Taylor & Francis
Taylor & Francis Group

Social Engagement with climate change: principles for effective visual representation on social media

Bienvenido León, Samuel Negredo & María Carmen Erviti

View supplementary material

Published online: 20 May 2022.

Submit your article to this journal

View related articles

View Crossmark data

RESEARCH ARTICLE

Social Engagement with climate change: principles for effective visual representation on social media

Bienvenido León ⬤, Samuel Negredo ⬤ and María Carmen Erviti ⬤

University of Navarra, Spain

ABSTRACT

Climate change communication on social media plays a prominent role in efforts undertaken by state agencies, NGOs, and international organizations, to make citizens aware of this phenomenon. The images used to communicate climate change are of great importance, since they can help to effectively raise citizen awareness. Building upon news values theory and the concept of availability heuristics, this research paper aims to identify principles that can be used for effective visual communication of climate change on social media on a cross-national scale, based upon analyses of characteristics of images that foster interaction on Twitter. We conducted a content analysis of a random selection of images (photographs, illustrations, and graphics, n = 380), posted on Twitter that were included in the so-called 'top tweets' about climate change. The results indicate that the types of images that are used on social media are relatively similar to those employed by conventional media, although images of identifiable people are less frequently shown on social media. We also deduced that four practical principles are especially relevant to foster user interaction on Twitter through images: (i) show 'real people' (i.e. non-staged images of people that transmit real emotions), (ii) tell a story, (iii) include a local connection, and (iv) show impacts or actions by people who are directly affected. These practical principles are based on the more general principles of meaningfulness and personification, two foundations that can help to overcome some of the main barriers to citizens' perception of climate change as a relevant issue with serious consequences in their lives. Campaigns on social media that use imagery based on these practical and general principles can be effective in communicating the shared responsibility to address climate change. This can have a relevant impact on social perception, since it can encourage citizens to care about climate, which is regarded as necessary to increase participation in climate action.

Key policy insights:

- Social media can play a prominent role in campaigns to make citizens aware of climate change.
- Images can help to effectively raise citizen awareness of climate change.
- Four practical principles can be effective in increasing user interaction on social media with images about climate: show 'real' people, tell a story, include a local connection, and show people who are directly affected.
- Visual campaigns based on the more general principles of meaningfulness and personification can be effective in representing climate change as a relevant issue in citizens' lives.
- These practical and more general principles can have a relevant impact on the social perception of climate change and increase citizen participation in climate debate and action.

Introduction

Climate change is expected to have severe effects on many citizens all over the world (IPCC, 2021). Consequently, considerable efforts have been undertaken to make citizens aware of this phenomenon, for example, through campaigns organized by state agencies, NGOs, and international organizations. Campaigns play an important role in shaping local, national, and international policy agendas (Whitmarsh et al., 2013), especially when considering that climate change is not among the main concerns for many citizens (Geiger et al., 2017). However, communicating climate change is not an easy task, due, among other factors, to the invisibility and complexity of the phenomenon, and the lack of immediacy and direct experience with the impacts (Moser, 2010). Information provision about the impacts of climate change by itself is not generally effective at promoting behavioural change (Derygina & Schurchkov, 2016; Moser, 2016), and the social debate is often characterized by homophily and polarization, which provides a fertile ground for misinformation to spread (Treen et al., 2020).

Climate change communication in the media is a prolific field of research that includes, among other approaches, historical overviews (i.e. Moser, 2010), explorations of political implications (i.e. Carvalho, 2010), the roles of different stakeholders in the social debate (McCright & Dunlap, 2003), and characteristics of the representation in different media outlets (i.e. Painter, 2013).

Within climate change communication, images (including photographs, graphics, and videos) are enormously important to effectively raise awareness of this phenomenon and foster citizen engagement in mitigation and adaptation actions (O'Neill & Smith, 2014). Images can attract audiences by creating emotional connections (Joffe, 2008), and they can help people remember information more easily (Graber, 1990). This is related to three distinctive characteristics of images (O'Neill, 2017): they are a likeness of the real world, they can be interpreted differently by different people, and they are indexical (they are often perceived as a direct representation of reality). Keib et al. (2018, p. 204) argue that 'news images in social media posts are far more than decoration; they govern attention, perception, and engagement'.

In traditional media, images of climate change impacts (i.e. ice melting, polar bears, etc.) have been employed more frequently than those of causes (i.e. factory smokestacks belching out gasses into the atmosphere), both in print media (Smith & Joffe, 2009) and on television (Lester & Cottle, 2009; León & Erviti, 2015). In addition, images related to climate summits (i.e. meetings of politicians, protests, etc.) are also used frequently (León & Erviti, 2015).

Some of these images do not foster engagement since they do not convey the importance of climate change or the need for urgent action. Faced with this difficulty, some experts consider that it is best to represent climate change through certain images that act as iconography people can identify with (Hulme, 2004), and to use positive images of climate change solutions as a more effective way to motivate environmentally friendly behaviour (Carlson et al., 2020).

Social media platforms have become important communications channels for climate change. Through social networks, many citizens receive information (Painter et al., 2016, 2018) and come into contact with 'debates, actions and social input' (Segerberg, 2017) about this phenomenon. In addition, social media can play a decisive role in bringing climate change psychologically closer to people (Anderson, 2017), facilitating public awareness (Mavrodieva et al., 2019), and fostering actions to tackle it (Vraga et al., 2015). However, research on the role social media images play in climate change communications has barely scratched the surface (Schäfer & Schlichting, 2014; Pearce et al., 2019).

Whereas traditional media are non-interactive, social media use is driven by a need for influence and interaction that leads citizens to become active users who share knowledge and opinions and connect with other individuals with similar interests (Zolkepli & Kamarulzaman, 2015). This suggests that the effect of climate change images can differ significantly between social media and traditional, non-interactive media.

In this context, the identification of principles for effective visual communication on social media becomes crucial to promote citizen engagement in a complex issue like climate change. Zhang and Skoric (2018, p. 397) stress 'the potential in social media to encourage grassroots environmental participation' and their study 'highlights the role of social media in spreading environmental knowledge and mobilizing citizens to participate in daily pro-environmental activities'.

Gil de Zúñiga et al. (2012, p. 311) explained 'the positive relationship between social media use, social capital and citizen engagement'. Interaction with climate content on social media is relevant to citizen actions on climate and their attitudes towards climate policy. A Pew Research Center survey in the United States found that climate-engaged social media users show greater support for policies to deal with climate impacts (Pew Research Center, 2021, p. 26). In addition, images are believed to influence public and policymaker attention because 'they convey a truth or evidentiary proof that cannot be expressed as powerfully in words' (Jenner, 2012, p. 275).

This research paper aims to identify principles that can be used for effective visual communication of climate change on social media, based on analyses of the image type, or the characteristics of the images that foster interaction on Twitter. In this article, the term 'effective' is understood as the ability to achieve the effect that is pursued, which in this case is user interaction. Specifically, we pose two research questions (RQs):

RQ1: What kinds of images are used most frequently to represent climate change in the 'top tweets' on Twitter?

RQ2: What principles can be applied to visual communication of climate change on social media in order to foster user interaction?

Engagement with climate change issues can be understood in at least two different ways: as an active participant in climate science and/or policy processes (Few et al., 2007) that is part of a wider effort to 'democratize' science (Lewenstein & Brossard, 2006); or as caring about this phenomenon, but without necessarily taking part or publicly participating in policy making (Lorenzoni et al., 2007). In the second sense, we argue that user interaction on social media can be regarded as a sign of engagement with climate change, and thus a sign of caring about the issue.

Literature review

Much of the research on images of climate change has focused on how it is visually represented in the media (Smith & Joffe, 2009; Ahchong & Dodds, 2012; DiFrancesco & Young, 2011; O'Neill, 2013). Among the most common types of images are identifiable people, the impacts of climate change, depictions of energy, emissions, pollution, protests, and scientific images (O'Neill, 2017). This classification will be used in our study to analyze the images posted on Twitter, as explained in the methods section.

The effectiveness of images to foster engagement with climate change

Research indicates that images can play an important role in promoting the engagement of citizens in climate change (DiFrancesco & Young, 2011, p. 533), although some images can be more effective than others, depending on the objective, context, and intended audience (O'Neill, 2017). For example, images of extreme weather (floods, hurricanes) can increase the perception of the importance of climate change, but can also cause fear, denial, and apathy (Metag et al., 2016; O'Neill & Nicholson-Cole, 2009). This is because, among other reasons, a single image can be perceived differently by different observers. For example, images showing nature can be perceived in different ways, due to a person's cultural background, education, and religion (Buijs et al., 2009). Risk perceptions and policy support related to climate change are influenced by experiential, psychological, and socio-cultural factors (Leiserowitz, 2006; Maess, 2017).

Other experts have examined what makes for effective visual communication regarding climate change. According to Duan et al. (2019), specific images work better than abstract ones, since abstract ones tend to foster the perception of climate change as a problem for a distant time and place.

Furthermore, in the review of the existing literature on traditional media (mainly print media and television), O'Neill (2017) states that new images are more effective than those that have become clichés, and images that convey the importance of climate change (i.e. impacts of extreme weather events) may be effective to draw the interest of people with little previous involvement with this issue. In addition, images of politicians, business-people, and celebrities do not usually help to engage audiences, while images of 'real' people in authentic situations work better than photographs of staged situations.

Based on research conducted worldwide and their own combination of qualitative and quantitative methods (Chapman et al., 2016), the British think tank Climate Outreach proposed seven fundamental

principles for the visual communication of climate change that will be used as the basis for our research (Climate Change Visuals, 2018), as explained in the following methods section. The seven principles are: (i) showing 'real' people, (ii) telling stories, (iii) showing the causes of climate change on the appropriate scale, (iv) showing powerful climate impacts, (v) showing solutions, (vi) establishing local connections, and (vii) showing people who are directly affected.

Climate change images on social media

Digital media in general, and social media in particular, have become important sources of information. A multi-national survey (Newman et al., 2021, p. 23) indicates that 66% of adult internet users get their news on any topic from social media, with Facebook (32%), YouTube (20%), WhatsApp (17%), and Twitter (11%) as the most popular channels across twelve markets.[1] The popularity of each social medium as a source of news varies across regions. Twitter is more popular in Africa (35%) than in the other regions, such as in North America (12%) and Europe (9%). Social media is now one of the main sources of information on climate change for young people aged 18-24, since 17% get their information this way, versus 23% through television and 16% through online news media (Andi, 2020).

Research regarding climate change on social media points towards the existence of notable differences between what traditional media and social media aim to convey (Painter et al., 2018), although there is some interdependence between the two (Neuman et al., 2014). Content about climate change on social media is characterized by the use of mainstream information sources and the discussion of 'settled science' (Pearce et al., 2019), although there may be significant differences between what the news media publish and what people share on social media (Olteanu et al., 2015). Furthermore, social media use is driven by inter-action, which can transform passive individuals into active producers who share content (Zolkepli & Kamarulza-man, 2015). As Olesen (2020) points out, a distinctive characteristic of social media platforms is the ease with which they can communicate messages using images. This has at least two implications. Firstly, visual represen-tation no longer depends so much on the media's choices but on the users' decisions. Secondly, visual rep-resentation is increasingly easy to produce and reproduce, thanks to the many new tools that can be used to effortlessly create and edit digital images in the social media landscape. These characteristics suggest that the characteristics of the images that circulate on social media may differ from those published in tra-ditional media.

Theoretical framework: news values from the audience perspective and availability heuristics

News values are defined as 'the set of criteria that journalists use to assess news-worthiness' (De Maeyer, 2020, p. 1). There is an abundant corpus of research about news values that followed Galtung and Ruge's (1965) seminal study (e.g. Harcup & O'Neill, 2017; O'Neill & Harcup, 2020). More recently, news values have been studied from the audience perspective (Temmerman & Mast, 2021), an insight that provides a useful theoretical framework for the purpose of our study.

As Paulussen and Van Aelst (2021) recall, there are several approaches to news values. The 'replication approach' considers news values as cognitive clues that attract people's attention and is especially relevant in the digital age, which is characterized by information abundance. The authors propose that future research on news values might focus on cognitive cues to find out which news values the audience applies for making a selection from the constant stream of information, for sharing this information, and for assessing it.

Audiences try to make sense of the overflow of information and employ similar principles to those used by journalists to determine the relevance of information (García-Perdomo et al., 2018). This relationship between news values and audience interest was explored by Muñoz Torres (1996, p. 249), who states that news values work as factors that make the reader or viewer reach a 'certain degree of implication that makes him/her want to know what is being told.'

From this perspective, we argue that news values – as outlined by two themes of meaningfulness and per-sonification (see below) – provide a valid theoretical framework for our study, as they can help to explain the

underlying principles and factors that drive people's interaction regarding climate change images on social media.

Although news values are originally applied to news stemming from traditional journalism, this theory is 'based on general principles of the psychology of perception [and therefore] it can be argued that news factors guide not only journalistic decisions but also how users on social media might select and pay attention to certain topics' (Araujo & van der Meer, 2020, p. 636). Therefore, we assume that some of the criteria that are used by journalists to decide what is news can also be applied to identify key characteristics of the content that is regarded as more interesting for social media users, and results in more interaction online.

Previous research has found that some news values are specifically associated with audience interaction on social media. Social impact, geographical closeness, and facticity can explain the intensity of online activities (Araujo & van der Meer, 2020), while human interest, conflict, and controversy are the key news values to explain what news articles are shared on Facebook and Twitter (García-Perdomo et al., 2018). A study based on a survey conducted in 15 countries concluded that perception of news and news values varies significantly across different countries. However, some values, like proximity and unexpectedness, seem to be of universal appeal, in terms of raising the attention of audiences in all cultures (Wilkinson et al., 2021).

No taxonomy of news values can be definitive. We focus here on two specific news values that are frequently cited in the literature (see, e.g. Harcup & O'Neill, 2017; Shoemaker & Reese, 2013; Caple & Bednarek, 2013), because they can help to explain relevant characteristics of the images we analyze in this study:

- Personification: to present actions of named people, based on the assumption that events are the outcome of a free will.
- Meaningfulness: this concept includes several ideas, like familiarity or cultural proximity (what fits into the selector's frame of reference) and relevance (impact on the 'home' culture).

Additionally, people's interaction with climate change images can be better understood by considering the concept of availability heuristics. When thinking about risks, people rely on certain heuristics or rules of thumb that help to simplify their inquiry (Kahneman et al., 1982). In other words, we tend to process new information on a complex issue, like climate change, using heuristics (or shortcuts) rather than through a systematic analysis (Bostrom et al., 1994; Chaiken, 1989; Loewenstein et al., 2001; Weber & Stern, 2011). In this context, personal experience (e.g. memorable events like extreme weather events) can play a key role in influencing lay judgements and risk perceptions, becoming availability heuristics (Bostrom et al., 1994; Weber & Stern, 2011).

Most people do not have personal experiences they can associate with climate change and cannot bring examples to mind. However, it is possible to draw on second-hand experience, like images. For example, movies can provide experiences with vivid imagery and emotions that can connect with our experiential processing system and, in some cases, can bypass critical analysis (Leiserowitz, 2004). According to Mazur and Lee (1993), a few simple images of environmental issues that are often repeated in the media 'become an availability heuristic of real or potential danger, raising dire consequences in the minds of the audience' (p. 683). This vicarious experience can affect how people perceive, interpret, and respond to risk (Marx et al., 2007).

From this perspective, the concept of availability heuristic provides a secondary theoretical approach that can be useful in our study. We know that familiarity can affect the availability of instances that are used in this mental process, and a risk that is familiar will be perceived as more serious than a risk that is not familiar (Sunstein, 2006). Therefore, this process can help to explain why people tend to interact more with images that are perceived as familiar and meaningful.

Methods

Sample selection

Although climate change images are shared on several social media networks, we selected Twitter because it is regarded as a popular network in the use of news-related discussion and consumption (Newman et al., 2021), and it allows us to select an appropriate sample for the purpose of our study.

We carried out a content analysis of images (photographs, illustrations, and graphics) posted on Twitter during five weeks, with these being randomly selected weeks during the one-year period between 28, October 2019 and 27, October 2020. The Twitter API delivers about 100 'top tweets' per week from all over the world. It was important to select a sample that covers a whole year, since interest in climate change may vary depending on several factors (e.g. prominent public climate events or extreme weather events). The sampling period included the 25th Conference of Parties of the United Nations on Climate Change (COP25), held from 2-13, December 2019 in Madrid, Spain. Twitter defines the 'top tweets' as 'the most relevant', based on the 'popularity' of the tweet (for example, interactions, and shares), along with the keywords they contain and 'many other factors'. Despite not knowing exactly how the search algorithm worked, we considered that this met our research objectives and needs, and it enabled us to select the tweets with the greatest potential reach and influence on Twitter users.

Each of these search queries yielded a result of between 90 and 100 tweets, after we exhausted the chances to load more top tweets. The results were saved on a spreadsheet and all of the still images (photographs, graphs, illustrations, etc.) were downloaded, identified and tagged . When several images appeared on the same post, we considered each one of them as an independent unit. Besides the images, we saved the following information for each tweet: date, user, number of likes, number of retweets, number of comments, and text associated with each tweet.

The interactions (number of likes, number of retweets, and number of comments) were considered indicators of interest in, and engagement with, the content of the message, and therefore an indication of the potential of that image (along with the text associated) to foster public engagement on climate change.

Of the 419 images collected in the starting sample, 39 contained words only and were excluded, which resulted in a final sample (n) of 380 images, which were sorted in chronological order.

Coding

We developed the codebook based on criteria and examples from previous studies. To classify the types of images, we used the classification system proposed by O'Neill (2017). As mentioned in the literature review section, O'Neill's classification system organizes climate change images by type of content, including: identifiable people; impacts of climate change; depictions of energy; emissions and pollution (i.e. causes of climate change); protests, and scientific images (O'Neill, 2017). In case an image showed elements of more than one category we coded only the most meaningful information. For example, an image showing 'protests' and 'non-identifiable people' was counted only as 'protests'.

We also based our coding work on the seven principles outlined by Andi (2018) to explore how these principles or factors lend effectiveness to images to foster engagement with climate change. The seven principles are: (i) showing 'real' people, (ii) telling stories, (iii) showing the causes of climate change on the appropriate scale, (iv) showing powerful climate impacts, (v) showing solutions, (vi) establishing local connections, and (vii) showing people who are directly affected. Thus, applying O'Neill's classification (2017) and the Climate Visuals principles (2018), we developed the first version of the codebook (see also SM, Appendix 1). Two independent coders studied the codebook and participated in a training session using similar images, the quantity of which was 10% of our sample size, to detect comprehension problems and unify encoding criteria. After this test period, we developed the definitive version of the codebook (SM, Appendix 1). After the first training session was finished and the definitive codebook was drafted, an inter-coder agreement test was performed (SM, Appendix 3).

Results

Types of images

The most common images are those that show people (52.36%); in many cases they are identifiable people (31.26%), meaning they depict famous people, such as politicians, business leaders, actors, and writers. The least common images are those that represent the causes of climate change (3.82%), such as the emission of greenhouse gasses into the atmosphere (Table 1).

Table 1. Types of images.

Type of image	N	%
People (in general)	200	52.63
Identifiable people	131	31.26
Solutions	124	29.59
Impacts	81	19.33
Protests	53	12.65
Scientific images	37	8.83
Causes	16	3.82
Other images	85	20.29

N = 380 (*t*he categories are not exclusive).

Interactions

Images of people (in general) receive more interactions than the rest, with significant differences with respect to the other kinds of images in likes ($p < 0.01$, p-tail = 0.008, df = 375) and retweets ($p < 0.05$, p-tail = 0.011, df = 375). Images of causes and, above all, scientific images get less interaction than the others (Table 2).

Representations of people

Images containing people (in general) yielded more interactions than those that did not contain people, with significant differences in likes ($p < 0.01$, p-tail = 0.008, df = 375) and retweets ($p < 0.05$, p-tail = 0.011, df = 375). This suggests that images with people would have a greater ability to result in engagement with climate change issues. By contrast, there were hardly any differences between the interactions with images of identifiable people or those of non-identifiable people (SM, Appendix 2, Table 3).

Images of 'real' (non-staged) people posted on Twitter yielded much higher levels of interaction than images of 'non-real' (staged) people (SM, Appendix 2, Table 2). These differences are significant regarding likes ($p < 0.1$, p-tail = 0.058, df = 375) and retweets ($p < 0.1$, p-tail = 0.097, df = 375). Therefore, images showing people that are perceived as non-staged can be more effective to use for those seeking greater user interaction. Figure 1 shows the image that had the most likes (4,162) and retweets (955) in our sample. It was posted on Twitter (11-11-2019) by the account @DaveOCKOP and it shows a group of young Liverpool Football Club fans in Uganda taking part in an initiative that aimed to plant 500 million trees in the Nakaseke region. This can be considered as an example of an image with 'real people', since those who appear are not posing for the camera.

Images containing storytelling elements had more interactions than images that did not (see SM, Appendix 2, Table 4). These differences are significant with regard to likes ($p < 0.01$, p-tail = 0.007, df = 375) and retweets ($p < 0.01$, p-tail = 0.005, df = 375). Figure 2, posted on Twitter (12-1-2020) by the account @JakelinTroy, contains storytelling elements that are summarized in the text of the tweet. It describes how a horse died as a result of heat and smoke exposure and that the horse's owner also suffers from asthma aggravated by the smoke from wildfires in Canberra, Australia. The text includes the words: 'This is what climate change feels like. It kills.' This image occupies the fifth position for most likes among our sample (2688) and garnered 937 retweets and 200 comments.

Table 2. Interactions according to the type of image (mean).

	Mean no. of *likes*	Mean no. of *retweets*	Mean no. of *comments*
People (in general)	219.76	70.27	12.53
Solutions	202.73	52.65	5.05
Impacts	166.22	65.17	9.89
Identifiable people	159.50	55.50	15.80
Protests	143.02	60.04	18.58
Causes	122.19	62.56	31.81
Scientific images	79.62	35.46	6.81
General media	157.13	53.86	10.95

Figure 1. Example of an image with 'real people'. Source: @DaveOCKOP.

Impacts of climate change

Among the 380 images in the sample, 81 showed climate change impacts, while 64 of them were considered 'powerful impacts', which were representing imminent threats to people's lives. Interactions with images showing climate change impacts were higher than those with images not showing impacts, except in the number of comments. In the case of what we called 'powerful impacts', the average for the likes, retweets, and comments was higher than for the other impacts' images (see SM, Appendix 2, Table 5).

Figure 3 shows an image posted on 16-11-2019 by the user account @ClimateReality. This is an example of an image that, per the codebook, showed a 'powerful impacts' climate change image. It shows a view of a flooded region in Venice, Italy, accompanied by the following text: Venice council is flooded minutes after rejecting climate change measures. It got 339 likes, 255 retweets, and 18 comments.

Causes of climate change

The 16 images that represented causes of climate change achieved fewer likes than the images in other image categories. However, they received more comments on average than images not related to causes ($p < 0.1$, p-tail = 0.075, df = 375) (see SM, Appendix 2, Table 6).

Scientific images

The 37 scientific images in the sample obtained a considerably smaller mean number of interactions compared to the mean number of interactions for the whole sample of images: 80 vs. 166 likes; 25 vs. 56 retweets; 7 vs. 11 comments (Table 2). These data indicate that representing scientific research by itself does not generate enough interest from users for them to interact. The *t*-tests do not show significant differences in any kind of interaction (SM, Appendix 3, Table 6).

Figure 2. Example of an image that contains the basis for a story. Source: @JakelinTroy.

Solutions

Images of solutions that involved the mitigation of or adaptation to climate change received more likes than images that did not show solutions (203 vs. 135 likes). However, the same is not true for other interactions, since images of solutions received, on average, fewer retweets (53 vs. 54 retweets) and fewer comments (5 vs. 14) (Table 2).

   Some examples of images of solutions that had a higher number of interactions were those that showed an action that citizens take directly, such as photographs of people planting trees (Figure 1).

Local connection

An image with a local connection is often related to other aspects of the image, such as its photographic and realistic nature and its connection with a specific personal or collective action. In our analysis, we found that images classified as having a local connection received an average of up to five times more comments than images without a local connection (15 vs. 3 comments on average), almost triple the amount of likes (215

Figure 3. Example of an image that shows 'powerful impacts'. Source: @ClimateReality.

vs. 74 likes), and more than double the retweets (70 vs. 30 retweets) (SM, Appendix 2, Table 6). These data empirically confirm that images showing a local connection is a highly important characteristic to facilitate user interaction. Significant differences were seen in the three types of actions: likes ($p < 0.01$; p-tail = 0.01; df = 377), retweets ($p < 0.01$, p-tail = 0.001; df = 377), and comments ($p < 0.01$; p-tail = 0.001; df = 377) (SM, Appendix 3, Table 12). Two examples of images with the most interactions (Figures 1 and 2) had a clear local connection that links the causes, consequences, and reactions to a specific environment.

Protests

Compared to the general average for the whole sample, images of protests received almost twice as many comments (18 vs. 10 comments), and attracted slightly more retweets (60 vs. 53 retweets). However, they attracted fewer likes (143 vs. 157 likes) (Table 2). In the images of protests with more interactions, as well as those that received more likes or more retweets, directly-affected people always appear. The *t*-tests do not show significant differences in any interaction (SM, Appendix 3, Table 7), which indicates that showing protests does not affect user interaction significantly.

Protests by people who are directly affected

Some people shown in images of protests are directly affected by climate change causes or consequences (e.g. air pollution, forest fires, rising sea levels, migrations, desertification, etc.). The fact of being directly affected can be deduced from the image itself and/or the associated text. For example, people claiming they breathe polluted air are considered to be directly affected.

Interactions in the form of likes and retweets approximately double for images of protests if the people shown are directly affected by climate change impacts (258 vs. 152 likes; 133 vs. 51 retweets). By contrast, showing protests of those directly affected makes the comments rate fall dramatically to less than half of

that for protest images (7 vs. 11 comments). The *t*-tests do not show significant differences in any interaction, with the exception of retweets (p = 0.05, p-tail = 0.023, df = 377) (SM, Appendix 3, Table 12).

Figure 4 is an example of an image showing protests of people directly affected. It shows seven women protesting against the polluted air they breathe. It was posted on 12-09-2020 by the account @xnclejessie.

Discussion

RQ1. What kinds of images are used most frequently to represent climate change in the 'top tweets' section on Twitter? The comparison between the results of our study, where the focus is on images of climate change on social media, and those of previous research in traditional media (O'Neill, 2017), reveals that, generally, the images used on social media to portray climate change are similar to those used in traditional media. Images of people are the most commonly used, followed by those of climate impacts and climate solutions. The least commonly used images are those portraying protests and scientific images.

The main differences between the climate change images used on social media and traditional media are that identifiable people (i.e. politicians and celebrities) are less frequently shown on social media than in traditional media. For example, O'Neill's (2013) study on Australia, US, and UK print media found that 48% of news articles about climate change were associated with an image of an identifiable person. This is well ahead of the 31% found in our study. Conversely, non-identifiable people (ordinary citizens) are more frequently represented on social media than in traditional media. This is in line with the results of prior studies, which confirm that messages on social media pay more attention to non-famous people than traditional media outlets do (Olteanu et al., 2015).

RQ2: What principles can be applied to visual communication of climate change on social media in order to foster user interaction?

Of the seven possible driving factors for fostering user interaction on social media, our results provide empirical evidence on four of these factors as being particularly effective. These reinforce previously identified principles for effective visual communication regarding climate change (Climate Visuals, 2018). Specifically, four principles seem especially advisable to create images that foster interaction:

Figure 4. Example of an image of protests by people who are directly affected. Source: @xnclejessie.

1. Show 'real' people

Images of people perceived as 'real', meaning not staged for the camera, have the ability to convey identifiable emotions (happiness, sadness, fear, pain, etc.), and they are considered more authentic, which makes audiences more likely to interact with them in the form of likes, retweets, and comments.

In our study, images of people, generally, elicited a high number of interactions. However, images of identifiable people did not garner a substantially higher number of interactions compared to non-identifiable people. This confirmed that these kinds of images (showing politicians, businesspeople, celebrities) did not help to engage citizens when shown on Twitter, which is consistent with O'Neill's 2017 study on traditional media. Conversely, ordinary citizens (non-identifiable people) could play an important role in the visual communication of climate change on social media.

This finding is relevant to climate change communicators and campaigners on social media. Images of ordinary people, especially those that are perceived as spontaneous (non-staged) and display emotions, can be used as key elements to communicate climate change issues. The effectiveness of these kinds of images may be related to the news values of cultural proximity and familiarity, which in turn result in meaningfulness (Harcup & O'Neill, 2017).

Additionally, the use of images that are perceived by users as familiar can help to create a connection between climate change and lived experience that is not easy to establish, given that the phenomenon of climate change is a slow process that is often difficult to detect and track at a personal level (Weber, 2016). This connection can be explained by considering that instances that are perceived as familiar can provide examples that are used as availability heuristics, which, in turn, can reinforce the relevance of the risk that is represented in the images (Sunstein, 2006), resulting in higher levels of interaction.

2. Tell a story

Our results (SM, Appendix 2, Table 4) indicate that including storytelling elements is key in fostering interaction through images. As a consequence, it could encourage public engagement with climate change. Keib et al. (2018, p. 208) summarize that 'emotions—perhaps particularly ones that are highly arousing or negative in valence—play a role in what gets attention and engagement on social media'.

The use of images of people, in particular those that tell a story, can be related to the news value of personification. A story always has a protagonist. Presenting a topic or event through human beings makes it easier for social media users to identify with the main character of the image. This relationship is based on a process of implication that makes users eager to know what is being told (Muñoz Torres, 1996).

Personification is frequently used not only in climate change but in other areas of science communication. As scholars have emphasized, the strength of many scientific concepts relies, at least in part, on the fact that they connect science with human actions (Petra, 1993, p. 32). This narrative resource takes advantage of the fact that telling and understanding stories is not only well established in human societies but has been an ability of human beings since the origin of our species (Forster, 1983, p. 332). Furthermore, stories are 'intrinsically persuasive, which offers science communicators tactics for persuading otherwise resistant audiences' (Dahlstrom, 2014, p. 13614). In the specific case of climate change communication, this idea has many possible implications. Namely, it can help communicators foster engagement among 'resistant audiences' through social media. For example, climate change campaigns on social media could focus on personal stories about successful adaptation or mitigation.

3. Include a local connection

In our study, we found that images with a local connection achieved higher levels of user interaction (SM, Appendix 2, Table 5). The concepts of cultural proximity and resonance with personal or lived experience seem to work as the basis of interaction with images with an explicit local connection. The fact that this connection is made can be regarded as a news value indicator of meaningfulness, in the sense that climate change has a 'real impact' on 'real people'. On social media, the local connection provides users with an important

element to select what they feel closer to from the huge amount of information they have access to. The local connection can make it easier to empathize with those who experience climate change first-hand and, therefore, can be part of the availability heuristics that help to explain people's interaction with images.

In the case of climate change, this connection proves invaluable, as this phenomenon is often represented as a geographically and temporally distant challenge (Gifford, 2008; Lorenzoni et al., 2007; Ungar, 2007; Vlek, 2000), and its visual representation in the media tends to be linked to a global frame (DiFrancesco & Young, 2011; León & Erviti, 2015). This generates a low perception of severity of the problem (Lorenzoni & Pidgeon, 2006; Nisbet, 2009; Pidgeon, 2012) and it reduces willingness to act on a personal level or to support policy action (Spence et al., 2012). In this context, we argue that the use of imagery with a local connection on social media can have positive implications and can help foster user interaction which could lead to engagement and support for climate action.

4. Show people who are directly affected

The principle of meaningfulness can explain the fact that images showing people protesting and who are directly affected by the consequences of climate change are associated with higher levels of interaction. In addition, although this is not included in the news values theory, the principle of authenticity can help to explain this result, when considering that 'images produced by varying modalities of eyewitness enact a perceived immediacy and authenticity, as they appear consonant with what audiences believe to be first hand recordings of events as they truly unfolded (and produce) a shared sense of proximity' (Borges-Rey, 2015, p. 573).

This also has implications for climate change communicators using social media. Showing images of directly-affected people can work as a counterweight to the usual representation of climate change as a distant challenge, as we mentioned above, and thus it can foster user interaction, and thus lead to potential engagement on climate change.

The results of our study also allow us to propose that other general principles of effective visual communication regarding climate change, which have been proposed based on previous research, are less relevant in the realm of social media. This is the case in showing the powerful impacts of climate change. Although powerful impacts (those that can seriously affect lives) garner higher levels of user interaction, the impacts of climate change, as a whole, generate less interaction than other content. In the same way, the principle of 'showing causes on the appropriate scale' and 'showing solutions' elicit less interaction than other images.

Limitations of this research

Our analysis was limited to one social media platform, Twitter, and was carried out using a limited sample of images corresponding to a specific time period and selected using a particular algorithm that picks Twitter's 'top tweets'. Therefore, our study does not necessarily utilize a representative sample of all types of climate change images depicted on Twitter. However, our sample represents those image types that are potentially most influential on this social networking site, which makes this an appropriate sample for the purpose of our research.

In addition, not only visual characteristics influence the interactions that each image receives. Other factors also intervene, such as the Twitter account itself – which has a certain number of followers – and also the actual text that accompanies the image in the tweet. Since we used a multi-modal approach, it was sometimes necessary to analyze the images while taking into account the text accompanying each tweet. Therefore, the effectiveness of the images, which we measured based on number of user interactions, can also be influenced by non-visual information.

Lastly, we equated interaction as a sign of caring or interest about climate change, with a link to possible public engagement. Future research could focus on the relationship between images and actual public engagement on climate change, in the sense of taking actual action or participating in activities related to this phenomenon and influencing climate politics, policy or action. Furthermore, we analyzed the relationship between images and all the three types of interactions available on Twitter together (likes, retweets, and

comments). However, as we have indicated, each type of interaction may respond to different stimuli, a matter that may be the subject of future research. Since images can vary dramatically from one social media platform to another (Pearce et al., 2019), future research should investigate climate change images on other platforms as well as on Twitter.

Conclusions

Our results identify four practical principles, based on empirical evidence, that can be applied to the creation and selection of images that can be effective in terms of fostering user interaction on social media. These four practical principles are: show 'real' people, tell a story, include a local connection, and show people who are directly affected by climate change.

These practical principles are based on the more general underlying principles of meaningfulness and personification, two foundations that help to overcome some of the main barriers to people's perception of climate change as a relevant issue with serious life consequences.

The four practical principles, as well as the more general principles of meaningfulness and personification, derived from news values and illustrated here, can be used as guidance to orient public climate change communication on social media. Campaigns on social media that use imagery based on these practical and general principles can be effective in communicating the shared responsibility to address climate change issues and to foster user interaction. This can have a relevant impact on social perception, since it can encourage citizens to care about climate change, which is regarded as necessary to increase citizen engagement and participation in climate.

Note

1. UK, USA, Germany, France, Spain, Italy, Ireland, Denmark, Finland, Japan, Australia, and Brazil (n ≈ 2000 in each market).

Disclosure statement

Funding

ORCID

Bienvenido León 🆔 http://orcid.org/0000-0001-8556-9367
Samuel Negredo 🆔 http://orcid.org/0000-0002-8441-1231
María Carmen Erviti 🆔 http://orcid.org/0000-0003-1588-0955

References

Ahchong, K., & Dodds, R. (2012). Anthropogenic climate change coverage in two Canadian newspapers, The Toronto Star and The Globe and Mail, from 1988 to 2007. *Environmental Science and Policy*, *15*(1), 48–59. doi:10.1016/j.envsci.2011.09.008

Anderson, A. (2017). Effects of social media Use on climate change opinion, knowledge, and behavior. *Oxford Research Encyclopedia of Climate Science*, Retrieved 2 March, 2020, from https://oxfordre.com/climatescience/view/10.1093/acrefore/9780190228620.001.0001/acrefore-9780190228620-e-369 doi:10.1093/acrefore/9780190228620.013.369.

Andi, S. (2020). How People Access News about Climate Change. *Digital News Report*. Oxford: Reuters Institute for the Study of Journalism. Retrieved 5 March, 2020, from https://www.digitalnewsreport.org/survey/2020/how-people-access-news-about-climate-change/

Araujo, T., & van der Meer, T. G. (2020). News values on social media: Exploring what drives peaks in user activity about organizations on twitter. *Journalism*, *21*(5), 633–651. doi:10.1177/1464884918809299

Borges-Rey, E. (2015). News Images on Instagram. *Digital Journalism*, *3*(4), 571–593. doi:10.1080/21670811.2015.1034526

Bostrom, A., Morgan, M. G., Fischhoff, B., & Read, D. (1994). What do people know about global climate change? 1. Mental models. *Risk Analysis*, *14*(6), 959–970. doi:10.1111/j.1539-6924.1994.tb00065.x

Buijs, A. E., Elands, B. H., & Langers, F. (2009). No wilderness for immigrants: Cultural differences in images of nature and landscape preferences. *Landscape and Urban Planning*, *91*(3), 113–123. doi:10.1016/j.landurbplan.2008.12.003

Caple, H., & Bednarek, M. (2013). *Delving into the discourse: Approaches to news values in journalism studies and beyond*. Reuters Institute for the Study of Journalism. Retrieved 2 November, 2021 from https://reutersinstitute.politics.ox.ac.uk/our-research/delving-discourse-approaches-news-values-journalism-studies-and-beyond

Carlson, J. M., Kaull, H., Steinhauer, M., Zigarac, A., & Cammarata, J. (2020). Paying attention to climate change: Positive images of climate change solutions capture attention. *Journal of Environmental Psychology*, *71*, 101477. doi:10.1016/j.jenvp.2020.101477

Carvalho, A. (2010). Media(ted) discourses and climate change. A focus on political subjectivity and (dis)engagement. *WIREs Climate Change*, *1*(2), 172–179. doi:10.1002/wcc.13

Chaiken, S., Liberman, A., & Eagly, A. (1989). Heuristic and systematic information processing within and beyond the persuasion context. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 212–252). New York: The Guilford Press.

Chapman, D. A., Corner, A., Webster, R., & Markowitz, E. M. (2016). Climate visuals: A mixed methods investigation of public perceptions of climate images in three countries. *Global Environmental Change*, *41*, 172–182. doi:10.1016/j.gloenvcha.2016.10.003

Climate Change Visuals. (2018). The 7 Climate Visuals principles. Retrieved 20 March, 2022, from https://climateoutreach.org/reports/climate-visuals-seven-principles-for-visual-climate-change-communication/

Dahlstrom, M. F. (2014). Using narratives and storytelling to communicate science with nonexpert audiences. *Proceedings of the National Academy of Sciences*, *111*(Supplement 4), 13614–13620. doi:10.1073/pnas.1320645111

De Maeyer, J. (2020). A nose for news": from (news)Values to valuation. *Sociologica*, *1*(2), 109–132. doi:10.6092/issn.1971-8853/11176

Derygina, T., & Schurchkov, O. (2016). The effect of information provision on public consensus about climate change. *PLoS ONE*, *11*(4), e0151469. doi:10.1371/journal.pone.0151469

DiFrancesco, D. A., & Young, N. (2011). Seeing climate change: The visual construction of global warming in Canadian national print media. *Cultural Geographies*, *18*(4), 517–536. doi:10.1177/1474474010382072

Duan, R., Takahashi, B., & Zwickle, A. (2019). Abstract or concrete? The effect of climate change images on people's estimation of egocentric psychological distance. *Public Understanding of Science*, *28*(7), 828–844. doi:10.1177/0963662519865982

Few, R., Brown, K., & Tompkins, E. (2007). Public participation and climate change adaptation: Avoiding the illusion of inclusion. *Climate Policy*, *7*(1), 46–59. doi:10.1080/14693062.2007.9685637

Forster, E. (1983). *Aspectos de la novela*. Debate.

Galtung, J., & Ruge, M. (1965). The Structure of Foreign News: the presentation of the Congo, Cuba and Cyprus crises in four Norwegian newspapers. *Journal of International Peace Research*, *1*(1), 64–91. doi:10.1177/002234336500200104

García-Perdomo, V., Salaverría, R., Kilgo, D. K., & Harlow, S. (2018). To share or Not to share: The influence of news values and topics on popular social media content in the United States, Brazil, and Argentina. *Journalism Studies*, *19*(8), 1180–1201. doi:10.1080/1461670X.2016.1265896

Geiger, N., Swim, J. K., & Fraser, J. (2017). Creating a climate for change: Interventions, efficacy and public discussion about climate change. *Journal of Environmental Psychology*, *51*, 104–116. doi:10.1016/j.jenvp.2017.03.010

Gifford, R. (2008). Psychology's essential role in alleviating the impacts of climate change. *Canadian Psychology*, *49*(4), 273–280. doi:10.1037/a0013234

Gil de Zúñiga, H., Jung, N., & Valenzuela, S. (2012). Social Media Use for News and individuals' social capital, Civic Engagement and Political participation. *Journal of Computer-Mediated Communication*, *17*(3), 319–336. doi:10.1111/j.1083-6101.2012.01574.x

Harcup, T., & O'Neill, M. (2017). What is news? News values revisited (again). *Journalism Studies*, *18*(12), 1470–1488. doi:10.1080/1461670X.2016.1150193

Hulme, M. (2004). Pictures, scenarios or probabilities: How should we portray dangerous climate change? Proceedings of the conference perspectives on Dangerous climate change. UEA-Norwich, 28-29 June. Retrieved 5 November, 2021 from https://www.researchgate.net/publication/239925560_Pictures_Scenarios_or_Probabilities_How_Should_We_Portray_Dangerous_Climate_Change

IPCC. (2021). AR6 Climate Change 2021: The Physical Science Basis. Retrieved 5 November, 2021, from https://www.ipcc.ch/report/ar6/wg1/

Jenner, E. (2012). News Photographs and Environmental Agenda setting. *Policy Studies Journal*, *40*(2), 274–301. doi:10.1111/j.1541-0072.2012.00453.x

Joffe, H. (2008). The Power of Visual Material: persuasion, emotion and identification. *Diogenes*, *55*(1), 84–93. doi:10.1177/0392192107087919

Kahneman, D., Slovic, P., & Tversky, A. (eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge Univ. Press.

Keib, K., Espina, C., Lee, Y., Wojdynski, B. W., Choi, D., & Bang, H. (2018). Picture This: The Influence of Emotionally Valenced Images, On Attention, selection, and Sharing of Social Media news. *Media Psychology*, *21*(2), 202–221. doi:10.1080/15213269.2017.1378108

Leiserowitz, A. (2004). Surveying the impact of "the day after tomorrow". *Environment*, *46*(9), 23–44. doi:10.1080/00139150409603663

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: The role of affect, imagery and values. *Climatic Change*, *77*(1-2), 45–72. doi:10.1007/s10584-006-9059-9

León, B., & Erviti, M. C. (2015). Science in pictures: Visual representation of climate change in Spain's television news. *Public Understanding of Science*, *24*(2), 183–199. doi:10.1177/0963662513500196

Lester, L., & Cottle, S. (2009). Visualizing climate change: Television news and ecological citizenship. *International Journal of Communication*, 3, 920–936.

Lewenstein, B., & Brossard, D. (2006). *Assessing models of public understanding in ELSI outreach materials: Final report*. Cornell University. Retrieved October 28, 2021, from https://ecommons.cornell.edu/handle/1813/5242

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, 127(2), 267. doi:10.1037/0033-2909.127.2.267

Lorenzoni, I., Nicholson-Cole, S., & Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change*, 17(3-4), 445–459. doi:10.1016/j.gloenvcha.2007.01.004

Lorenzoni, I., & Pidgeon, N. F. (2006). Public views on climate change: European and USA perspectives. *Climatic Change*, 77(1-2), 73–95. doi:10.1007/s10584-006-9072-z

Maess, A. (2017). The visual divide. *Nature Climate Change*, 7(4), 231–233. doi:10.1038/nclimate3251

Marx, S. M., Weber, E. U., Orlove, B. S., Leiserowitz, A., Krantz, D. H., Roncoli, C., & Phillips, J. (2007). Communication and mental processes: Experiential and analytic processing of uncertain climate information. *Global Environmental Change*, 17(1), 47–58. doi:10.1016/j.gloenvcha.2006.10.004

Mavrodieva, A. V., Rachman, O. K., Harahap, V. B., & Shaw, R. (2019). Role of social media as a soft power tool in raising public awareness and engagement in addressing climate change. *Climate*, 7(10), 122. doi:10.3390/cli7100122

Mazur, A., & Lee, J. (1993). Sounding the global alarm: Environmental issues in the US national news. *Social Studies of Science*, 23(4), 681–720. doi:10.1177/030631293023004003

McCright, A. M., & Dunlap, R. E. (2003). Defeating kyoto. The conservative movement's impact on US climate change policy. *Social Problems*, 50(3), 348–373. doi:10.1525/sp.2003.50.3.348

Metag, J., Schäfer, M. S., Füchslin, T., Barsuhn, T., & Kleinen-von Königslöw, K. (2016). Perceptions of climate change imagery: Evoked salience and self-efficacy in Germany, Switzerland, and Austria. *Science Communication*, 38(2), 197–227. doi:10.1177/1075547016635181

Moser, S. C. (2010). Communicating climate change: History, challenges, process and future directions. *Wiley Interdisciplinary Reviews: Climate Change*, 1(1), 31–53. doi:10.1002/wcc.11

Moser, S. C. (2016). Reflections on climate change communication research and practice in the second decade of the 21st century: What more is there to say? *Wiley Interdisciplinary Reviews: Climate Change*, 7(3), 345–369. doi:10.1002/wcc.403

Muñoz Torres, J. R. (1996). *El interés informativo*. Fragua.

Neuman, W., Guggenheim, L., Mo Jang, S., & Bae, S. Y. (2014). The dynamics of public attention: Agenda setting theory meets big data. *Journal of Communication*, 64(2), 193–214. doi:10.1111/jcom.12088

Newman, N., Fletcher, R., Schulz, A., Andi, S., Robertson, C. T., & Nielsen, R. K. (2021). *Digital News report*. Reuters Institute for the Study of Journalism. Retrieved 22 March, 2022, from https://reutersinstitute.politics.ox.ac.uk/sites/default/files/2021-06/Digital_News_Report_2021_FINAL.pdf

Nisbet, M. C. (2009). Communicating climate change: Why frames matter for public engagement. *Environment*, 51(2), 12–13. doi:10.3200/ENVT.51.2.12-23

Olesen, T. (2020). Greta Thunberg's iconicity: Performance and co-performance in the social media ecology. *New Media & Society*, 1461444820975416. doi:10.1177/1461444820975416

Olteanu, A., Castillo, C., Diakopoulos, N., & Aberer, K. (2015). Comparing events coverage in online news and social media: The case of climate change. Proceedings of 9th International AAAI Conference on Web and social media, May 26-29, 288–297.

O'Neill, D., & Harcup, T. (2020). News values and news selection. In K. Wahl-Jorgensen, & T. Hanitzsch (Eds.), *Handbook of journalism studies* (2nd ed., pp. 213–228). Routledge. doi:10.4324/9781315167497-14.

O'Neill, S. (2017). Engaging with climate change imagery. *Oxford Research Encyclopedia of Climate Science*, Retrieved 10 March, 2020, from https://oxfordre.com/climatescience/view/10.1093/acrefore/9780190228620.001.0001/acrefore-9780190228620-e-371 doi:10.1093/acrefore/9780190228620.013.371.

O'Neill, S., & Nicholson-Cole, S. (2009). Fear won't do it": promoting positive engagement with climate change through visual and iconic representations. *Science Communication*, 30(3), 355–379. doi:10.1177/1075547008329201

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

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

Painter, J. (2013). *Climate change in the media: Reporting risk and uncertainty*. Reuters Institute for the Study of Journalism. doi:10.5040/9780755694525.

Painter, J., Erviti, M. C., Fletcher, R., Howarth, C., Kristiansen, S., León, B., & Schäfer, M. S. (2016). *Something old, something new: Digital media and the coverage of climate change*. Reuters Institute for the Study of Journalism.

Painter, J., Kristiansen, S., & Schäfer, M. S. (2018). How 'digital-born' media cover climate change in comparison to legacy media: A case study of the COP 21 summit in Paris. *Global Environmental Change*, 48, 1–10. doi:10.1016/j.gloenvcha.2017.11.003

Paulussen, S., & Van Aelst, P. (2021). News values in audience-oriented journalism: Criteria, angles, and cues of Newsworthiness in the (Digital) media context. In *News values from an audience perspective* (pp. 37–55). Palgrave Macmillan. doi:10.1007/978-3-030-45046-5_3.

Pearce, W., Niederer, S., Özkula, S. M., & Sánchez Querubín, N. (2019). The social media life of climate change: Platforms, publics, and future imaginaries. *Wiley Interdisciplinary Reviews: Climate Change*, 10(2), e569. doi:10.1002/wcc.569

Petra, L. (1993). *Imágenes y metáforas de la ciencia*. Alianza.

Pew Research Center. (2021). "Gen Z, Millennials Stand Out for Climate Change Activism, Social Media Engagement With Issue". Retrieved 10 November, 2021, from https://www.pewresearch.org/science/2021/05/26/climate-engagement-and-activism/

Pidgeon, N. (2012). Public understanding of, and attitudes to, climate change: UK and international perspectives and policy. *Climate Policy*, *12*(Suppl. 01), S85–S106. doi:10.1080/14693062.2012.702982

Schäfer, M. S., & Schlichting, I. (2014). Media representations of climate change: A meta-analysis of the research field. *Environmental Communication*, *8*(2), 142–160. doi:10.1080/17524032.2014.914050

Segerberg, A. (2017). Online and social media campaigns for climate change engagement. *Oxford Research Encyclopedia of Climate Science*, Retrieved 12 March, 2020, from https://oxfordre.com/climatescience/view/10.1093/acrefore/9780190228620.001.0001/acrefore-9780190228620-e-398 doi:10.1093/acrefore/9780190228620.013.398.

Shoemaker, P. J., & Reese, S. D. (2013). *Mediating the message in the 21ˢᵗ century: A media sociology perspective*. Routledge. doi:10.4324/9780203930434.

Smith, N. W., & Joffe, H. (2009). Climate change in the British press: The role of the visual. *Journal of Risk Research*, *12*(5), 647–663. doi:10.1080/13669870802586512

Spence, A., Poortinga, W., & Pidgeon, N. (2012). The psychological distance of climate change. *Risk Analysis*, *32*(6), 957–972. doi:10.1111/j.1539-6924.2011.01695.x

Sunstein, C. R. (2006). The availability heuristic, intuitive cost-benefit analysis, and climate change. *Climatic Change*, *77*(1–2), 195–210. doi:10.2139/ssrn.844444

Temmerman, M., & Mast, J. (2021). *News values from an audience perspective*. Palgrave Macmillan. doi:10.1007/978-3-030-45046-5.

Treen, K. M., Williams, H. T., & O'Neill, S. J. (2020). Online misinformation about climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(5), e665. doi:10.1002/wcc.665

Trilling, D., Tolochko, P., & Burscher, B. (2017). From newsworthiness to shareworthiness: How to predict news sharing based on article characteristics. *Journalism & Mass Communication Quarterly*, *94*(1), 38–60. doi:10.1177/1077699016654682

Ungar, S. (2007). Public scares: Changing the issue culture. In S. C. Moser, & L. Dilling (Eds.), *Creating a climate for change: Communicating climate change and facilitating social change* (pp. 82–89). Cambridge University Press. doi:10.1017/CBO9780511535871.007.

Vlek, C. (2000). Essential psychology for environmental policy making. *International Journal of Psychology*, *35*(2), 153–167. doi:10.1080/002075900399457

Vraga, E. K., Anderson, A. A., Kotcher, J. E., & Maibach, E. W. (2015). Issue-specific engagement: How Facebook contributes to opinion leadership and efficacy on energy and climate issues. *Journal of Information Technology & Politics*, *12*(2), 200–218. doi: 10.1080/19331681.2015.1034910

Weber, E. U. (2016). What shapes perceptions of climate change? New research since 2010. *Wiley Interdisciplinary Reviews: Climate Change*, *7*(1), 125–134. doi: 10.1002/wcc.377

Weber, E. U., & Stern, P. C. (2011). Public understanding of climate change in the United States. *American Psychologist*, *66*(4), 315. doi:10.1037/a0023253

Whitmarsh, L., O'Neill, S., & Lorenzoni, I. (2013). Public engagement with climate change: What do we know, and where do we go from here? *International Journal of Media and Cultural Politics*, *9*(1), 7–25. doi:10.1386/macp.9.1.7_1

Wilkinson, K. M., O'Neill Zimmerman, T., & Light, J. (2021). Visual attention to Cued Targets in Simulated Aided Augmentative and Alternative Communication Displays for Individuals With Intellectual and Developmental disabilities. *Journal of Speech, Language, and Hearing Research*, *64*(5), 1726–1738. doi:10.1044/2021_JSLHR-20-00451

Zhang, N., & Skoric, M. M. (2018). Media use and environmental engagement: Examining differential gains from news media and social media. *International Journal of Communication*, *12*, 380–403.

Zolkepli, I. A., & Kamarulzaman, Y. (2015). Social media adoption: The role of media needs and innovation characteristics. *Computers in Human Behavior*, *43*, 189–209. doi:10.1016/j.chb.2014.10.050