations conveying norms and values considered acceptable for society. Those representations of values (family, obedience, sacrifice, gender roles, and so on) shape how society interprets and responds to other media's visual inputs. In turn, individuals' responses may reproduce or contest a dominant culture, a relation of power, or influence political actions. In the CRISPR-Cas example, corn is an iconic resource used to protest against biotechnological applications in food crops (Clancy and Clancy 2016). The corn represents "traditional" knowledge and values involved in food production. The corn cob is a historic cultural icon for diverse cultures. The use of corn as a symbol of genetic manipulation in Europe triggers identity and defense responses of non-biotechnological food production systems.

Empirical Focus

Hariman and Lucaites (2007) use content analysis, critical discourse analysis, or interpretivist approaches to study issues of power, culture, and political behavior in iconic visualizations. Their focus is on the connotative message of visualizations and their effect on viewers. The literature in this cluster also takes a critical approach to analyze visualizations' cultural connotations. Authors like Hariman and Lucaites (2007), Rose (2012), Thompson (2005), and Mitchell (1994) describe the role of visualizations as a vehicle to establish relations of power. For Hariman and Lucaites (2007) and Mitchell (1994), politics in and around visualizations connect deeply with issues of representation and construction of cultural icons. These icons reflect social norms and relations of power in society.

Explanatory: Role of Visuals in Policy and Politics

The communication of sentiments in the visualizations' connotative message is a common characteristic across the cluster. Ahmed (2004) proposes that emotions are relational responses and, through their repetition, shape cultural norms that are followed collectively. The role of visualizations in this process is one of repetition and mobilization of emotions in the public. Sentiments can become a way for actors to get people invested in political or policy issues by appealing to social norms and enticing a particular behavior. Connotative emotions in iconic visualizations are an essential part of the schemata used by individuals and groups for the meaning-making of visuals and processing new information. In this way,

political actors can stoke sentiments of rejection or approval toward a particular political or policy issue by strategically deploying and mobilizing iconic visualizations. Our CRISPR-Cas visualization is an example of negative sentiments towards novel genomic technologies applied to food crops, drawing on two icons: one referencing an iconic art piece by Magritte and the other referencing the corn, an iconic image to protest against GMO foods. Through both iconic pieces, the visualization conveys a connotative emotional appeal to see and beware of novel biotechnologies such CRISPR-Cas, because they are GMOs.

Aesthetics as Representation (AR)

This cluster focuses on the role of aesthetic values underpinning what is worth representing in a visualization. These aesthetic values influence the representation of issues and people, conferring agenda-setting power to the actors producing and reproducing visuals in the media.

Theoretical Starting Point

Authors in this cluster understand visualizations (especially photographs and video) to represent reality revealing (international) issues or conflicts. However, this reality is also socially constructed as the meaning of those visualizations is negotiated between nations' leaders and institutions. The central point shared by authors like Campbell (2007) and Hansen (2015, 2011) is the issue of who is represented, how, and by whom as presented in the media coverage of (international) issues. However, Bleiker's work (Bleiker 2001) brings attention to the aesthetic power of representation in (international) policy and politics. Aesthetic values underpin photojournalism, TV footage, images, narratives, visual arts, and caricatures. The producer(s) of visualizations decides what elements of a political event matter to be portraited and broadcasted. The aesthetics of representations brings out power relations issues as Westernized media values dominate global affairs' coverage (and framing). In our example, the visualization is deeply rooted in the context (and values) of actors representing the European CRISPR-Cas technology debate as equal to the GMO debate.

Empirical Focus

At the empirical level, analyses in the cluster draw from diverse methods. Hansen (2015, 2011) advances multi-level methods combining visual, textual, and contextual analysis (i.e., discourses, policies, or intertextual contexts). Alternatively, authors such as Williams (2003) and Campbell (2007) opt for heuristic methods. However, Bleiker (2001, 2015) acknowledges the methodological challenges of implementing an empirical aesthetic approach to study visuals in (international) politics and policy and hence advocates for the development, validation, and adoption of pluralist methods to visualizations research in politics and policy.

Explanatory: Role of Visuals in Politics and Policy

Here, international politics considers the production and transmission of visual images complementary to how a nation perceives an issue and decides its international policy (Williams 2003). In Bleiker's proposed aesthetic turn, he calls for researchers to be acutely aware of which actors are engaging in the representation of political and policy issues and what values underpin the visualizations used as data because those decisions have implications over how a particular issue is represented and understood, also influencing policy decisions. In our CRISPR-Cas example, the values represented in the visualization are about the types of technologies acceptable in food crops to the actors that produced the visualization in the European context.

Table 2. Summary and Contribution Per Cluster to the Study of Visualizations in Political and Policy Sciences

Cluster	What are visualizations?	How are visualizations studied?	What do visualizations do?	How do they do it?
VAS	Frames of reference	Content analysis and experiments with media photographs and footage	Prime and convince audiences passively (use is not necessarily strategic)	Visuals work as sensemaking devices by evoking references to previous information
VAP	Emotional triggers	Engagement analysis and digital methods on candidates' image projections, pictures, and videos	Strategic appeal to emotions to influence viewers' behavior.	Visuals trigger emotional responses that influence cognitive (political) behavior
VAD	Objects of political meaning-making	Semiotics and multimodality in a mixture of visuals (photographs, cartoons) and text	Produce, reproduce (dominant) discourses	Visuals work as a sphere for meaning-making of social problems by combining signs and text in (visual) discourses
CIR	Symbolic icons	CDA and interpretivist approach to famous photographs and videos	Provide cultural references to audiences	Famous visuals resonate with culture, societal norms, identity, and historical references to audiences
AR	Aesthetical representations	Pluralist methods to portraits of conflicts in photographs and footage	Represent a situation according to what the maker of the visual considered valuable	Visuals define what values matter when representing a situation in society

Discussion and Conclusions

The systematic review of the literature identified five explanatory roles for the influence of visualizations on policy and politics:

1. *VAS*: Visualizations work as visual framing by passive (cognitive) priming or active visual rhetorical framing. Visuals work as sense-making devices by evoking references to previous information, emotions, or experiences at individual or group levels. They help to interpret complex information and (actively or passively) inform opinion formation on policy issues.

2. *VAP*: Visualizations work as emotional triggers to strategically manipulate the viewers' sentiments and emotions for political gains. Actors use *VAP* as a strategy to influence the public's cognitive (political) behavior.

3. *VAD*: Visualizations are objects of political meaning-making and intrinsic parts of larger discourses. Visualizations work as language: structures of symbols and signifiers that different knowledge groups use, produce, and reproduce in their rhetoric over time. However, influential visualizations' visual language is flexible enough to converge shared discourses across (groups of) actors as different knowledge groups use visualizations. Over time, successful groups of actors manage to ascertain specific symbols as discursive resources.

4. *CIR*: Visualizations work as icons that convey social and cultural norms. Visuals directly influence political dynamics by constructing iconic imagery widely known and used to reference popular culture. These icons become referential by intensive reproduction in the media. At the societal level, iconic imagery provides cultural context to (re)produce visual frames reinterpreting over time the social and cultural norms associated with those icons.

5. *AR*: Visualizations work as objects to define what values matter when representing a situation in society. Production and circulation of visualizations underlie what a valuable representation of, by, in, and for a particular society is. Decisions about what is worth representing in visual framing are inherently relations of power. The aesthetics of representation can influence a policy issue's framing, how it is valued and assessed.

The limitations of this study include a low probability of recent works to meet our quantitative parameters in the co-occurrence analysis. Recent works tend to have lower incidences of co-occurrence, which is also a measure of their influence. Interestingly, there were not many studies in our dataset focusing on data visualizations, whereas in environmental studies and studies on climate change—the role of data visualization is increasingly studied (Metze 2020). Finally, information

stored in a different repository than WoS is a limitation in our data; however, our co-occurrence parameters offset the impacts of our repository selection.

Our five clusters offer valuable concepts to explain the multiple ways in which visualizations influence policy and politics. These clusters reject the understanding of influential visualizations as static events; they see visualizations as constructed by their makers and (constructed and reconstructed) by the audience. However, their methods collect and study empirical data as snapshots in time and space of public debates. They research how a particular visual can prime and convince audiences; how selected visuals influence their viewers' political behavior by appealing to emotions; how dominant visuals produce and reproduce discourses; how iconic visuals provide cultural references to audiences, or how normative influences from visualizations' makers underpin representations of societal issues. Notwithstanding, visualizations can simultaneously do all of these things—for different groups of actors—across platforms (in newspapers, online, in social media), shifting the way they influence policy and politics over time.

In our example, the "This is not a GMO" visualization (Figure 2) was produced as a strategic device for the European Greens to position their policy in the European Parliament. However, the Confédération Paysanne in France repurposed the visual reference to frame their CRISPR as GMO campaign in the public debate. Simultaneously, similar visualizations of CRISPR as GMO travelled as discursive objects across a coalition of local and international actors who successfully replicated their discourse, influencing the ruling of the CJEU to regulate CRISPR techniques in food as GMOs (Confédération Paysanne and Others *v.* Premier Ministre and Ministre de l'Agriculture 2018). An alternative visualization of CRISPR-Cas9 is as molecular scissors (Science 2013). This visualization has been used as a framing device to make sense of the CRISPR technology in online and traditional media. The scissors visualization is also part of alternative discourses like the precision of the technology, novelty of the technology, or differentiation from GMO. In their interactive setting, the meaning of these contesting visualizations of the technology would be negotiated over time by groups of actors in the debate about CRISPR in different policy scenarios—these negotiated shifts in meaning change over time the way visualizations influence local policy and politics.

Hence, there are at least two reasons to further combine elements of the five clusters in studying shifts in meaning and influence of visualizations over time and the ways these shape policies, political behavior, and public debates:

1. In a globalized and mediatized world, multiple policy actors (at local and global levels) use visualizations differently in their struggles to frame issues, set agendas, position discourses, shape contexts, and set values in public debates to influence policy decisions. Policy making takes place in a complex network of actors. These actors in different settings use visualizations to

convince others—but they also form coalitions around visualizations that may compete over problem definitions of policy issues.

2. The public is no longer a passive receiver of visualizations: they reproduce and produce their own. New media technology landscapes change the dynamics of (visualizations in) public debates. The online sphere has opened new avenues of participation in modern democracies' political life, challenging traditional understandings in political sciences about the emergence and dynamics of policy and politics in society (Green 2010; Castells 2008, 2011). Visualizations online on policy and political issues are an increasingly common form of political participation. The dynamics of visualizations in online debates raise questions such as how a particular visual becomes iconic/symbolic. Do actors with similar discourses also use similar visualizations, and if so, how? What discourses have been used with different visualizations? By which actors? What actors and positions are represented in the visualizations of an emerging controversy? And equally importantly, which are not? How has the use of visualizations evolved? How do controversies emerge and evolve along with the use of visualizations? These are all relevant questions to understand better the dynamics of visualizations in the emergence and evolution of online policy and political debates.

When we want to trace better the different roles that visualizations play in policy making and politics over time and for different groups of actors, we propose conceptualizing and empirically studying the traveling of visualizations over different (internet) regions, different policy settings, and across platforms. This will give better insights into their shifts in meanings for different actors, shifts in meaning and influence through time, and their shifts in ways of influencing policy and politics at local levels. This (digital) approach can be implemented by adopting an encompassing analysis of textual and visual framing, including the online network dimension in the research.

The focus on the visual as a boundary object (Metze 2020; Star and Griesemer 1989; Carlile 2002) that can be traced through policy-making processes enables for the study of their (online) traveling, the different meanings it can have for different policy actors—and the shift in meanings and influence it can have over time. Understanding these dynamics of visualizations in online policy issues offers an untapped source of information on the interplay between the role(s) of visualizations, the dynamics of (globalized) online debates, and their link to local policy decisions.

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APPENDIX 1.

Search Criteria for Raw Data Download from Web of Science Repository

To retrieve our raw data, we conducted a Boolean search of the Web of Science (WoS) repository comprised of the terms on the June 25, 2020, followed by a refined inclusion criteria and exclusions of research topics using the following string:

TS= (Poli* AND Visual*) [including]: web of science categories: (communication or social sciences interdisciplinary or political science or psychology applied or psychology multidisciplinary or multidisciplinary sciences or psychology or social issues or psychology experimental) AND [excluding]: research areas: (area studies or psychiatry or development studies or literature or environmental sciences ecology or sport sciences or education educational research or geriatrics gerontology or ophthalmology or engineering or computer science or art or rehabilitation or biotechnology applied microbiology or criminology penology or family studies or transportation or biomedical social sciences or medical ethics or film radio television or health care sciences services or nursing or business economics or mathematics or respiratory system or history philosophy of science or telecommunications or information science library science or philosophy or audiology speech language pathology or public environmental occupational health or social work or genetics heredity or anthropology or life sciences biomedicine other topics or physiology or zoology or neurosciences neurology or substance abuse).

Timespan: All years (1945-2020) Indexes: SCI-EXPANDED, SSCI, A & HCI, ESCI

The resulting entries were manually curated by relevance of title (or abstracts in case of doubt) and the raw retrieved data consisted of 1,500 entries. Entries were downloaded with all 28 fields of records selected in .txt file format to be processed and analyzed with R package *bibliometrix* and mapped in a network on VOSviewer.

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APPENDIX 2.

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Additional Information on the Quantitative Method of Social Network Analysis

All txt. files containing the co-citation data of 1,500 papers (for a total amount of 63,442 cited references) were uploaded in the R package *bibliometrix*. First, the raw data was filtered to avoid duplicates. Then, the data was analyzed for fundamental bibliometrics analysis and creating a co-citation matrix.

The co-citation of bibliographic data was visualized in the extension VOSviewer for bibliographic mapping. First, two distance-based maps of co-citations were configured in VOSviewer. The first map was intended for a degree centrality analysis of the co-citation matrix. The second map was intended for a betweenness centrality analysis of the co-citation matrix.

The parameters of both maps were configured based on fractional counting of links to account for differences in the number of references between journal articles and between journal articles and books. For the degree centrality map, the minimum amount of co-cited references was set at 10, as lower numbers resulted in unmanageable numbers of nodes and higher numbers resulting in low numbers of nodes. Afterward, the data were manually filtered to remove references to research methods and statistics literature identified in the bibliometric analysis but not relevant to the research. The number of resulting nodes in the degree centrality map was 102 (before the manual filtering of references unrelated to the study). Similarly, the minimum amount of co-cited references for the betweenness centrality map was set at 4, resulting in 885 nodes.

The data for both maps were normalized by fractionalization of the strength of the links in the network. The layout of the VOS mapping algorithm was set to default values for co-citation mapping; 2 for attraction and 1 for repulsion, with a random start for the optimization of the algorithm and a maximum iteration of 10,000 times. Clustering of the maps Several node sizes were performed with the VOS technique, and minimum node sizes were set to 10 and 4 for degree centrality and betweenness centrality maps, respectively.

GML files for the betweenness centrality network were exported from VosViewer to run SNA statistics in Gephi, as the software supports estimation and display of statistical values per node instead of by the network. The data was organized from the highest centrality values to the lowest. Most of the degree centrality was found as top values of betweenness centrality, indicating a considerable overlap. Therefore, the focus of the manual search was on the top 20% of the highest value in betweenness centrality. From that top 20% of betweenness entries, six papers were manually included to achieve the final 95 nodes network used for the qualitative step.

APPENDIX 3.

Coding Book

A. ID	B. Title	C. Authors	D. Type of publication	E. Key words	F. Cluster	G. Field of study	H. Definition of visualization	I. Ontology of visualization research
			D1 Book		**E1 VAS**			
			D2 Article		**E2 VAP**			
					E3 VAD			
					E4 CIR			
					E5 AR			

J. Epistemology of visualization research	K. Category of visualizations	L. Issues researched (policy issue, topic)	M. What methods are used to study visualizations?	N. What is the link between visuals and text?	O. What roles do visuals have in policy processes?
	H1. Pictures				
	H2. Photographs				
	H3. Cartoons				
	H4. Infographs				
	H...i. etc				

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