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Opposing positions, dividing interactions, and hostile affect: A systematic review and conceptualization of "online climate change polarization"

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Abstract

Online climate change polarization has increasingly received academic interest over time. Online media facilitate and accelerate processes of climate change polarization. Yet, throughout the years, online climate change polarization became a fuzzy concept, holding different meanings in different academic contexts. By reviewing the available evidence, the current article identified three ontological distinctions in online climate change polarization research: (1) focus on different groups that polarize; (2) either investigate the positions, relations, or emotions of actors; and (3) states or processes of polarization. Based on the latter two ontological distinctions, the article reconceptualizes online climate change polarization as a multidimensional phenomenon, by introducing a framework comprising six dimensions of polarization. Accordingly, by identifying gaps in the literature, the article proposes a future research agenda.

This article is categorized under:

Perceptions, Behavior, and Communication of Climate Change > Communication

Perceptions, Behavior, and Communication of Climate Change > Perceptions of Climate Change

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KEYWORDS

climate change, echo chamber, online climate change polarization, online media, polarization

1 | INTRODUCTION

There is a scientific consensus that the climate is changing due to human activity (IPCC, 2018). Yet, climate skepticism about this consensus has for a long time obstructed effective climate action in many Western countries (see, e.g., Whitmarsh & Capstick, 2018). The academic field of climate change communication, a field that is rapidly

maturing (Moser, 2016), addresses the role of communication in this "science-action gap" (Moser & Dilling, 2011). The field has given considerable attention to the phenomenon of climate change polarization, often by arguing that opposing climate change beliefs represent the politicization of the issue. To exemplify, McCright and Dunlap (2011) characterized the divide as between those that acknowledge the negative impacts of capitalism on the environment and the ones who relentlessly defend this economic system from changing. Over the last decades, newspaper media in the United States indeed increasingly represented climate change as a politicized and polarized issue (Chinn et al., 2020), which could be explained by the journalistic bias of false balance (Boykoff, 2007; Boykoff & Boykoff, 2007). However, more recent research suggests that journalists moved beyond false balance reporting by contextualizing skeptical voices in line with mainstream science (Boykoff, 2007; Brüggemann & Engesser, 2014, 2017).

In the 2000s, academic attention increasingly shifted to studying online media, as it opened up an entirely new realm of research possibilities to investigate the climate change polarization phenomenon. Online media offers an enormous dataset about the public's reasoning about climate change. It also dramatically changed the media landscape, and, therewith the dynamics of the polarized climate change debate (Painter et al., 2018; Schäfer, 2012). On the one hand, academics are positive about the advent of online media. The internet provides opportunities for minorities to voice their opinion about climate change. Therefore, the level of deliberation is potentially higher, since online media promote "the development of understanding, knowledge, and positions that would otherwise be invisible, silenced, or squelched in general debate" (Sunstein, 2017, pp. 86–87). Moreover, online media provide opportunities for science and societal communication about climate change. Scientists have new channels through which they can communicate and exchange their scientific work. Another example is that environmental nongovernmental organizations benefit from online media by utilizing it's potential, for example, mobilizing action and fundraising. The user engagement features of online media can enhance engagement with the issue (Schäfer, 2012). For instance, comment sections could provide users with a space for deliberation about climate change (Collins & Nerlich, 2015). However, on the other hand, academics are concerned about the advent of online media, as they facilitate and accelerate existing polarization dynamics. Moreover, also new dimensions of polarization inherent to the online world are identified.

Problematically, throughout the years, "online climate change polarization" has become a fuzzy concept (Elgesem & Brüggemann, 2022). Academics start from different ontological and epistemological premises. Accordingly, climate change polarization is operationalized differently across and within several academic fields. Researchers are interested in different variables (e.g., ideologies, emotions), underlying explanatory mechanisms (e.g., homophily, echo chambers), platforms (e.g., Twitter, blogs), and so forth. They apply divergent theories to analyze online climate change polarization, for example, theories stemming from social psychology, political theory, and communication theory. Lastly, academics employ different methods to understand the phenomenon, both quantitative and qualitative. Online media have enabled academics to employ novel methodologies to analyze polarization, such as computational methods. As a result, the concept of polarization has become even more blurry (Kligler-Vilenchik et al., 2020; Yarchi et al., 2020). Thus, online climate change polarization holds different meanings in different academic contexts.

The current paper offers a conceptual framework of "online climate change polarization," to provide more theoretical clarity about which dimensions of this phenomenon academic scholarship has to date focused on. The following section presents the methodological approach to the literature review that informed the framework. By means of reviewing the available evidence, the paper continues by presenting three ontological differences in previous research on online climate change polarization, respectively: (1) the groups that polarize; (2) positional, interactional, and affective polarization; and (3) states and processes of polarization. Based on the latter two ontological distinctions, the article reconceptualizes online climate change polarization as a multidimensional phenomenon, by introducing a framework comprising six dimensions of polarization. Finally, the current paper proposes a future research agenda.

2 | METHOD

The current paper conducted a systematic literature review to synthesize the theoretical and methodological approaches for studying online climate change polarization (Hulme, 2018). The articles needed to meet the following criteria:

1. The research primarily focuses on climate change/global warming. It is not sufficient to name climate change merely as an example, in a broader discussion about environmental issues (Bremer & Meisch, 2017).
2. The research explicitly discusses polarization theory (or the associated concepts of echo chambers and political homophily). It does not matter if the theory is discussed in the theoretical background section that informed the

methodological approach, or, in the results or discussion sections to interpret the results. The main interest here is in how the theory is defined and possibly extended, as arguably both contribute to theory-building.
3. The research focuses on online media in general or a specific online platform, for example, Twitter or blogosphere.
4. The research is peer-reviewed and in English.

Based on these criteria, search strings were constructed that contained at least the keyword "climate change" or "global warming"; contained the keyword "polarization" or "echo chamber" or "homophily"; and contained the keyword "social media," "online," "Twitter," "blogs," "blogosphere," "Facebook," "YouTube," "Reddit," "Instagram," "TikTok," "Snapchat," "Pinterest," "LinkedIn," or "WhatsApp." Based on these search strings and reviewing the studies' titles, abstracts, and keywords, 52 articles were identified in the *UvA Library* that seemed to meet the aforementioned criteria. UvA Library has an extensive database, including *Scopus* and *Web of Science*. Yet, to validate the results, a similar procedure was conducted on *Google Scholar* to verify whether key publications were included. Two articles were added after this search.

Subsequently, the dataset of 54 articles was subject to closer inspection to exclude irrelevant papers. For example, papers were excluded because they named "polarization" in their paper, but refrained from defining and theorizing on the concept. The final dataset included 36 peer-reviewed articles (see Appendix). The majority of studies was published in communication (e.g., *Environmental Communication*) and environmental (e.g., *Global Environmental Change*) journals, between a timeframe of 2015–2022.

After data collection, the papers were analyzed by carefully reading and re-reading the papers. Subsequently, the following aspects were noted down about each article[1]: (a) definition (if any) of polarization; (b) platform; (c) methodology; (d) groups that polarize; (e) positional, interactional, and/or affective polarization; and (f) state versus process; and (g) underlying mechanism explaining polarization. Finally, the results were synthesized (which again included rereading the papers) to search for congruence and outliers.

3 | A CONCEPTUAL FRAMEWORK OF ONLINE CLIMATE CHANGE POLARIZATION

By reviewing the available evidence, the current article identified three ontological distinctions in online climate change polarization research: (1) focus on different poles that polarize; (2) either investigate the positions, relations, or emotions of actors; and (3) states or processes of polarization.

3.1 | The groups that polarize

The first ontological difference concerns the groups that polarize or are polarized. Tracing back, social psychologists have analyzed the effects of talking in groups for decades. Before the 1970s, research mostly focused on the "risky shift" phenomenon, which explains that groups collectively take more risky decisions than individual members on their own (Isenberg, 1986; Myers, 1975, 1976; Stoner, 1959). After the 1970s, social psychologists explored an empirical generalization of this theory, which has led to the "group polarization hypothesis" (Myers, 1975). According to Myers (1975, p. 700), this hypothesis entails: "the average of group members' responses following group discussions will generally be more extreme in the same direction as the average of individual pregroup preferences." While the hypothesis did not indicate the presence of two groups for polarization to happen, political scientists generally understand "ideological," "partisan," or "political" polarization as the distance between the political parties or the electorate in the political spectrum (see, e.g., Casal Bértoa & Rama, 2021).

Predominantly, the political science understanding of polarization has impacted how climate change polarization is conceptualized, most likely feeding on the notion that the science of climate change has become politicized (McCright & Dunlap, 2011). In both academic and public discourse, climate change polarization is generally understood as a phenomenon that involves two groups, also in the studies included in the current literature review. Academics apply a wide range of labels to both climate change camps and subgroups within these camps. While not all reviewed studies define their labels and the exact wording of labels slightly differ, the large majority of research seems to understand online climate change polarization as what Rekker (2021, p. 355) defined as "science polarization": "partisan or ideological alignment over authority of science or a scientific consensus." In the context of climate change, there is a group of people that rejects the scientific consensus that anthropogenic climate change is happening, while

the opposing group supports this consensus. The first group is being labeled as either "climate skeptics" (see, e.g., Häussler, 2018; van Eck & Feindt, 2022; Xia et al., 2021), "unconvinced" (Holmberg & Hellsten, 2016), "disbelievers" (Tyagi et al., 2021) or another variation. The latter group is being labeled as either "mainstream" (see, e.g., Brüggemann et al., 2020; Kaiser & Puschmann, 2017; van Eck et al., 2019), "activist" (see, e.g., van Eck & Feindt, 2022; Williams et al., 2015), "advocates" (Häussler, 2018), "convinced" (Holmberg & Hellsten, 2016; Treen et al., 2022), "believers" (Moernaut et al., 2020; Tyagi et al., 2021) or a variation.

A few studies followed a narrower perspective rooted in the political research tradition, by distinguishing the groups based on their political leaning, that is, "right"/"conservative"/"Republican" or "left"/"progressive"/"Democrats" (Cann et al., 2021; Helmuth et al., 2016; Jang & Hart, 2015). With roots in social psychology, one study differentiated the groups based on low- versus high-risk perceptions of climate change (van Eck et al., 2021).

Overall, the question is to what extent these groups and accompanying labels are sustainable and reflect the dynamics of the climate change debate. The current paper raises two critical remarks. First, climate labels have the potential to maintain or further polarize the debate. Labels can be pejorative, frame the debate as antagonistic, and mask the details of particular points of view as they oversimplify (Howarth & Sharman, 2015; O'Neill & Boykoff, 2010). Consequently, it is unknown to what extent the labels merely reflect reality, or instead, actively construct reality by acting as discursive elements (Howarth & Sharman, 2015; Parmar, 2014). While some of the studies provided a justification and/or disclaimer on their labeling practices (see, e.g., Brüggemann et al., 2020; van Eck et al., 2019), the majority of the reviewed studies has not investigated how these practices impacted their findings.

Foremost, it remains unknown how deductively determining the groups and accompanying labels skews the results. Plausibly, if one searches for polarization around the scientific consensus, one will find such polarization. For example, Arlt et al. (2019) set out to identify the Twitter communities in the wake of the Swiss referendum on the Nuclear Withdrawal Initiative. They inductively identified seven distinct communities that actively exchanged both within and between the communities, which is in contrast with the large number of studies that finds evidence for echo chambers. Their inductive approach allowed for finding evidence for multiple groups, which goes against the general understanding of polarization theory that rests on the premise of binary groups. Academic scholarship would benefit from empirical studies that aim to understand how biased labeling practices affect evidence for climate change polarization.

Second, in many Western countries, public debates have shifted from discussions about whether anthropogenic climate change is happening to discussions about proportionate solutions to climate change (Painter et al., 2023). In other words, in certain contexts, the scientific consensus is becoming more widely accepted and debates have moved beyond discussions about this consensus. Thus, the groups and accompanying labels that the majority of research on online climate change polarization currently adopts are up for reconfiguration in future research. In the current review, three studies embodied this shift. Two studies focused on polarization around climate solutions. Sanford et al. (2021) differentiated between "meat/dairy supporters" and "plant-based advocates" and Arlt et al. (2019) focused on communities supporting and opposing the Nuclear Withdrawal Initiative. The groups opposing climate policies can be linked to "directed response scepticism," defined as those instances "where a specific policy is critiqued for being insufficient in scope and scale to address the climate problem, or unrealistic due to political and other obstacles" (Painter et al., 2023, p. 3). Elgesem and Brüggemann (2022) took an actor-centered approach. They differentiated between supporters and critics of Greta Thunberg to understand to what extent she was a polarizing figure in European countries, revealing diverging polarization dynamics across countries. Overall, newer forms of skepticism, for example, response skepticism (van Rensburg, 2015), and actor-centered approaches challenge previous conceptualizations of the groups in polarization, but are arguably better suited to understand contemporary climate change debates.

3.2 | Positional, interactional, and affective polarization

The second ontological difference concerns whether online climate change polarization is understood as a matter of opposing positions, dividing interactions, or hostile affect. Based on the platform structure and communication practices of online media, Yarchi et al. (2020) recently reconceptualized "political polarization" as positional, interactional, and affective polarization. The current article draws from this reconceptualization, as it offers a useful framework to understand online climate change polarization. Yet, it also shows how this framework is limited in explaining the full breadth of online climate change polarization research.

3.2.1 | Positional polarization

When online users are only exposed to views that are consistent with their own beliefs and shielded away from views that are opposed to these beliefs, they are trapped in an "echo chamber." Due to the constant repetition of views that confirm individuals' beliefs and the lack of challenging ideas, individuals' beliefs are reinforced and groups can become more extreme in their viewpoints (Jasny et al., 2015). Consequently, online groups can become fragmented and subsequently polarized (Sunstein, 2017). Yarchi et al. (2020, p. 5) define these "increases in antagonistic and extreme political preferences" as positional polarization. The previous section about the groups already addressed that online climate change polarization in some cases is not about individuals' *political* climate change preferences, but for example also about individuals' stance toward the scientific consensus on climate change.

Many of the reviewed studies focused on users' climate change positions, or more precisely, opposition. A few studies that clearly focused on positional polarization are the following. Jang and Hart (2015) conducted a cross-national framing analysis on Twitter and found that hoax frames about climate change are most prevalent in "red states" in the United States. With content and statistical analyses, Walter et al. (2018) showed how user comment sections of professional news outlets operate as echo chambers, where commenters adapt to the dominant climate change opinion of that newspaper. Based on a qualitative classification tool, Allgaier (2019) showed how most climate-related videos on YouTube do not support the scientific consensus view on climate change. Based on interviews with climate skeptical and climate mainstream bloggers, van Eck et al. (2019) showed how these bloggers' journalistic norms inform the selection and composition of polarized blog content. Sikder et al. (2020) present a minimalistic model of social learning that captures how individuals form their opinions on global warming according to the principle of confirmation bias: individuals tend to selectively accept information that confirms their pre-existing beliefs, while avoiding information that undermines these beliefs (del Vicario et al., 2017; McPherson et al., 2001). With bot detection software and topic modeling, Marlow et al. (2021) showed how automated bots generate climate denialist discourses on Twitter. Finally, van Eck & Feindt (2022) conducted a discourse analysis of climate skeptical and climate activist blog posts to understand how polarization is grounded in the discursive realities of these bloggers.

All in all, by investigating a wide range of platforms, previous research consistently provided evidence for positional polarization or the underlying mechanisms that explain this dimension of polarization. These can be roughly categorized as mechanisms concerning the platform structure (see, e.g., Marlow et al., 2021), communication practices (see, e.g., van Eck et al., 2019; van Eck & Feindt, 2022), and sociopsychological factors (see, e.g., Sikder et al., 2020).

3.2.2 | Interactional polarization

Individuals' tendency to associate with like-minded others is called "homophily" (Andersson, 2021). Yarchi et al. (2020, p. 4) define these "processes whereby participants in a debate increasingly interact with like-minded individuals, while disengaging from interactions with others who hold opposing viewpoints" as interactional polarization. These processes of interactional polarization could ultimately lead to the existence of echo chambers and therewith facilitate and accelerate positional polarization. Important here is the nuance of van Eck, Mulder, and van der Linden (2021, p. 149) who stated: "While a strict definition of echo chambers does not allow for *any* kind of counter-attitudinal exposure, we posit that it is in reality more often the case that audiences are *disproportionality* exposed to one view versus another." Their study showed how audience members with high climate change risk perceptions *primarily* consume climate mainstream blogs, whereas audience members with low climate change risk perceptions *primarily* consume climate skeptical blogs.

Other examples of reviewed studies that fit Yarchi et al.'s (2020) definition of interactional polarization are the following. By employing statistical methods to identify conversational connections between Twitter users (e.g., hashtags), Pearce et al. (2014) identified communities of users that shared each other's views toward the IPCC. Helmuth et al. (2016) conducted an ordination and network analysis on Twitter and showed how Senate Republicans and Democrats were each part of distinct and semi-isolated subnetworks based on their science follows. Employing community detection with brokerage analysis and exponential random graph models, Häussler (2018) explored tie formation processes in German hyperlink networks on climate change. Another study of Häussler (2019) investigated linking behavior in a high-contentious (United States) and low-contentious setting (Switzerland). Overall, all these studies provided consistent evidence of interactional polarization. Contrastingly, by investigating the topics, networks, and sources of information, Treen et al. (2022) did not find strong evidence for networks operating as echo chambers on Reddit. They suggest that this finding, contradicting earlier research, could be attributed to the platform's architecture.

However, Yarchi et al.'s (2020) definition of interactional polarization does not encompass the full breadth of previous research that focuses on users' interactions. Their definition focuses on both the existence of homophilic interaction patterns and the increasing absence of heterophilic interaction patterns. The current paper posits that this definition is too narrow, as heterophilic interactions in which participants are increasingly contrasting others who hold opposing climate change viewpoints is also a dimension of interactional polarization. For example, Elgesem (2019) showed how bloggers primarily link to sources that they agree with. Though, the study also showed that when bloggers link to sources that they do not agree with, they link to express their criticism about the source. A study by van Eck, Mulder, and Dewulf (2020) demonstrated how when framing differences between users in climate change blog comment sections emerge, the users mostly deploy polarizing interaction strategies to deal with the framing difference. Research by Oswald and Bright (2022) similarly found that users on Reddit were more likely to comment again if the content opposed their views. They speculated that these users were more engaged, as they were protecting their identity and therewith reducing feelings of dissonance.

Thus, Yarchi et al.'s (2020) definition does not cover participants' discursive interactions where they contrast others who hold opposing viewpoints by reaffirming or upgrading their own issue framing (Dewulf & Bouwen, 2012), while the aforementioned studies found congruent evidence for this dimension of polarization. It also contradicts Sunstein's (2017, p. 68) "group polarization" hypothesis that asserts that "groups of like-minded people engaged in discussion with one another will typically end up thinking the same thing they thought before- but in a more extreme form." Instead, Brüggemann et al.'s (2020, p. 1043) "mutual group polarization" hypothesis better explains this dimension of polarization, referring to the idea that "the internal affirmation of extreme views and the mutual provocation of more extreme views" occurs when groups are confronted with opposing views.

Overall, previous research on interactional climate change polarization mostly focused on Twitter and blogs, perhaps not surprisingly given that these platforms provide features to analyze relations among actors. Indeed, network analyses such as community detection and hyperlink network analysis were frequently employed to investigate this form of polarization. Previous research that investigated how users increasingly contrast others, generally employed qualitative and quantitative manual content analyses. The underlying mechanisms that previous research puts forward to explain interactional climate change polarization can be roughly categorized as mechanisms concerning the discursive communication practices (see, e.g., Elgesem, 2019; Kaiser, 2017; van Eck, Mulder, & Dewulf, 2020), forms of homophily (see, e.g., Pearce et al., 2014; Schmid-Petri et al., 2018), socio-psychological processes (Elgesem, 2019), and media consumption patterns (Kaiser & Puschmann, 2017; van Eck, Mulder, & van der Linden, 2021).

3.2.3 | Affective polarization

Finally, concerns are raised that users are more uncivil online, as they can operate anonymously from behind their computers (Walter et al., 2018). Incivility negatively affects the quality of deliberation about climate change (Collins & Nerlich, 2015). Yarchi et al. (2020, p. 5) define "rising hostility in political talk toward opposing political groupings" as affective polarization. This dimension of polarization, in the context of climate change, clearly received less academic attention than the other two dimensions. An example of a study that followed Yarchi et al.'s (2020) definition is Tyagi et al.'s (2021) research. They employed stance mining and sentiment analysis to analyze hostility in discourse between believers and disbelievers. Another example includes Holmberg and Hellsten's (2016) study, which found that most tweeters used negative words around the publication of the fifth IPCC report. Both of these studies found that disbelievers/unconvinced generally use more negative words. The majority of reviewed studies employed a sentiment analysis to investigate affective polarization. However, consistent with previous research that investigates affective polarization beyond the online world (see, e.g., Iyengar et al., 2019; Rogowski & Sutherland, 2016), one may argue that Yarchi et al.'s (2020) definition lacks a focus on actors' affect, emotions, and non-discursive expressions (e.g., previous research on affective evaluations of political candidates). This lack illustrates a limitation of research focusing on the online world, that researchers have no to limited opportunity to directly interact with the humans behind the computers.

3.2.4 | Interrelationships between the various dimensions of polarization

Often by employing a mix of methods, a large number of the reviewed studies did not only investigate one dimension of polarization, but investigated two or three of the various dimensions of polarization. These research studies raise an important question about how online positional, interactional, and affective climate change polarization interact with

one another. To date, little research is available that explores the directionality, while such research is important as it could provide a road map on how polarization could be addressed, also in other contexts than climate change. Some of the reviewed studies do not address this question, some studies speculate about the directionality in their discussion of the results, and only a few studies answer this question based on their evidence. Perhaps this lack of research can also be explained by the fact that it is difficult to clarify the directionality, given that it is a chicken-and-egg problem (Layman, Carsey, & Horowitz, 2006).

Albeit, there seems to be one line of reasoning that is dominant across the reviewed studies, which is the following: the form of interactional polarization where participants are increasingly contrasting others who hold opposing climate change viewpoints, is characterized by affective polarization, ultimately reinforcing positional polarization. For example, with mixed methods, Moernaut et al. (2020) investigated heatwave tweets that were related to climate change. They concluded that if there are discursive interactions between opposing groups (i.e., interactional polarization), these are antagonistic (i.e., affective polarization) and lead to more polarization (i.e., positional polarization). Van Eck, Mulder, and Dewulf (2020) similarly found that once actors deployed negative identity frames (i.e., affective polarization) in their discursive interactions, that always led users to respond with polarizing interaction strategies (i.e., interactional polarization), which ultimately left their framing differences unresolved (i.e., positional polarization). Williams et al. (2015, p. 136) also found evidence of "open forums" where users interacted with opposing views and speculated the following: "these users, who hold a strong view about climate change but inhabit a community where conflicting views are often expressed, have a strong perception that there exists a genuine and contested debate about climate change. Thus, these users make greater efforts to influence the debate towards their own view and appear more confrontational or aggressive towards users who express conflicting views." Lastly, Brüggemann et al. (2020) and Xia et al. (2021) drew similar conclusions, by reasoning that being exposed to the opposing camp, including accusations (i.e., affective polarization), likely leads to more polarization.

Thus, in this perspective, affective polarization *causes* positional polarization, which is *facilitated* by interactional polarization. However, alternative perspectives are circulating in academia. For example, Iyengar et al. (2019) explained that many assume that a lack of balanced content leads audience members to adopt extreme positions (i.e., positional polarization), which in turn increases affective polarization. In this perspective, positional polarization is *facilitated* by interactional polarization and *causes* affective polarization.

The precise relationships between these different polarization dynamics are not well understood yet (Iyengar et al., 2019). Most likely, different perspectives provide explanations for how the different dimensions of climate change polarization interact with one another. To illustrate, Van der Linden (2014) showed how risk perception and affect reciprocally influence one another, which potentially suggests that positional and affective climate change polarization are reciprocally influencing each other. In line with this reasoning, other studies showed how audience members that are already polarized pre-exposure become more extremely polarized after being exposed to unbalanced media content (Levendusky, 2013; Newman et al., 2018). Thus, in all likelihood, the relationship between the various polarization dynamics is inherently interactive (Jacobson, 1999) and mutually reinforcing (Van der Linden, 2014). Yet, more research is needed to gain a better understanding of the interactions between the various polarization dynamics.

3.3 | States and processes of polarization

The third ontological difference concerns whether polarization is understood as a "state" or a "process". DiMaggio et al. (1996, p. 693) explained: "Polarization as a state refers to the extent to which opinions on an issue are opposed in relation to some theoretical maximum. Polarization as a process refers to the increase in such opposition over time." The majority of reviewed research focused on polarization as a state (see, e.g., Jang & Hart, 2015; Sanford et al., 2021), which essentially means that these studies captured polarization at a defined point in time.

A part of the studies also focused on processes of online climate change polarization. Some investigated discursive interactions between users in comment sections, which are generally relatively short periods (see, e.g., Oswald & Bright, 2022; van Eck, Mulder, & Dewulf, 2020; Walter et al., 2018). These studies provide insight into *how* users shape their positions. A discourse analysis by van Eck & Feindt (2022) showed how the climate skeptical and climate activist blogging discourse shifted between 2009 and 2015. Analyses of discourse over a longer period shed light on how users could strategically change their communication practices. Cann et al. (2021) and Chen et al. (2021) investigated how networks changed over time around a certain event, which provides explanations for how these events affect the formation of networks. It is remarkable though, that most of these studies showed how the polarizing dynamics were quite persistent over time. Another exceptional finding is the study of Tyagi et al. (2021), which investigated affective polarization over a period of 100 weeks and showed *asymmetric* patterns of polarization.

3.4 | Six dimensions of online climate change polarization

The current literature review showed that online climate change polarization is a multidimensional phenomenon. The current paper proposes a framework consisting of six dimensions of *online climate change polarization* (see Table 1), along the ontological distinctions of (a) positional, interactional, and affective polarization and (b) states and processes of polarization, to capture this multi-dimensionality.

This review identified in Section 3.1 another ontological difference relating to the groups that polarize. However, this notion is not incorporated into the framework, as it was argued that the groups under investigation are up for reconfiguration in future research. The review also revealed that researchers already investigate multiple dimensions of polarization or even explore the interactions between the different dimensions. Thus, the boxes in the framework are not mutually exclusive. For example, the review revealed that Boxes 1 and 2 and Boxes 5 and 6 often go hand in hand. Table 2 provides an overview of how many studies can be categorized into each dimension, but it is important to note

TABLE 1 Six dimensions of online climate change polarization.

	Positional	Interactional	Affective
State	1 Extreme climate change opposition	2 Absence of or almost no interaction between actors with opposing climate change positions	3 Extreme affective or emotional evaluations that reflect hostility toward opposing climate change groupings
Process	4 Increasingly opposing climate change positions	5 Interactions in which actors increasingly contrast others with opposing climate change positions	6 Increasingly affective or emotional evaluations that reflect hostility toward opposing climate change groupings

TABLE 2 Situating the studies and methodologies in the framework.

Dimension	Number of studies	Exemplary study	Primary methods
(1) Extreme climate change opposition	12	Allgaier (2019)	Topic modeling; framing analyses; qualitative and quantitative manual content analyses
(2) Absence of or almost no interaction between actors with opposing climate change positions	16	Pearce et al. (2014)	(Hyperlink) network analyses; community detection
(3) Extreme affective or emotional evaluations that reflect hostility toward opposing climate change groupings	8	Elgesem and Brüggemann (2022)[a]	Sentiment analyses; automated and qualitative and quantitative manual content analyses
(4) Increasingly opposing climate change positions	8	Walter et al. (2018)	Topic modeling; automated and quantitative manual content analyses
(5) Interactions in which actors increasingly contrast others with opposing climate change positions	8	van Eck, Mulder, and Dewulf (2020)	Automated and qualitative and quantitative manual content analyses
(6) Increasingly affective or emotional evaluations that reflect hostility toward opposing climate change groupings	3	Tyagi et al. (2021)	Sentiment analyses; automated and qualitative and quantitative manual content analyses

[a]Affective polarization results.

when interpreting the table that studies can be situated in multiple dimensions. The overview shows how most studies focus on interactional polarization as a state (second dimension) and least on affective polarization as a process (sixth dimension). Finally, this conceptual framework rests on the assumption that the wide range of mixed methods that academics employ each provide complementary, not competing, insights into the online climate change polarization phenomenon.

This conceptualization aims to provide researchers across different disciplines with clarity about what this phenomenon comprises and work toward a unified language. The conceptualization also identifies gaps in existing research, which will be elaborated on in the next section. As such, the framework provides a starting point for future research by understanding the framework as six theoretical approaches. While this conceptualization is based on the reviewed evidence in the online realm, it could also be applied to the offline realm. The framework might also provide a starting point to analyze other polarized discussions, such as COVID-19.

4 | A RESEARCH AGENDA

The literature review showed that overall the large majority of studies provided evidence for dimensions of online climate change polarization. However, there are a few outlier studies that contradict traditional understandings of polarization theory (see, e.g., Arlt et al. 2019; Treen et al., 2022). It also became apparent that certain theoretical approaches, methodologies, and platforms gain more attention than others. Moreover, the reviewed studies also raise new questions about the dynamics of online climate change polarization. The current paper identifies the following potential future research directions.

4.1 | Revisiting assumptions about polarization theory and its underlying mechanisms

One common understanding of the group polarization hypothesis is that group discussions lead to uniformity in opinion, in a more extreme form (Myers, 1975; Sunstein, 2017). However, this review provided substantial evidence that contradicts this hypothesis (Elgesem, 2019; Oswald & Bright, 2022; van Eck, Mulder, & Dewulf, 2020), by showing how exposure to opposing views can lead to mutual group polarization where individuals criticize each other and become further removed from each other (Brüggemann et al., 2020). While the review also provided evidence for echo chambers (Häussler, 2019; Helmuth et al., 2016; Pearce et al., 2014; van Eck, Mulder, & van der Linden, 2021), it is important to recognize that the common understanding of group polarization is not the only conclusive hypothesis. This finding has practical implications for depolarization work, provided that depolarizing society is not simply a matter of breaking out of the echo chambers.

This also immediately raises the question of which mechanisms underlie processes of polarization. There seems to be an ongoing discourse in academic scholarship that points to social psychological mechanisms explaining processes of group polarization, for example, social comparison theory, persuasive arguments theory (or social/informational influence theory), or "confidence, extremism, and corroboration by others" theory (Isenberg, 1986; Sunstein, 1999, 2017). However, this review clearly showed that it is not only these social psychological mechanisms that are driving processes of polarization, but that for example the technical architecture of platforms (Marlow et al., 2021; Treen et al., 2022) and the discursive communication practices (Brüggemann et al., 2020; van Eck, Mulder, & Dewulf, 2020) also explain polarization dynamics. Hence, if researchers move beyond capturing snapshots of positions, interactions, or sentiment, their results will have the potential to unravel the underlying mechanisms that explain polarization and in turn give direction into how the adverse effects of polarization could be addressed. One potentially interesting research avenue is investigating processes of asymmetrical polarization.

Last, generally, but also in the reviewed papers, it is assumed that polarization is undesirable. Indeed, the extreme directions that groups move into during processes of group polarization are rarely desirable for society at large, and, even for the individuals belonging to these particular groups (e.g., the rise of Nazism). Extreme polarization could put social stability at risk and is therefore largely perceived as a threat to democracy, as it can lead to "extremism" (Sunstein, 2017). Extreme polarization here refers to a more extreme point in the direction indicated by individuals' pre-existing views, whereas extremism is defined as a state that is inseparable from hostile acts against the other group (Berger, 2018). Yet, polarization can also be regarded as a positive development, as it is a sign that society has a broad range of ideas. Extreme polarization could give rise to civil movements that effectuate change (e.g., Extinction Rebellion). Therefore, the current paper wants to stimulate researchers to critically reflect on this and the other assumptions about polarization theory that are underlying their research.

4.2 | Reconfiguring the groups, issues, and scales in online climate change polarization

The vast majority of reviewed research focused on users who either support or reject the scientific consensus on climate change. While this distinction has evidently served its academic purpose in the last decade, debates in many countries are shifting (Painter et al., 2023). For that reason, academics are encouraged to follow public debates closely and adjust the groups and issues accordingly. For example, investigating polarization dynamics around climate policies (see, e.g., Arlt et al., 2019; Sanford et al., 2021) is a critical future research direction, also for advancing our understanding of "response skepticism" (van Rensburg, 2015).

Furthermore, researchers are encouraged to reflect on how their theoretical and methodological designs impact their results. For example, it is advised to inductively identify patterns of polarization, as deductive, binary labeling practices risk that biased evidence is found that greatly oversimplifies the debate (Howarth & Sharman, 2015; O'Neill & Boykoff, 2010). Inductive approaches not only allow for finding evidence that reveals more than two groups, but also more moderate positions.

A dimension of polarization that the review has not touched upon yet is the geographical scale. The majority of studies focused on the United States, Europe, or English-language platforms, ignoring the Global South, which is not uncommon in climate change communication research. Hence, it is important to investigate to what extent the dimensions of the framework extend to online platforms used in the Global South. Furthermore, since in many countries cities are now increasingly devoted to climate policy-making (Fuhr et al., 2018), it is worth exploring how polarization dynamics play out on a local level and how this in turn influences national and international climate discourse.

4.3 | Investigating interactions between positional, interactional, and affective polarization

The current literature review clearly showed that most previous research investigated multiple dimensions of polarization in their studies. Yet, only a small part of the studies speculated about the interactions between positional, interactional, and affective polarization, and only very few provided evidence for the directionality of polarization. The question of how these various forms of polarization interact is one that begs more research, as it could provide a roadmap on how climate change polarization could be addressed. For example, how do users' emotions affect climate conversations between people who have different viewpoints?

4.4 | Focusing on visual content and other platforms than Twitter

The large majority of reviewed studies focused on Twitter, closely followed by blogs. Yet, provided that each platform has its own distinct platform culture (Pearce et al., 2019), more research is also needed that does not rely on collecting its data from the Twitter API. To illustrate, platforms that provide visual content, such as YouTube and TikTok, have received very little academic attention, but also other platforms such as Facebook and online news media are largely overlooked. One question that needs answering, for example, is how do the distinct technological features of these platforms exacerbate polarization?

4.5 | Shifting the focus from polarization to depolarization

Now that we increasingly gain a better understanding of how positions, interactions, and sentiment are polarized or polarizing, the time has also come to investigate processes of *de*polarization. Considering that merely exposing individuals to others with opposing views likely leads to mutual group polarization, deliberation and dialogue are often put forward as alternatives (Arlt et al., 2019; Treen et al., 2022). Both approaches provide conditions for having conversations with people that are not likeminded (Fishkin & Luskin, 2005; van Burgsteden et al., 2022), to develop mutual understanding and better thinking as a result (Sunstein, 2017). One condition is for example that participants ought to talk and listen with civility and respect. Yet, it is largely unknown how such norms can be effectively implemented in the online world.

5 | CONCLUSION

The current article started from the notion that there is a wide variety of research available on online climate change polarization, which has resulted in the fact that the phenomenon became a fuzzy concept, holding different meanings in different contexts. A systematic literature review revealed three ontological differences in how previous research conceptualized the phenomenon. The reviewed articles (1) focused on different groups that polarize; (2) either investigated the positions, relations, or emotions of actors; and (3) states or processes of polarization. Based on the latter two ontological differences, the current paper presented a framework comprising six dimensions of online climate change polarization. Overall, the framework provides clarity about what the multi-dimensional phenomenon of "online climate change polarization" encompasses. As such, it stimulates collaboration across scientific disciplines to advance the science of climate change polarization. More generally, researchers are encouraged to reflect on the assumptions that underpin their online climate change polarization research.

AUTHOR CONTRIBUTIONS

Christel W. van Eck: Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); visualization (equal); writing – original draft (equal).

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CONFLICT OF INTEREST STATEMENT

The author declares no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as the paper comprised a systematic literature review.

RELATED WIREs ARTICLES

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The social media life of climate change: Platforms, publics, and future imaginaries

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ENDNOTE

[1] Preliminary conceptual ideas that were discussed in the dissertation of van Eck (2021) informed the systematic analysis.

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APPENDIX: INCLUDED ARTICLES IN THE LITERATURE REVIEW

1. Allgaier, J. (2019). Science and environmental communication on YouTube: Strategically distorted communications in online videos on climate change and climate engineering. *Frontiers in Communication*, *4*, 36. https://doi.org/10.3389/FCOMM.2019.00036/BIBTEX
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