

5-2021

Climate Change Frames and Emotional Responses on Reddit

Isabel Iruani Villanueva
University of Arkansas, Fayetteville

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Villanueva, I. I. (2021). Climate Change Frames and Emotional Responses on Reddit. *Graduate Theses and Dissertations* Retrieved from <https://scholarworks.uark.edu/etd/4076>

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Climate Change Frames and Emotional Responses on Reddit

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Communication

by

Isabel Iruani Villanueva
Cornell University
Bachelor of Arts in Science & Technology Studies, 2017

May 2021
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

Myria Allen, Ph.D.
Thesis Director

Ron Warren, Ph.D.
Committee Member

Stephanie Schulte, Ph.D.
Committee Member

Abstract

Climate change remains a highly polarized topic in the United States. Research suggests that the divide in climate change beliefs is partly a result of news media's representation of select aspects of the problem, or framing. Frames influence individuals' attitudes, emotions, and behaviors towards climate change. Overwhelming representation of certain climate change frames has led to a lack of emotional connection to the issue, resulting in inaction or dismissal. Climate change researchers have investigated the presence and effects of frames on both news media and select social media sites, particularly Twitter. However, little research has investigated the climate change conversation on other social media sites, such as Reddit. Reddit is a community-based social media site whose users represent a unique demographic in the United States. Reddit users rely heavily on Reddit for news and are highly engaged with the site. Unlike Twitter, Reddit does not have a small character limit on posts, allowing for longer conversation and a potential for greater peer influence. Using both human coders and computer-aided textual analysis, this thesis investigated which climate change frames are the most popular on Reddit and which emotions appear most frequently in the discussion sections of those posts. This study sampled posts from six subreddits that represent a range of climate change stances. The data found that political/ideological struggle was the most common frame and that anger was the most expressed emotion. Further results and implications are discussed.

Key words: climate change, framing, emotion, social media, Affective Intelligence

Theory

Acknowledgements

First, I would like to thank my thesis chair, Dr. Myria Allen, for her help and patience throughout this process. You have been an incredible mentor during this project, and I know I have grown as a scholar with your guidance. I would also like to thank my committee members, Dr. Ron Warren and Dr. Stephanie Schulte for their support and encouragement as this project took shape over the past year and a half.

I would like acknowledge the coders for this project – Dani Scoles, Sam Buchanan, and Jake Pedersen – for their overwhelming amount of patience as we worked through the codebook and for meeting with me for training over winter break.

Last, but definitely not least, I would like to thank my family. Tyler, you have been the most amazing pillar of support during this entire project and I could not have done it without you. From reading sections of this paper multiple times to listening to my ramblings about Reddit, you have been my biggest support in this and in life. To my parents, brothers, and sisters, thank you for reminding me to keep things fun and exciting. I love you all!

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Chapter 1

Introduction

The 2019 United Nations Climate Action Summit took place September 21st-23rd, 2019. The event, called by UN Secretary General Antonio Guterres of Portugal, was to be a platform for world leaders to come together to face the climate crisis and present their plans for carbon emissions reduction (Rosane, 2019). The goal for the summit was to reduce global carbon emissions by 45 percent and reach net zero emissions by 2050, in an attempt to limit mean temperatures around the world from rising 1.5°C. To this end, 65 countries announced their next steps towards net zero emissions, with notable exceptions such as the United States, China, and India (Sengupta & Friedman, 2019). The summit is a significant event to study because it demonstrated to a global audience how individual nations are collectively confronting the looming shared threat of climate change. The decisions made at the summit have significant consequences for the creation and enforcement of climate change mitigation policies in countries around the world.

While the results of the 2019 UN Climate Action Summit were disappointing to many climate activists, the event received a substantial amount of attention from the media and the public, particularly as a result of Greta Thunberg's speech. On August 28th, 2019, after a 15-day and 4000-mile journey overseas, Thunberg arrived in Lower Manhattan. Hundreds of people lined the streets to greet the then 16-year-old environmental activist as she arrived from Plymouth, England to attend the summit (Law, 2019). On September 23rd, she would go on to give one of the most highlighted speeches of the event, asking world leaders - "How dare you?" (Piven, 2019).

Coverage of climate change news is event driven (Boykoff & Boykoff, 2007) and Thunberg's speech was one such catalyst. Attention to climate change and Thunberg spiked

across social media platforms on the days surrounding this event. Posts on Reddit mentioning the term “climate change” spiked significantly on September 23rd, reaching upwards of 4,500 unique posts in one day. According to Jung, Petkanic, Nan, and Kim (2020), tweets containing the query “Greta Thunberg” peaked on the day of her speech, reaching over 150,000. #Howdareyou trended on Twitter on September 23rd with over 100,000 tweets using the hashtag just in the United States (getdaytrends, 2020). On YouTube, two videos of Thunberg’s speech reached a combined 7.4 million views (PBS News Hour, 2019; Sky News, 2019).

As social media increasingly become an integral part of our lives, the dissemination of climate change messages through social media platforms has important implications. Social media platforms are important tools for advocacy, activism, protesting and presenting the salient issues in climate science for everyday users (Kim & Cooke, 2018). Many young individuals receive their news from social media (Shearer & Grieco, 2019) and social media platforms allow individuals to post almost anything without filtering through the mass media’s traditional gatekeepers (Pearce et al., 2018). Individuals tend to view, share, and trust information they find on social media more than information they receive from official sources (Nielsen, 2015). As a result, individuals can influence each other through daily online conversations, particularly when it comes to controversial issues such as climate change (Williams et al., 2015).

Climate change researchers have looked extensively at the source and content of climate change messages occurring on social media platforms, particularly Twitter (Pearce et al., 2018) partly due to its functions such as geotagging, time stamps, hashtags, retweets, etc., (Newman, 2016). In a meta-analysis of climate change communication research, Pearce and colleagues (2018) found that social media climate change content 1) continues to be influenced by a select few mass media sources and influential users, 2) mostly approaches climate science as a

certainty, 3) remains polarized into like-minded communities, and 4) increases in response to temperature anomalies. Researching the posting and discussion trends on social media is a method of understanding the transmission of climate change information and the general public's view on the topic (Pearce et al., 2018).

Significant gaps persist in social media related climate change communication research. For instance, much social media research is focused on Twitter, with limited research on other platforms (Pearce et al., 2018). However, social media platforms all differ in terms of content, user demographic, and functionality. Research is needed on platforms that allow for longer conversational opportunities, as opposed to the 280-character limit imposed on Twitter (Pearce et al., 2018). Reddit is a conversational and participatory social media platform, that engages millions of people around the world. Reddit serves as a primary news source for its users, who, while representing a specific demographic, are more engaged with news than users of other social media platforms.

This study expands climate change communication research by conducting a content analysis of top climate change posts on Reddit, investigating the climate change-related frames (or the emphasis placed on a particular aspect of an issue), appearing in the posts, and analyzing the emotional response from the audience in the discussion sections of these posts. This study will help further the understanding of which frames are most popular on Reddit. It will also explore the emotions present in the discussion sections of the posts, as emotional responses to climate change stories have important implications for climate change attitudes and policy support. The next section discusses Reddit as an appropriate research site, provides an overview of the premise Reddit, and describes its userbase. Then this chapter will discuss framing and emotions, ending with a list of the study's RQs.

Reddit

With over 430 million active users and billions of page-views a month, Reddit is a fruitful source of data for researchers (Amaya et al., 2019). Around 22% of American adults aged 18-29 and 14% of adults aged 30-49 use Reddit (Tankovska, 2021), and 70% of those users use it as their primary source of news (Balther et al., 2016). Redditors spend more time on the site and are more engaged with the content they see than are users of other social media sites (Kemp, 2019). Additionally, as opposed to other social media platforms, Reddit does not generally impose a character limit on their posts and comments. This provides researchers an opportunity for more in-depth text-based analysis of posts and comments. Reddit is also unique because of users' anonymity (Kilgo et al., 2018; Willet & Carpenter, 2020). Due to a "online disinhibition effect" (Kilgo et al., 2018, p. 2), anonymous users can create supportive online communities to discuss otherwise sensitive topics. However, this lack of accountability may also lead to trolling, misogyny, and toxic communities (Zannettou et al., 2018).

The basic premise of Reddit begins with the concept of subreddits. Reddit users, or Redditors, can create communities based on any topic, broad or narrow (Choi et al., 2015). For instance, popular subreddits can be as broad as /r/worldnews or as narrow as /r/gameofthrones. Redditors can join, follow, and post to established communities, which are denoted by '/r/' (Suran & Kilgo, 2017). Overall, there are over 138,000 communities (Amaya et al., 2019). These thousands of communities on Reddit may act as discussions forums, news aggregators, or even as support groups for illnesses or addiction (Julien, 2019). Each subreddit has its own set of rules that determine the medium of the post, the content of the post, and even which users can post. Depending on the subreddit, users can post user-generated content (UGC) or user-selected content (USC), content shared from other internet sites, such as news articles (Neuendorf, 2017).

Due to the wide array of subreddits and their varying rules, it is difficult to characterize Reddit as any one type of social media site.

Due to the nature of its users and their higher engagement with the news, Reddit is an important research site to explore. Reddit user demographics are not representative of the general United States population. They tend to be male, young, white, liberal and heavy internet users (Barthel et al., 2016; Straub-Cook, 2018). Additionally, active contributors tend to be older than the average Reddit user, have strong personalities, and be more engaged with news stories (Kilgo et al., 2018). Because of the “heavy emphasis placed on dissemination and discussion of news,” Reddit provides researchers an insight into those who value news exchange and discuss information (Straub-Cook, 2018, p.1317), especially when it comes to controversial social issues such as climate change.

The next section will introduce framing theory (Entman, 1993) and its application to climate change. Then, it will introduce the frames that are used in this study, with a brief definition of each.

Framing

Framing theory (Entman, 1993) plays an important role in this study, which seeks to identify the climate change frames appearing in Reddit posts. A major factor in how messages are perceived by an audience depends on how they are framed, or the emphasis placed on a particular aspect of an issue (Entman, 1993), which help audiences interpret and make sense of events (Nabi et al., 2018). Climate change frames contribute to how individuals perceive climate change by focusing on specific aspects of the climate change discussion, such as the health and economic consequences of pursuing mitigation policies (Maibach et al., 2010) or the morality of climate change mitigation (Markowitz, 2012). Climate change frames are powerful, as they can

increase awareness or potentially lead to inaction or apathy (Bord, et al., 2000). Communication researchers have studied climate change framing as a potential way to understand the gap between climate change believers and skeptics (Nisbet, 2009).

Some consistent frames have been identified in past research. O'Neill and colleagues (2015) conducted a study on the frames found in Twitter and traditional media surrounding the release of the Intergovernmental Panel on Climate Change (IPCC) report in 2014. O'Neill et al. (2015) developed a list of climate change frames found in social media and traditional media which other researchers have since used (e.g., Kim & Cooke, 2018; Painter et al., 2018; Roxburgh et al., 2019). These frames include settled science, uncertain science, political or ideological struggle, disaster, opportunity, economic, morality and ethics, the role of science, security, and health. The *settled science* frame focuses on the scientific and expert consensus on the realities of climate change, while the *uncertain science* frame questions the anthropogenic nature of climate change and the uncertainty of climate science. The *political/ideological struggle frame* focuses on the conflicting strategies for addressing climate change and finding appropriate policy solutions. The *disaster* frame emphasizes the catastrophic consequences of climate change on the environment. The *opportunity* frame is used to discuss the potential innovations that may benefit humankind while addressing climate change. It could also be used to discuss the positive impacts of climate change on the world even if no actions are taken. The *economic* frame focuses on the potential economic actions that can be taken to mitigate climate change or the economic consequences of acting. The *morality and ethics* frame is a call to action or inaction in order to protect the vulnerable.

The *role of science* frame emphasizes the process of climate science and the public's understanding of climate change, without focusing on the debate around evidence. *Security*,

similar to *disaster*, focuses on the consequences of climate change. However, *security* looks at the threat of climate change on human livelihood, such as diminishing food/water security. Lastly, the *health* frame highlights the effects of climate change on human's health such as increases in malnutrition and insect-borne diseases. Subsequent researchers have added additional context-specific and time-sensitive frames to this scheme, such as *promotion/piggybacking* (i.e., climate change is used to promote tangential events or people; Fellenor et al., 2017), *extremes* (i.e., discussion revolves around the weather extremes that occur as a result of climate change; Roxburgh et al., 2019), and *engagement/empowerment* (i.e., emphasis on small-scale action; Kim & Cooke, 2018).

The same frame can appear differently depending on the partisan orientation of the message designer. For example, in terms of Thunberg's statement "How dare you", the statement seems to showcase the *morality and ethics* frame identified by O'Neill et al., (2015), as it is an urgent call to world leaders for action to protect the vulnerable. If used by climate change skeptics, frames such as the *morality and ethics* frame can also be used as a plea for no action to be taken (O'Neill et al., 2015). Similarly, Republican politicians use the *economic* argument that climate change action will harm the economy (Bidwell, 2016). Meanwhile, others have suggested using the *economic* frame to elaborate on the potential of renewable energy for the job market (Li & Su, 2018).

Social media exacerbate the partisan divide surrounding climate change discussions (Stroud, 2011; Jang, 2014). Social media users utilize the same polarized frames found in partisan news, indicating that opinions are simply reinforced when users turn to social media (Jang & Hart, 2015). This is especially true if users enter politically homogenous groups, such as political subreddits. With time, interactions with like-minded individuals lead to further

entrenched opinions (Colleoni et al., 2014). Therefore, it is reasonable to believe that posts on Reddit, a site whose users are more engaged with news than other social media sites (Kemp, 2019), would be heavily influenced by and repeat the frames appearing in traditional media. Understanding which frames appear in social media, such as in ideologically homogenous Reddit communities, is an important part to understanding the polarization of climate change communication. In this study I compare the climate change frames identified by O’Neill et al. (2015), Fellenor et al. (2017), and Kim and Cooke (2018) and appearing in 3 types of subreddit communities – climate believers, climate skeptics, and ideologically neutral – in order to identify difference in preferred frames. In climate change discussions, users often split into “skeptical” and “activist” groups (Jones-Jang et al., 2019; Williams et al., 2015). This is true on Reddit as well, where even the names of the subreddits are labeled as “climate skeptics” and “climate change.”

Frames affect individuals’ attitudes and behaviors, but also their emotional response to a message. This study investigates how individuals on Reddit respond emotionally in the discussion sections of the posts. The next section introduces emotions and the Affective Intelligence Theory as a theoretical foundation to this study.

Emotion

Studies have found that frames not only alter how the audience interprets messages, but how the audience responds to these messages emotionally (e.g., Leviston et al., 2014; O’Neill et al., 2013; O’Neill, & Nicholson-Cole, 2009). In turn, emotional responses to stories have consequences for subsequent attitudes and behaviors. For instance, Meijnders, Midden, and Wilke (2001) found that negative emotions can lead to greater processing of climate change information and therefore, more attention to the risks and greater support of policies. Fear and anger appear to be correlated with greater support for climate change mitigation policies (Lu &

Schuldt, 2015; Smith & Leiserowitz, 2014), but hope also can play a role (Feldman & Hart, 2018).

To understand the processes through which frames affect emotional responses to Reddit posts, this study draws from the Affective Intelligence Theory (AIT). AIT suggests that there are two paths which the brain takes to influence judgement and behavior, both of which are regulated by discrete emotions (Marcus et al., 2000). The first path is the disposition system, and the second is the surveillance system. The disposition system, regulated by anger and enthusiasm, is associated with the development of heuristics and behavioral routines. Anger can lead to greater polarization and avoidance of opposing political views (Song, 2017). On the other hand, the surveillance system encourages thinking, information seeking, and effortful processing. MacKuen et al. (2010) found that fear and hope, which activate the surveillance system, encouraged political compromise because people did not rely on their habits and pre-existing beliefs. Hope was found to lead to the consideration of compromise.

This study investigates emotional responses to climate change story frames appearing in the discussion sections of each Reddit post using computer-aided textual analysis.

Purpose

The purpose of this study is twofold. The first goal is to identify the climate change frames appearing in the top posts on Reddit for two months before and two months following the 2019 UN Climate Action Summit. The second goal is to examine the emotions displayed in the discussion sections of these posts.

In light of the first goal, top posts were identified as those which result in most engagement through likes and comments. I used the climate change frames based on O'Neill et al.'s (2015) study of the frames surrounding the release of the IPCC report in 2014. Human

coders categorized Reddit posts into the aforementioned framing categories to understand the distribution of frames around the 2019 UN Climate Action Summit. Frames were identified overall and by subreddit. Six subreddits were selected because they represent the spectrum of climate change opinions. They are classified into 3 groups – climate believers, climate skeptic, and neutral.

The second part of the study investigated the emotional responses of users in the discussion sections generally, by subreddit, and by the predominant frame appearing in each post. AIT posits that emotional responses to information can influence individuals' attitudes and behaviors (Marcus et al., 2000), including social media posting behaviors (Heiss, 2020). Drawing from previous research on affect, climate change opinions and social media expression, this paper investigates the appearance of anger, anxiety, and hope emotions in the discussion sections of climate change posts generally and depending on the post's frame and the specific subreddit.

Drawing from Entman's (1993) framing theory and the Affective Intelligence Theory (Marcus et al., 2000), this study investigated the frames in top posts two months prior to and two months following the 2019 Climate Action Summit and the emotions represented in the comments sections for these posts. The following research questions are proposed:

RQ1: What is the distribution of climate change frames surrounding the 2019 UN Climate Change Action Summit?

RQ2: Do climate change frames differ depending on the subreddit (i.e., neutral, climate change believers, climate change skeptics)?

RQ3: Which of the three emotions (i.e., anger, anxiety, and hope) appears most frequently in climate change post discussions surrounding the 2019 UN Climate Change Action Summit on Reddit?

RQ4: Is there a difference in emotions expressed in the discussion section depending on the predominant climate change frame appearing in the post?

RQ5: Do key emotions differ in the discussion section following the post depending on the subreddit (i.e., neutral, climate change believers, climate change skeptics)?

Chapter 2

Literature Review

This literature review synthesizes previous research on framing, intermedia framing, emotional responses to framing, and Reddit. The section begins by presenting a brief overview of framing theory, with a focus on Entman's (1993) conceptualization of framing and its application to the study of climate change. Next, the literature review describes the flow of frames between traditional media and social media. The paper next introduces frames in the context of climate change and presents O'Neill et al.'s (2015) climate change frames which serve as a basis for the study. Then, the section transitions to an overview of emotional responses to climate change frames, an introduction to Affective Intelligence Theory, and the role of emotion in social media engagement. The literature review then introduces Reddit as a potential site for research and delineates its advantages and disadvantages. Lastly, the research questions are posed.

Framing

For decades, researchers have found support for the idea that a simple change of phrasing can drastically alter people's opinion, a concept called "framing effects" (Chong & Druckman, 2007). Framing theory suggests that issues can be presented from a variety of perspectives and people reorganize their thinking about the issue in response (Chong & Druckman, 2007). Small changes in framing changes how individuals make sense of a message or situation which, in turn, alters the way they respond to the information. Framing theory serves as the theoretical foundation in this study's investigation of climate change frames on Reddit and the emotional responses to these frames.

Specific conceptualizations of framing have varied (Scheufele, 1999) with researchers using distinct definitions of framing that vary slightly (e.g., Hamill & Lodge, 1986; Wicks,

1992). Framing has been discussed alongside other terms such as schema, agenda setting, and priming (Iyengar & Kinger, 1987; McCombs et al., 1997). Lacking paradigmatic reference, researchers used context-specific conceptualizations and operationalizations of framing, “with much left to an assumed tacit understanding of reader and researcher” (Entman, 1993, p. 52). Without a standard definition or measurement of framing, framing research is filled with inconsistencies in the conceptualization and measurement of frames (Scheufele & Tewksbury, 2007).

In 1993, Entman called for the establishment of framing as a research paradigm. To this end, he defined framing as “to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described” (p. 52). By emphasis or repetition, frames can increase the importance of certain aspects of a text and cause individuals to ignore other aspects. This emphasis affects how individuals remember a problem and choose to act. According to Entman (1993), communicators use frames to emphasize the main problem, identify the causes of the problem, understand the effects of the problem, and lastly, provide potential solutions.

Frames are shaped and performed in multiple instances during the communication process (Entman, 1993) including by the communicator, in the communicating text, by the message receiver, and lastly by the cultural context. First, communicators decide which frames to use when delivering a message. In traditional media, journalists, politicians, organizations, and other elites use frames to “refine and present news events to the audience” (Wasike, 2011, p. 58). Gamson and Modigliani (1987) define media frames as “a central organizing idea or story line that provides meaning to an unfolding strip of events” (p. 143). Journalists actively set frames of

reference that readers or viewers use to interpret and discuss public events (Tuchman, 1978) by giving a story a “spin” (Neuman et al., 1992, p. 120). During the frame construction process, elite actors create and communicate competing frames to influence individuals’ views, attitudes, and behaviors on social issues (Benford & Snow, 2000; Scheufele & Tewksbury, 2007).

Second, in the communication text itself, frames appear as the “presence or absence of certain keywords, stock phrases, stereotyped images, sources of information, and sentences” that reinforce the communicators’ intent (Entman, 1993, p. 52). For instance, texts can make certain information more important with “placement or repetition, or by associating them with cultural familiar symbols” (Entman, 1993, p. 52). One such framing tool is figurative language such as metaphors, similes, and analogies (Tewksbury & Scheufele, 2019). “Figurative language can influence audience interpretations of an issue without explicitly presenting new information and arguments” (Tewksbury & Scheufele, 2019, p. 57). Additionally, as a text emphasizes certain aspects, it draws attention away from other aspects of the discussion.

Third is the message receivers’ own framing of the topic. What the receivers conclude about an issue and how the receivers frame the issue in their minds may not always reflect how the communicators intended to frame the message. Individuals interpret things according to their own perspectives, experiences, and social interactions (Neuman et al., 1992). Therefore, even if a text emphasizes a particular idea, it may be difficult for readers to engage with it if it is not part of their preexisting schema (Entman, 1993). One commonly cited moderator of framing effects is individual predisposition to values (Chong & Druckman, 2007). Individuals with strong values are less inclined to be influenced by frames that may contradict their preexisting beliefs on the issue. Another moderator is prior knowledge, though there are conflicting results (Chong & Druckman, 2007). On one hand, prior knowledge may increase entrenched attitudes and decrease

susceptibility to change. However, knowledgeable individuals may also be able to more deeply understand the position of the framed argument. While individuals may interpret frames differently, many frames have a “dominant meaning,” which is the aspect of a message that individuals are most likely to notice (Entman, 1993, p. 56).

Lastly, there is culture, which refers to the commonly used frames in a discourse depending on the place and the time (Entman, 1993). There is a “cultural stock of frames” (Van Gorp, 2007, p. 62) which is simultaneously “large and confining” (Tewksbury & Scheufele, 2019, p. 57). There are many available frames to choose from but if a communicator chooses a frame that is not culturally resonant, it is unlikely to be effective (Tewksbury & Scheufele, 2019).

Framing affects individuals’ attitudes and behaviors towards important social issues and influence how individuals discuss these issues with others. Many research experiments focus on the effects of a single frame on individuals’ attitudes (Chong & Druckman, 2007). However, individuals are exposed to a wide array of competing frames (Sniderman & Theriault, 2004). Chong and Druckman (2007) suggest that various moderators can reduce the effectiveness of frames in a competitive environment. The perceived strength of the frame can moderate framing effects – more credible sources are more likely to persuade individuals, as are frames that discuss longstanding cultural values. Lastly, Druckman & Nelson (2003) found that individuals who frequently engage in conversation with others with opposing views are less likely to be influenced by framing effects.

These studies have looked at the effects of competitive frames on individuals in a traditional media environment. However, this study uses a social media site, Reddit, as its research site. Reddit is a social media site that relies heavily on news for its posts and its users

are highly engaged with the news. Thus, the following section describes how traditional media framing influences framing on social media, the implications of intermedia framing on science communication, and how framing on social media affects individuals' perceptions of climate change.

Intermedia Framing and Frame Contagion

Previous research on frames has focused predominantly on frames appearing in traditional media but research on the connection between framing, traditional media, and social media is slowly emerging (e.g., Jang et al., 2016; Jones-Jang et al., 2019; Neuman et al., 2014; Wang & Guo, 2018). Although traditional media still often propel the conversation about socially important topics, there is an interdependence between the framing of topics in traditional media and social media, called the intermedia framing effect (Neuman et al., 2014; Wang & Guo, 2018). For instance, Guggenheim and colleagues (2015) found in their study on gun control, video games, and mental illness, that Twitter influenced traditional media frames at the beginning of the news cycle but the relationship was reversed towards the end of the news cycle. Jang et al.'s (2016) study on the framing of the ice bucket challenge on Twitter found a similar pattern. Additionally, Lo and colleagues (2019) found that audience comments on Facebook posts have the potential to influence traditional media frames.

The intermedia framing effect occurs with texts discussing science-based issues. Science communication has traditionally followed a top-down approach, from elites (e.g., politicians, journalists, etc.) to the general public (Jones-Jang et al., 2019). Social media can diversify the communication of science topics from top-down to a two-way communication where the public participates in the creation and dissemination of knowledge (Jones-Jang et al., 2019). For example, Jones-Jang et al. (2019) found that Twitter's influence in propelling certain climate

change frames is increasing. However, some researchers question if social media are truly diversifying communication pathways for science issues (Allgaier et al., 2013; Park, 2018) or simply reinforcing elite frames and increasing partisanship (Jang & Hart, 2015).

In discussions of controversial topics (e.g., climate change), studies are increasingly finding the latter – social media are reinforcing elite frames and attitudes are increasingly polarized (Bakshy et al., 2015; Bennett & Iyengar, 2008). Various reasons for the reinforcement of elite frames and opinion polarization exist. Polarized elite media frames simply “trickle down” into social media from the dominating elites to the general public (Jones-Jang et al., 2019). Then, social media users “tend to practice selective exposure and confirm their partisan opinions due to confirmation bias, homophily, and algorithmic decisions” (Bakshy et al., 2015; Jones-Jang et al., 2019, p. 4).

Regarding climate change, the elite media promote frames and social media receive and spread that information (Feldman et al., 2012). “As ordinary users are not expected to be capable of evaluating climate change information, it is more likely that climate change frames flow from top to bottom” (Jones-Jang et al., 2019, p. 5). However, the lack of gatekeepers on social media allow for diverse climate change opinions to spread quickly (Jang et al., 2019).

Frame contagion, or the spread of frames across traditional and social media boundaries has important implications for climate change discussions. Generally, climate change scientists would embrace the dispersion of climate change discussion through social media and elite news, as social media provide diverse and underrepresented voices in elite media an opportunity to create and disperse their own frames in the discussion (Jones-Jang et al., 2019). However, not all diversifying outcomes are positive. For instance, increases in hoax frame coverage (placing an emphasis on whether climate change is fake or real) and polarized climate change views lead to

decreased trust in scientists and the politicization of the environmental issue (Hart et al., 2015). Social media lack quality control of information which leads to an emphasis on inaccurate information that could reach the mainstream media and harm the reputation of the science community (Jones-Jang et al., 2019).

Climate Change and Framing

In this section, literature about the purpose of climate change frames in science communication, the effects of climate change frames on individuals' attitudes, and the development of previous climate changes frame typologies will be reviewed in order to build a case for the use of O'Neill et al.'s (2015) climate change frames for this study. A list of frames used and their definitions are provided.

Climate change communication research draws heavily on the concept of framing. Many individuals do not feel the direct impacts of climate change, making the issue relatively abstract and difficult to grasp (Nisbet, 2009). Therefore, climate change frames aid in the public's understanding of the definition, causes, and solutions of climate change and can be used as a potential tool for increasing awareness and encouraging engagement (Nisbet, 2009). Historically, climate change was framed as an environmental issue and later as a political issue (Myers et al., 2012). However, researchers found that alternative frames may be more effective in garnering public engagement and issue support. For instance, studies on climate change framing note that focusing on the economic, public health, national security, morality, and public accountability facets of the climate change discussion may lead to greater citizen engagement in discussions, and ultimately with policy (Nisbet, 2009; Nisbet & Scheufele, 2009; Maibach et al., 2010).

While certain frames can increase climate change engagement among the general public, other frames can have a "boomerang effect" (Myers et al., 2012) or lead to polarization.

Emphasizing specific frames, such as the uncertainty of climate science, can confuse the public about the realities of climate change (Bord et al., 2000) and in turn, halt climate change mitigation efforts (McCright & Dunlap, 2011). On a large scale, how media outlets frame climate change heavily influences national-level discussions (Boykoff, 2007; Shehata & Hopmann, 2012). In the United States, the media's conflicting presentation of climate change frames has led to polarization in climate change discussions (Merkley & Stecula, 2018). Specifically, greater emphasis on the uncertainty of climate science in the mass media is directly related to the public's polarized conversations around climate change (Merkley & Stecula, 2018).

Because framing theory is conceptually vague (Entman, 1993), studies have operationalized climate change frames in a variety of ways. For instance, in a study on climate change beliefs along the ideological spectrum, Singh and Swanson (2017) focused on human rights, environmental, and security frames. In a study on generating advocacy behavior, Nabi, Gustafson, and Jensen (2018) used gain/loss frames as their stimuli. Feldman and Hart (2018) studied the effects of public health, economy, national security, environment, morality and political conflicts frames on selective exposure to climate change news. Han, Sun, and Lu (2017) found that climate change news stories use conflict, attribution of responsibility, human interest, leadership, collaboration, and environmental and human impact frames. Additionally, and most importantly for this study, O'Neill et al. (2015) used settled science, political/ideological struggle, role of science, uncertain science, disaster, security, morality and ethics, opportunity, economic, and health frames in their study of traditional and social media news surrounding the release of an Intergovernmental Panel on Climate Change report in 2013. This study will use O'Neill et al.'s (2015) climate change frames because of the typologies' strong theoretical background and clear operationalization.

Entman's (1993) framing definition has been used by many scholars investigating climate change communication (e.g., Schäfer & O'Neill, 2017). In their work on climate change, O'Neill et al. (2015) used Entman's (1993) framing theory to develop a list of climate change frames found in social media and traditional media. Other researchers (e.g., Kim & Cooke, 2018; Painter, Kristiansen, & Schafer, 2018; Roxburgh et al., 2019) have since used O'Neill et al.'s (2015) framing typology. O'Neill et al. (2015) developed their coding typology by conducting a meta-analysis of previous climate change framing research, considering elite frames circulated by institutions and organizations, and incorporating non-elite frames from past research.

As a result of this process, O'Neill et al. (2015) identified 10 frames, the definitions of which are listed in Table 1. The *settled science* frame, which emphasizes the certainty of climate science, is distinguishable in text that includes phrases such as “greatest challenge of our time,” “what more proof do we need,” or the “unequivocal nature of climate change.” During the release of the 2014 IPCC report, both politicians and scientists used this frame to eliminate any skepticism and emphasize the need to act now. The *uncertain (and contested) science* frame uses phrases such as “mistakes,” describes scientists' behavior as silly or hysterical, or questions the anthropogenic nature of climate change. *Political/ideological struggle* focuses on the political struggle to address climate change, the conflict between political actors in finding solutions, and can also include details of policy. Scientists, organizations, and people affected by climate change use the *disaster* frame to discuss the consequences of ignoring climate change with phrases such as “immense risk” or “unnatural weather.” The *role of science* frame emphasizes aspects of the process of conducting science, including debates on the transparency of science, public opinion and knowledge, and media coverage of science. This frame uses “false balance” or “threats to free speech” as key words or may discuss how the media provides an unbalanced

amount of time to skeptics on the media. Military leaders, government officials, or NGOs may use the *security* frame to highlight the dangers of climate change on world peace, such as mass migrations, conflicts between nations, or loss of food/water/energy security. O’Neill et al.’s (2015) final frame is *health*. The *health* frame discusses the impacts of climate change on human health such as malnutrition or air pollution.

Some frames can be used to promote contrasting viewpoints. *Opportunity* is a frame that is recently emerging for climate change which can be interpreted in two ways. First, *opportunity* can mean that climate change presents people with a way to “re-imagine how we live” and to innovate solutions to address climate change and improve our lifestyle. On the other hand, *opportunity* can also serve as an argument for lack of action; letting climate change run its course will have beneficial impacts. The *economic* frame can also be used by individuals on either side of the climate change discussion. For instance, the *economic* frame can describe creating new green jobs and divesting from fossil fuel. However, the opposing side may use the *economic* frame to say that any mitigation action will “kill industry” and “damage economic growth”. The *morality and ethics* frame is similar. Religious and moral leaders can use it as an urgent call to action or as a call to inaction, including mentions of religion, God, and morality.

While O’Neill et al.’s (2015) frames provide a thorough coding typology from which to begin, many studies have expanded upon the typology with additional context-specific frames. For instance, Kim and Cooke (2018), in their study of climate change and ocean acidification tweets, added three additional frames to their coding typology – *promotion/piggybacking*, developed by Fellenor et al. (2018), *engagement/empowerment*, and *unknown*. In their study of Tweets during extreme weather events, Roxburgh et al. (2019) added the *extremes* frame which emphasizes the link between climate change and extreme weather. In this study, the

promotion/piggybacking and *unknown* categories were added to the initial list of 10 in the current study.

Table 1
Description of Frames

Frame	Description
Settled Science	Scientists and expert agree on the reality of climate change. There's enough evidence for action to take place. There is no uncertainty.
Uncertain (and Contested) Science	Emphasizes uncertainty in climate science, impacts, and solutions. Questions the anthropogenic nature of climate change and discusses the natural changes of temperature.
Political or Ideological Struggle	Conflicting strategies for addressing climate change between nations or persons.
Disaster	Climate change impacts will be catastrophic and threaten humanity.
Opportunity	Facing climate change could provide a chance for humankind to change how they live, for the better. Also, climate change will bring about positive impacts that will benefit us, so we need not act.
Economic	Focuses on the potential economic actions to mitigate climate change, such as divestment. Also focuses on the costly consequences of acting now.
Morality and Ethics	The moral, ethical, or religious reasons for the action or inaction. Such as protection of the vulnerable or uncertainty.
Role of Science	Explores the process of climate science and the public's understanding. Also, involves the journalists' role as the knowledge mediators.
Security	Climate change consequences could threaten human security, such as water or food security.
Health	Impacts of climate change directly affect human health such as through air quality, water quality, or food production.
Promotion/ Piggybacking	Climate change issues not discussed directly, emphasis is promotion of tangential issues/event/product
None/Unknown	Not enough information to identify frame
Words vs. Action/Hypocrisy (original frame)	Emphasizes the contradictory nature of climate change believers' words and their actions

Adapted from O'Neill et al. (2015) and Kim and Cooke (2018).

Previous work using a similar coding typology has captured a variety of frames as the most common, depending on the time and study site, either Twitter or traditional print media. For

instance, in their investigation of the frames appearing around the release of the 2014 IPCC report, O'Neill and colleagues (2015) found that the *settled science* frame, or the emphasis that climate change is real, was most common on Twitter, while the *political/ideological* frame, or the emphasis on the conflicting strategies of politicians addressing climate change, was most common in print media. In their temporal analysis of climate change tweets surrounding Trump's withdrawal from the Paris agreement, Kim and Cooke (2018) found that the *political/ideological* frame was the most common frame on Twitter, especially after the announcement. Lastly, Roxburgh et al.'s (2019) study on climate change tweets during three distinct hurricanes found that the frame of the tweet varied with the impact and timing of the hurricane. In terms of impact, Hurricane Sandy caused the greatest damage to the Northeastern United States and had the highest number of fatalities. Tweets during Hurricane Sandy were largely framed as a *political/ideological struggle*, potentially because it occurred in late October 2012, near the presidential election. During Hurricane Jones, *extremes* and *contested science* frames reached the forefront of the conversation. Hurricane Jones had the least amount of damage and the fewest fatalities. Roxburgh et al. (2019) suggest that the extreme cold weather that occurred during the event increased individuals' skepticism of climate change. Thus, individuals used the *extremes* frame to display the connection between the hurricane and climate change or the *contested science* frames to say that climate change is a hoax because of the cold weather. Lastly, Hurricane Irene, which occurred in August 2011, saw the fewest number of Tweets, but a significantly large proportion of the Tweets were framed as *settled science*. The hurricane received relatively little attention from public figures since it occurred during a calm political time and caused less damage than Hurricane Sandy.

Climate change frames not only alter how the individuals interpret messages, but also influence the receivers' emotional response to messages (e.g., Leviston et al., 2014; O'Neill et al., 2013; O'Neill, & Nicholson-Cole, 2009). Thus, this literature review will focus on emotion and its relevance in the climate change discussion.

Emotions

The following section will review Lazarus' (1991) theory of emotion, providing a brief definition and descriptions of the discrete emotions used in this study. Then, the section will introduce Affective Intelligence Theory (Marcus et al., 2000) to understand how framing influences emotions. Lastly, the section will discuss the role of emotions in the climate change discussion and how emotions affect social media posting behaviors.

Emotions are “psychological responses of varying strength and duration that are evoked in response to an external stimulus” with distinct relational themes (Feldman & Hart, 2018, p. 586; Lazarus, 1991). Lazarus (1991) names anger, anxiety, and hope as discrete emotions due to their distinct “unique appraisal patterns, core relational theme, and behavioral associations” (p. 619). A core relational theme is an individual's appraisal of the emotion based on their relationship to the environment in terms of benefits/harms (Lazarus, 1991). For instance, anger's core relational theme is a “demeaning offense against you or me” (Lazarus, 2006, p. 16), meaning that anger arises when harm to the self/environment is blamed on an external factor. Individuals experiencing anger attempt to remove the source of anger from their environment as a coping mechanism. Anxiety's core relational theme is “facing an uncertain, existential threat” (Lazarus, 2006, p. 16), or the emotion produced when people face an uncertain danger from their environment. Since the threat is vague, individuals are unsure on how to deal with the threat and may just avoid it. Lastly, hope's core relationship theme is “fearing the worst but yearning for

better and believing the wished-for improvement is possible” (Lazarus, 2006, p. 16). When individuals feel hope, their behavior aims towards maintaining their current commitment and coping strategies. Hope, anger, and anxiety all focus on external threats, which make them the most relevant emotions to study in the context of the uncertain, external threat that is climate change (Feldman & Hart, 2018).

Researchers have explored the implications of hope, anger, and anxiety in various contexts, including climate change (e.g., Feldman & Hart, 2018). Using the Affective Intelligence Theory (AIT), researchers have explored the implications of emotions on attitudinal and behavioral outcomes such as policy support or media posting (e.g., Feldman & Hart, 2018; Heiss, 2020). To understand the processes through which frames affect emotional responses to Reddit posts, this study draws from AIT.

Affective Intelligence Theory

Originally used to investigate emotions during political campaigns, the Affective Intelligence Theory (AIT), drawing from Lazarus’ (1991) emotion theory, posits that specific emotions (i.e., hope, anger, anxiety) are crucial in the development of judgements and behaviors (Marcus et al., 2000). AIT suggests that there are two paths which the brain takes to influence judgement and behavior, both of which are regulated by discrete emotions (Marcus et al., 2000). The first path is the surveillance system, and the second is the disposition system.

The surveillance system is a “subconscious emotional process” that raises awareness of the environment in case of threats and “serves to interrupt habitual routine and engage thought” (Marcus et al., 2000, p. 53). The surveillance system encourages thinking, information seeking, and effortful processing and appears to be activated by anxiety. MacKuen and colleagues (2010) found that anxiety encouraged political compromise because people did not rely on their habits

and pre-existing beliefs. “Fear dampens a reliance on party heuristics, thereby promoting more even-handed, balanced exposure to available information” (Song, 2017, p. 3). While fear and anxiety are “empirically distinguishable”, they often co-occur (Clayton, 2020, p. 2). Fear is a “higher-order, controlled reflection” to external stimulus, while anxiety includes both controlled reflection and automatic response to a threat. When encountering a novel, threatening situation, current available habits and routines are not sufficient to deal with the current threats. Thus, individuals seek out information to consider next steps and are more open to compromise (MacKuen et al., 2010).

Contrarily, the disposition system, regulated by hope and anger, is associated with the development of heuristics and behavioral routines. “[The disposition system’s] function is essential to the enaction of learned behaviors and to the acquisition of new behavioral routines” (Marcus et al., 2000, p. 46). When individuals face a hopeful situation, reactions are often positive and governed by previously learned habits. Similarly, with anger, the proceeding behavior is avoidance, a behavior which is also governed by previously learned habits (MacKuen et al., 2010).

After encountering climate change information, individuals’ emotional response to said information can lead them through the dispositional or surveillance systems and ultimately affect their behavior. This study investigates emotional responses (i.e., anger, anxiety, and hope) to climate change stories as expressed in the discussion section following each Reddit post. The next section discusses the effects of these discrete emotions on individuals’ attitudes in the climate change context.

Climate Change Frames and Emotions

Traditional media stories about climate change tend to focus on the catastrophic consequences of inaction and geographically distant threats which lead to greater hopelessness and less concern about the consequences of climate change (Hart & Nisbet, 2012; O'Neill & Nicholson-Cole, 2009). However, news stories that focused on mitigating actions increased hope and decreased fear, when compared to a story that focused solely on the impacts of climate change (Feldman & Hart, 2018). Discrete emotional responses to climate change stories have consequences for subsequent attitudes and behaviors. Almost 50% of the variance in climate change support policy is a result of emotional response to thinking about climate change, more than any other variable (e.g., sociodemographics) (Smith & Leiserowitz, 2014). Negative emotions can lead to greater processing of climate change information and therefore, more attention to the risks and greater support of policies (Meijnders et al., 2001). Fear and anger appear to be correlated with greater support for climate change mitigation policies (Lu & Schuldt, 2015; Smith & Leiserowitz, 2014), but hope also plays a role (Feldman & Hart, 2018). Traditional media frames that emphasize potential action for addressing climate change increased policy support across the ideological spectrum through hope but also increased policy support through fear for conservatives.

This study looks at the emotional responses expressed in the discussion sections of climate change posts on Reddit to investigate the relationship between O'Neill et al.'s (2015) climate change frames and emotional responses. Individuals feeling three discrete emotions after reading a story or post on Reddit may post as a sort of coping mechanism. The following section investigates how anger, anxiety, and hope can influence social media expression.

Emotions and Social Media Expression

Emotions – particularly anger, anxiety, and hope – also play a significant role in why people engage with and post content on social media (Heiss, 2020; Heiss et al., 2019). Angry individuals are more likely to participate in risk-seeking behavior and to participate on social media (Heiss, 2020). “Anger arises in individuals who feel that people in power are not appropriately addressing political or social problems,” and then create goals for alleviating those problems, such as engaging in discussion (Heiss, 2020, p. 7). Those experiencing anger are likely to try to directly attack the source of their anger (Lazarus, 1991), and turn to social media as an emotional- or problem-coping method (Heiss, 2020). However, anger can also decrease cognitive engagement which may result in lower quality arguments and opinion expression.

Anxiety is evoked when there is a lot of uncertainty about the threat, a lack of control, and no one to blame (Heiss, 2020). The influence of anxiety on social media participation is still debated (Wagner & Morisi, 2019). Anxious individuals try to avoid risky behaviors (e.g., posting political opinions on social media) (Song et al., 2017) and thus may be “lurkers” or those who seek information through passive activities. On the other hand, they may also use social media, like angry individuals, as an emotion- or problem- coping method (Heiss, 2020). Lastly, positive emotions, such as hope or enthusiasm, are more likely to foster a greater number of comments (Berger & Milkman, 2012; Heiss et al., 2019). One potential explanation is that social media users primarily go on social media for entertainment and thus will engage with content that matches this need (Baumgartner & Wirth, 2012).

This study investigates emotions appearing in Reddit discussions about climate change using computer software to detect anger, anxiety, and hope in the discussion sections of Reddit posts. Next, the focus shifts to Reddit as an appropriate research site for this project.

Reddit

This section will introduce Reddit as an emerging site for research by first describing its basic functions. Then, the section discusses the advantages and disadvantages of using Reddit and lastly, it describes the specific communities investigated in this study.

Social media platforms are popular sites for researchers to study human communication and interaction in the form of discourse, communities, and social networks (Namkoong et al., 2017). On these platforms, users are no longer simply consumers, but also producers and editors of content. Without great technical knowledge, users can create and share content with others through social media platforms' user-friendly interfaces (Neuendorf, 2017). Since the rise of social media, some platforms have garnered more attention from academic scholars than others, notably Twitter and Facebook (Schober et al., 2016). While both platforms have proved valuable to scholarly researchers, platforms such as Reddit remain relatively ignored (Amaya et al., 2019).

Reddit, also known as the “front page of the internet”, is one of the most popular social media sites. It is ranked as the 18th most visited website in the world (5th in the United States), has over 430 million active users, and sees over 21 billion page-views per month (About Reddit, 2020; Amaya et al., 2019).

Reddit users, or Redditors, have a lot of control over their social media experience. Redditors can post text, links to external websites, videos, images, and GIFs in thousands of topical communities, called subreddits. Then, other Redditors can interact with the posts by voting, commenting, or sharing the post on other suitable subreddits (Amaya et al., 2019). Users can join any number of communities and can elect to see posts only from those communities in their feed. Redditors can also decide how these posts are displayed: chronologically (“new”), by votes (“top”), or a combination of the two (“hot”). After joining a community, users can create

posts directed to their specific community. Depending on the subreddit, users can post user generated content (UGC) or user-selected content (USC), content shared from other internet sites, such as news articles (Neuendorf, 2017).

Though users enjoy a degree of anonymity on Reddit not often attained on other social media sites, over time, a user may lose that advantage. To create a user account on Reddit, individuals need only to supply an e-mail address and a unique username and password (Weninger et al., 2013). Therefore, users maintain a degree of anonymity not often found on other social media platforms (Amaya et al., 2019). However, users slowly chip away at their anonymity on the website with each post they create (Kilgo et al., 2018). Each Redditor's complete posting and commenting history is listed on their profile and other users have complete access to others' profiles. Therefore, a Redditor following /r/Fayetteville who comments about their current experience as a graduate student and posts on the /r/socialscience about gathering data from Reddit, will make it easier to deduce their identity. Anonymity is an important component of Reddit, but Reddit rewards individuals who are active users of the site by awarding them privileges, such as posting on a subreddit, by awarding them karma.

One factor that influences who can post on a subreddit is a Redditor's "karma", a point system that measures users' activity and reputation on Reddit (Bergstrom, 2011). Others can upvote a Redditor's post/comment, indicating agreement or enjoyment. That results in an increase in the posters' karma. Others can also downvote a post/comment to demonstrate disagreement, which results in a reduction in the poster's karma. Therefore, the more agreeable comments and posts that a Redditor contributes, the higher their karma points are likely to be. Moderators, particularly those of subreddits with a high number of followers, require a certain karma score before allowing users to post. This regulation ensures that bots, or computer

programs automating content, are not simply spamming the website (Maréchal, 2016). While karma may be a powerful incentive for interacting with the website, generating karma can also compromise users' anonymity on the site (Van der Nagel & Frith, 2015). Therefore, users who post on Reddit must balance the desire to post their opinion with the risk of chipping away at their anonymity. Reddit rewards those who partake in the conversation, making the social media a particularly unique site to conduct research on controversial issues.

Advantages/Disadvantages of Reddit as a Research Site

The various components of Reddit make it a versatile site to study. Researchers can decide to study posts within a community, posts overall, the community network, or the comment sections of a post. Additionally, they can study metadata (Amaya et al., 2019), such as a post's score or awards. Within each post, researchers can look at the comment sections, how many parent comments there are, conversations within a single post, and posts' "flair" or tag. For example, Lu and colleagues (2019) studied patterns in users' post and comment history in different subreddits to predict drug addiction. How a researcher uses Reddit is determined by the scope and topic of study.

One disadvantage of using Reddit is that the user demographics are not a representative sample of the general United States population. Reddit users tend to be male, young, white, liberal and heavy internet users (Barthel et al., 2016; Straub-Cook, 2018). Active contributors tend to be older than the average Reddit user, have strong personalities, and be more engaged with news stories (Kilgo et al., 2018). The most active users tend to post more, have higher karma, and have their posts reach the front page of Reddit, ultimately being the most viewed and influential. Although studies have found that around 65% of Reddit users are male, this may not be the case (Kilgo et al., 2018). Women may simply just be less likely to post or comment so as

to avoid the toxic misogyny that is present on Reddit. Since Redditors skew towards young, male, white, liberal, and educated, the posts that appear on the “hot” list of posts are likely to represent what is most important to that demographic.

Although researchers often present social media as capable of dismantling the power of traditional news media gatekeepers, gatekeeping still exists in social media, though in a different form (Pearce et al., 2018). Thus, an additional consideration when looking at Reddit as a research site are the multiple levels of gatekeeping built into the site. Before any story or article reaches Reddit, journalists must determine whether to publish a story and how to frame it (Suran & Kilgo, 2015). From there, users who decide to repost a journalist’s story are regulated by community moderators. Lastly, Redditors gatekeep posts using their voting power (Leavitt & Robinson, 2017). Prohibiting posts from reaching a larger audience by downvoting posts into obscurity is a form of second-level gatekeeping (Singer, 2014). Regardless, since Reddit experiences high levels of traffic and because of the “heavy emphasis placed on dissemination and discussion of news,” Reddit provides researchers an insight into how those who value news exchange discuss information (Straub-Cook, 2017, p.1317). These features of Reddit make it particularly important in the study of climate change, a topic for which most individuals do not have personal experience and thus rely on news for information and decision-making.

Research Justification

Climate change frames have the potential to influence beliefs toward climate science and support for mitigation policies at societal and individual levels. Certain frames can increase awareness and others can potentially lead to inaction or apathy (Bord et al., 2000). Competing frames presented by mass media have left the United States divided over whether we should be addressing climate change and the consequences of doing so (Boykoff, 2007; Shehata &

Hopmann, 2012). While the traditional mass media are partly responsible for perpetuating these competing frames, social media are exacerbating the division between opposing sides (Jang, 2014; Stroud, 2011).

Social media discussions on climate change are a key focus for researchers due to their unique potential as sites for peer influence. Social media can have a greater affect on individuals' perceptions of an issue because of media platforms' participatory nature (Williams et al., 2015). Individuals can selectively expose themselves and interact with like-minded individuals to create echo chambers of opinions, ultimately leading to further entrenched opinions. Particularly, individuals can influence each other directly on social media by bypassing traditional media gatekeepers (Williams et al., 2015), ultimately shaping offline climate change discussions (Pearce et al., 2018; Schäfer, 2012; Veltri & Atanasova, 2017).

Climate change discussions on social media are often split into climate “activist” and “skeptic” groups (Williams et al., 2015). These groups tend to interact with themselves, leading to “echo chambers” which increases polarization of climate change opinions and limits exposure to differing opinions. “Partisan online communities may also act as selective filters that impede transmission of unfavoured ideas across the broader social network” (Williams et al., 2015, p. 135). This division of groups is apparent on Reddit as well. Therefore, this study will look at the posts that use the phrase “climate change” in three types of subreddits – climate change believer subreddits (i.e. /r/climatechange, /r/climate), climate change skeptics subreddits (i.e. /r/climateskeptics, /r/the_donald) and neutral subreddits (i.e. /r/worldnews, /r/politics) – to determine how the frames differ in these three environments.

Drawing from Entman's (1993) framing theory and Affective Intelligence Theory (Marcus et al., 2000), this study will investigate the frames in top posts surrounding the 2019

Climate Action Summit and the emotions represented in the comments section for these posts. Climate change news is event driven (Boykoff & Boykoff, 2007), therefore this study aims to investigate the posts and comments of Redditors surrounding a globally significant climate change event that caught social media's attention – the 2019 UN Climate Action Summit.

The following research questions are investigated:

Research Questions

RQ1: What is the distribution of climate change frames surrounding the 2019 UN Climate Change Action Summit?

RQ2: Do climate change frames differ depending on the subreddit (i.e., neutral, climate change believers, climate change skeptics)?

RQ3: Which of the three emotions (i.e., anger, anxiety, and hope) appears most frequently in climate change post discussions surrounding the 2019 UN Climate Change Action Summit on Reddit?

RQ4: Is there a difference in emotions expressed in the discussion section depending on the predominant climate change frame appearing in the post?

RQ5: Do key emotions differ in the discussion section following the post depending on the subreddit (i.e., neutral, climate change believers, climate change skeptics)?

Chapter 3

Methodology

This study used a quantitative content analysis to answer the five research questions. The following section describes the sample, data collection, and data analysis for the project. The study used Pushshift.io to retrieve the sample posts and Reddit's Application Programming Interface (API) to gather the posts' comments. Then, to identify the posts' frames, human coders categorized each post based on a typology derived from O'Neill et al.'s (2015) previous work on climate change frames. Next, the study used Linguistic Inquiry and Word Count (LIWC) software to analyze the emotional content in the posts' comments. Lastly, SPSS was used to conduct statistical analyses.

Sample

The following section discusses the sample of the study. It begins with an overview of the criteria and process for selecting posts, an overview of the subreddits from which the posts were sampled, and a brief description of the final sample.

To investigate the research questions, the researcher gathered the top climate change-related posts, or those with the highest number of upvotes, from select subreddits. Posts were first filtered based on whether they contained the term "climate change," a phrase used to parse through climate change-related posts on social media in previous research (e.g., Kim & Cooke, 2018; O'Neill et al., 2015). Then, posts were ordered by their score, or the number of net upvotes that the post received. Selecting the top posts results in an exposure-based sample, identifying the content that users viewed and engaged with the most (Neuendorf, 2017). Then, posts were further filtered by their originating subreddits. Posts were selected from the date range July 23rd to November 23rd, 2019, which used the date of the 2019 UN Climate Action Summit on

September 23rd as the mid-point. This study gathered posts from two months prior and two months following the event to gather any posts that may be relevant to the event.

The final sample included 600 posts, 100 posts from six subreddits. The sample size was chosen based on previous work on Reddit and frames (e.g., Suran & Kilgo, 2017; Wasike, 2011) and as recommended by Neuendorf (2017) to maintain a 95 percent confidence level and a maximum ± 5 percent margin of error. Additionally, the sample size was determined based on logistical restrictions. The Pushshift API (described in greater detail below) allows for posts to be selected 100 at a time, meaning that the researcher was limited to drawing the top 100 posts from a specific subreddit at any time.

Subreddits vary greatly in terms of content, post type, and ideology. Therefore, an equal number of submissions from three types of subreddits – climate believers, climate skeptics, and ideologically neutral – were used to gather a wide range of climate opinions. Some subreddits explicitly deny certain types of content, so gathering a range of subreddits was important to gather the greatest range of frames. For instance, the rules for /r/climate prohibit any climate-denial posts, thus eliminating any chance for the *uncertain science* frame to be used. The specific subreddits within the three categories (i.e., climate believer, climate skeptic, and neutral) were selected by determining how often “climate change” appeared and selecting the subreddits where the term climate change appeared the most. The number of subscribers and mentions of climate change during the examined time period are listed in Table 2. Two subreddits were selected per subreddit type and are described below.

The two pro-environmental subreddits examined in this study are /r/climate and /r/climatechange. The description for the /r/climate community is “a community for truthful science-based news about climate and related politics and activism.” The community’s rules do

not allow for users to post about climate change denial or conspiracy theories. They had around 52 thousand subscribers as of September 23, 2019. The second community selected within the climate change believer subreddits was */r/climatechange*. The community description of */r/climatechange* in 2019 was simply “Welcome to */r/climatechange*.” This description has since changed to “This is a place for the rational discussion of the science of climate change. If you want to post about politics or climate policy, try */r/ClimateNews* or */r/climatepolicy*.” The rules for */r/climatechange* in 2019 indicated that no posts about politics were allowed. While these subreddits have fewer subscribers than the neutral subreddits, they do have similar number of mentions of climate change and are comparable in size to the climate skeptic subreddits, which are described in further detail below.

Table 2
Subreddit Information

Subreddit	Subscribers (as of Sep 23, 2019)	Mentions of Climate Change (July 23 – Nov 23, 2019)
<i>/r/climate</i>	52,600	875
<i>/r/The_Donald</i>	775,389	1,442
<i>/r/climateskeptics</i>	17,459	669
<i>/r/climatechange</i>	18,045	806
<i>/r/worldnews</i>	22,138,787	1049
<i>/r/politics</i>	5,411,256	771

The */r/climateskeptics* and */r/The_Donald* communities were chosen to represent the climate skeptic groups that are in direct opposition to the climate change believer communities. The */r/climateskeptics* subreddit description is “Questioning climate related environmentalism” and does not have any rules for posting, except for disparaging the subreddit itself. While */r/The_Donald*, on the other hand, is not a climate-specific subreddit, it did have the most mentions of climate change of any other subreddit in this study. The description for */r/The_Donald* was “The_Donald is a never-ending rally dedicated to the 45th President of the

United States, Donald J. Trump.” and the rules prohibited trolling, racism, threats of violence, etc. Together, these two subreddits create the “climate skeptic” group. The climate believer and climate skeptic subreddits all frequently mention the keywords and are roughly the same size.

Lastly, the neutral subreddits selected were /r/politics and /r/worldnews. Both /r/politics and /r/worldnews have significantly larger followings than the climate believer and climate skeptic subreddits. However, both subreddits mention climate change a similar number of times as the other communities. The /r/politics community description was “/r/politics is the subreddit for current and explicitly political U.S. news.” The rules for the community allow only for posts about U.S. politics and posts must be articles published within the calendar month. There is also a pre-approved list of sources from which the articles can be posted. /r/worldnews is one of the largest communities on Reddit, with over 22 million subscribers during September 2019. Its description is “/r/worldnews is for major news from around the world except US-internal news / US politics.” The community does not allow for posts about US news or U.S. politics. Together, all subreddits allow for an examination of climate change from a variety of perspectives and post types, allowing for a more thorough examination of the most popular frames in these distinct contexts.

The final sample included 600 posts from three types of subreddits – the climate skeptics, climate believers, and ideologically neutral. The climate skeptic type includes 100 posts from each /r/climateskeptics and /r/the_donald, the climate believer type includes 100 posts drawn from /r/climate and /r/climatechange, and the neutral type includes 100 posts from each /r/politics and /r/worldnews.

Data Collection

The following section introduces data collection on Reddit. The section discusses the common processes used to collect data from Reddit and how this study employed two popular methods – the Reddit API and Pushshift – to gather posts and comments. Next, the section introduces LIWC, a computer-aided textual analysis software used for linguistic analyses. LIWC was used to identify emotion in the comments.

There is limited academic writing on the procedures of gathering, storing, and analyzing data from Reddit (Amaya et al., 2019). Gathering Reddit’s hundreds of thousands of posts for analysis can be overwhelming, time consuming, and/or nearly impossible. Therefore, use of computer software and knowledge of programming languages for data scraping is helpful. There are various ways of gathering data from Reddit, but two methods are most cited in communication and social science research - Reddit’s application programming interface (API) and Pushshift (Amaya et al., 2019; Baumgartner, 2018).

The Reddit API allows researchers to gather “all posting, comment and aggregate user data” (Weninger et al., 2013, p. 579), including the title of the post, the date it was posted, the subreddit, all of the post’s comments, votes, awards, any tags, etc. with the use of a programming language. Reddit imposes three requirements for users of their API. First, researchers must create a Reddit account (About Reddit, 2019). Second, researchers must ensure that they will not breach any privacy regulations, such as using specific usernames in any written material. Lastly, Reddit places a limit on how much information one can gather, limiting users to the 60 items per minute (Amaya et al., 2019; Choi et al., 2015). Using the Reddit API requires some knowledge of programming language. The most commonly cited way of gathering data using the Reddit API is through PRAW (Python Reddit API Wrapper). To use the Reddit API and PRAW, users must

fill out a basic request form on the Reddit website and receive authorization to use their username for scraping data.

As an alternative to gathering data through Reddit's API, Baumgartner created Pushshift.io (Baumgartner et al., 2020). Pushshift.io is a downloadable database with every single comment and post from Reddit from December 2005 through December 2019, as of this writing, and its own API for real-time access to Reddit content (An et al., 2019; Baumgartner, 2018). Pushshift allows researchers to retrieve data without extensive programming knowledge and without making an account. Pushshift has larger query limits than does the official Reddit API and a subreddit for users to ask questions, keep up to date with announcements, and ask for feedback (Baumgartner et al., 2020). Downloading the dataset from Pushshift (Baumgartner, 2018) means downloading a large file with information that a researcher does not need. Files include comments and extramessage data for each month, meaning that one must download all data for the entire month and then parse through it (Amaya et al., 2019). Since its inception, over 100 peer-reviewed articles have used Pushshift data to study issues such as moderators' community governance (e.g., Jhaver et al., 2019), political extremism (e.g., Grover & Mark, 2019), social media trustworthiness (e.g., Zannettou et al., 2018), identity work (e.g., Dosono, Semaan, & Hemsley, 2017) and health informatics (e.g., Brett et al., 2019).

This study used both Pushshift.io and the Reddit API to gather complimentary data points. To gather the Reddit posts, I began with Pushshift.io. I queried the database for submissions that use the key word "climate change" in the predetermined subreddits submissions from July 23rd to November 23rd, 2019. Then, I ordered the submissions by upvotes to collect the top 100 posts and exported the data as a JSON file to Excel for further analysis. I gathered the submission date, domain, full_link, id, is_self, num_comments, score, selftext, subreddit, title,

url title, number of upvotes, subreddit, link to the post, number of comments, score, body, and link to the outside article.

Then, using the Reddit API and Python, I scraped each of the sampled posts' comments sections and exported the data to a text file. Overall, there were a combined 125,128 comments from all six subreddits analyzed in this study. The top 100 posts in the /r/climate community had a total of 1,954 comments, after removing all comments deleted on Reddit prior to data collection, which appear in the comments as *[deleted]* or *[removed]*. The collected posts from /r/climatechange community had a total of 2,921 comments, /r/climateskeptics had 3,437, /r/worldnews had 79,050, and /r/politics had 28,851. However, because the subreddit /r/The_Donald was banned at the time of data collection, I was not able to use the Reddit API to scrape for those comments. Instead, I used SQL to query Pushshift's archives of posts and comments to select for the comments from those posts. There was a total of 8,925 comments from the /r/The_Donald included in the analysis, after eliminating all comments that had been removed prior to the scraping of this data.

Lastly, using LIWC, I analyzed the comments sections for positive and negative affect. While there are dozens of software options for computer-aided textual analysis (CATA), a commonly used tool by researchers analyzing Reddit is LIWC (Pennebaker et al., 2015). LIWC is a textual analysis tool that delves into the linguistic and psychological characteristics of a text (Pennebaker et al., 2015). For instance, LIWC can be used to determine positive and negative affect, cognitive processes, drives, authenticity, etc. LIWC has been used to study linguistic differences between Republicans and Democrats on Reddit (e.g., An et al., 2019), semantic characteristics of the comments and posts of the top 100 subreddits (e.g., Choi et al., 2015), and hate comments on six political subreddits (e.g., Zannettou et al., 2020).

I used LIWC 2015's internal emotion dictionary to determine the emotional content of posts. LIWC 2015's dictionary for emotion separates emotion into four categories – positive, sadness, anxiety, and anger. In the dictionary, there are 620 words that indicate a positive emotion, such as love, nice, sweet; 116 words to detect anxiety, including worried, fearful; 230 words indicating anger, such as hate, kill, annoyed; and lastly, sadness is found using 136 words, such as crying, grief, and sad. However, this project sought to detect hope, and not positive emotions in general. To detect hope, I used LIWC 2001's internal "optimism" dictionary, which includes words such as hope, accept, and determined. While hope and optimism are distinct concepts, previous research has used LIWC's measure of optimism to operationalize hope (e.g., Bonfils et al., 2016). LIWC's output indicates the percentage of total words that represent the discrete emotion (Pennebaker et al., 2015).

Coders

To assign frames to the 600 posts, there was a total of four human coders working on the project, including the researcher. The additional coders were graduate students who were monetarily compensated for their work on the project.

Coder Training

Coders attended four two-hour long training sessions, for a total of eight hours of training. During the training sessions, the coders first learned about the components of a Reddit post and how the data were represented in the Excel spreadsheet they worked with. They learned about the Reddit-specific terms (e.g., subreddit, permalink, body, post id, etc.) and about the study's relevant variables (i.e., frames). The earlier training sessions focused on the definition of framing, the frames used in the study, and how to look for a frame in a Reddit post. Coders were

asked to pay attention to the narrative theme, quotes, headlines, keywords/metaphors, images, hashtag, and the content of the external links to determine the main frame.

Coders received a coding typology (see Appendix A) which included the name of the frame; a definition of the frame; themes, phrases, and images that are typically associated with the frame; and special conditions. They also received an Excel sheet with the data that included the title of the post, body of the post, and any link to external news sites. They were instructed that each post was to only be assigned one frame, based on the “dominant meaning” of the post (Entman, 1993, p. 56) and as previous work with this framing typology has done (e.g., O’Neill et al., 2015; Roxburgh et al., 2019).

Before coding the final data set, the coders reviewed the coding typology and variables during the training sessions to clear up any misunderstanding. Initially, the coders used 60 training posts that were not part of the final data to practice using the coding typology and the coding sheet. While these 60 posts were not included in the final data analysis, the researcher used the intercoder reliability from these 60 posts to determine whether or not the coders were adequately prepared to continue coding the final data set. Over the course of the training sessions, additional conditions and explanations were added to the codebook to better fit the context of the 2019 UN Climate Action Summit and to increase intercoder reliability. After coders were comfortable with the frames, posts, and logistics, coders independently assigned frames to their respective posts.

Intercoder Reliability

Cohen’s kappa was used to test for intercoder reliability. Cohen’s kappa is the most widely used reliability coefficient, since it takes into account chance agreement (Neuendorf, 2017). Studies looking into climate change framing have used this intercoder reliability statistic

in their analyses (e.g., Kim & Cooke, 2018; Roxburgh et al., 2019). Cohen's kappa scores above 0.6 are considered good and scores above 0.75 are considered excellent (Bakeman, 2000). After three training sessions, the intercoder reliability was .70 and after the fourth training session the intercoder reliability was .81. After the fourth training session, coders were then allowed to begin coding the final data set.

While coding the final data set, the researcher checked the intercoder reliability at multiple points. Out of the 600 posts, posts were split into 120 "shared" posts and 480 "individual" posts. All coders were responsible for coding the 120 shared posts and 120 of the 480 individual posts, for a total of 240 posts each. Over the course of four weeks, the coders submitted 25% of the shared posts each week to ensure intercoder reliability remained high. The intercoder reliability after the first week of individual coding was a .60, an acceptable level. However, after the second of week of individually coding shared posts, intercoder reliability dropped to .3, after which coding was halted and additional training sessions were held to go over any discrepancies and adjust the codebook. The messages during that week were recoded after a group discussion about discrepancies in the codebook. The final intercoder reliability for the 120 shared posts was a .7, which is considered good (Bakeman, 2000).

Coding Typology

All posts were coded using a predeveloped coding typology, based on O'Neill et al.'s (2015) coding schema. To amend the initial coding typology, I first read through a substantial number of Reddit posts in the data set related to climate change to determine whether the coding typology should be expanded or altered. For instance, Roxburgh et al. (2019) added the frames *extreme* and *unclear* to O'Neill et al.'s (2015) coding typology in their study about climate change framing and extreme weather events. Additionally, Kim and Cooke (2018) added two

additional frames to their coding typology -- *promotion/piggybacking* and *engagement/empowerment* -- in their study of climate change and ocean acidification tweets. They also combined two of O’Neill et al.’s (2015) frames, *disaster* and *security*, into a single category called *disaster/security*. Because frames are very context dependent, this study used the *promotion/piggybacking* frame but not *engagement/empowerment* and *extremes* since neither were present during a preliminary review of the data. After initial difficulties with intercoder reliability, this study combined the *disaster* and *security* categories, as was done by Kim and Cooke (2018). This study introduces a novel frame – *words vs. action* – which was found in a preliminary review of the data. This frame emphasizes the hypocritical or contradictory nature of individuals’ words/beliefs and their actions. It is often, though not always, used by climate change skeptics to point out the luxurious lifestyle of climate change believers.

Data Analysis

The data analyses for this study were conducted using SPSS. Two of the studies variables were measured using nominal level data (e.g., frame and subreddit type) while emotions provided ratio level data. One frame was assigned to each post, making frame a nominal level variable. For instance, a post containing the *settled science* frame was categorized as 1, while coders assigned a post framed as *uncertain science* as 2. The six subreddits are classified into one of three types (i.e., climate-skeptic, neutral, climate believers). LIWC was used to gather and count the number of words representative of each focal emotion (i.e., hope, anger, anxiety) resulting in ratio level data.

RQ1 asks “What is the distribution of frames surrounding the 2019 UN Climate Action Summit”? To answer this question, I conducted a frequency analysis on the distribution of frames. RQ2 asks “Do climate change frames differ depending on the subreddit (i.e., neutral,

climate change believers, climate change skeptics)?” Since I am comparing two nominal level variables (frames and subreddit types), I conducted a chi-square analysis to look at the distribution of frames between the three subreddit groups. RQ3 asks “Which of the three emotions (i.e., anger, anxiety, and hope) appears most frequently in climate change post discussions surrounding the 2019 UN Climate Change Action Summit on Reddit?” Descriptive statistics were computed to answer this question. RQ4 asks “Is there a difference in emotions expressed in the discussion section depending on the predominant frame of the post?” This question was answered using a one-way ANOVA since the frames are nominal level data and the count of emotion words in the discussion sections is ratio level. LSD post-hoc analysis was used to determine if there were significant differences between emotions in the discussion sections of different frames. Lastly, RQ5 asks “Do key emotions differ in the discussion section following the post depending on the subreddit (i.e., neutral, climate change believers, climate change skeptics)?” I used a one-way ANOVA to determine whether the representation of emotion (a ratio level variable) differs by subreddit type (a nominal level variable). Lastly, LSD post-hoc analysis was used to determine differences between emotional representation in distinct subreddit types.

Chapter 4

Results

The first research question asks about the distribution of climate change frames surrounding the 2019 UN Climate Action Summit. A frequency analysis of the frames was conducted to investigate the number of each frame that appears in the dataset. The results are displayed in Table 3. The results show that the most common frame was the *political/ideological struggle* frame, followed by *unknown/other*. The least common frames were *health* and *morality and ethics*, with only 6 (1.0%) and 4 (or .7%) posts using those frames, respectively.

Table 3
Frame Distribution

Frames	Frequency	
	N	Percentage
Settled Science	60	10.0%
Uncertain Science	65	10.8%
Political/Ideological Struggle	141	23.5%
Role of Science	35	5.8%
Disaster/Security	40	6.7%
Morality and Ethics	4	.7%
Opportunity	18	3.0%
Economic	18	3.0%
Health	6	1.0%
Promotion/Piggybacking	79	13.2%
Words vs. Action	32	5.3%
Unknown/Other	102	17%

The second research question asks if climate change frames differ depending on the subreddit (i.e., climate change believers, climate change skeptics, and neutral). The results of a two-way chi square analysis are presented in Table 4. Significant differences appeared in the distribution of frames between subreddits, ($X^2(22) = 346.8, p < .001$) and the effect size for this finding was strong, with a Cramer's V of .54. For instance, the *settled science*, *disaster/security*, *opportunity*, and *economics* frames appeared mostly in the climate believer and neutral

subreddits and either never appeared or appeared only once in the climate skeptic group. On the other hand, the *uncertain science* and *words vs. action* frames appeared predominantly in the climate skeptic group and not all or rarely in the neutral and climate believer group. All three groups showed the use of the *political/ideological frame*, but it appeared most often in the neutral subreddits (45%). All three also showed the use of the *role of science*, although it was most common in the climate believer subreddits. The neutral subreddits were more likely to portray climate change in the *promotion/piggybacking* frame (19%), while it appeared in the other two groups roughly the same amount.

Table 4
Frame Distribution between Subreddits

Frame	Subreddit Group					
	Climate Believer		Climate Skeptic		Neutral	
	n	%	n	%	n	%
Settled Science	39	19.5	0	0.0	21	10.5
Uncertain Science	3	1.5	62	31.0	0	0.0
Political/Ideological Struggle	30	15.0	21	10.5	90	45.0
Role of Science	14	7.0	11	5.5	10	5.0
Disaster/Security	26	13.0	1	.5	13	6.5
Morality and Ethics	3	1.5	1	.5	0	0
Opportunity	11	5.5	0	0	7	3.5
Economics	12	6.0	1	.5	18	3.0
Health	3	1.5	0	0	3	1.5
Promotion/Piggybacking	21	10.5	20	10.0	38	19.0
Words vs. Action	0	0	29	14.5	3	1.5
Unknown/Other	38	19.0	54	27.0	10	5.0

$\chi^2(22) = 346.8, p < .001$

The third research question asks which emotions (i.e., anger, anxiety, and hope) appear most frequently in climate change post discussions on Reddit surrounding the 2019 UN Climate Action Summit. 7 posts, or 1.17% of the sample, did not have any comments and were thus excluded from further emotion analysis. LIWC was used to determine the score, or the percentage of words in the discussion sections that represent each discrete emotion. The results

show that anger was the most commonly expressed emotion appearing in the comments, with a mean of 1.05 ($SD = .84$). The amount of anger in comments ranged from .00 to 11.11. Of all 593 remaining posts, 54 (9.1%), did not express any anger. Hope was the second more frequently expressed emotion with a mean of .64 ($SD = .63$), a range of .00 to 10.00. Of all posts, 45 posts (7.6%) did not express any hope. Lastly, anxiety was the least common emotion appearing in all of the posts' comments with a mean of .32 ($SD = .33$) and ranged from .00 to 2.67. 16.5% of all posts (98) did not express any anxiety. It is important note that a previous study found that the average number of emotion words in a text falls between .01 and 4.0 (McDonnell, Owen, & Bantum, 2020). Thus, while the resulting numbers for this study appear small, they are within the range of normal.

The fourth research question asked if there was a difference in emotions expressed in the discussion sections depending on the predominant frame appearing in the post. This question was investigated using a one-way ANOVA. Table 5 shows the means of each emotion expressed in different frame. The levels of anxiety varied significantly between frames, $F(11, 588) = 2.38, p < .01$. In particular, expressions of anxiety were significantly higher in the *health* frame ($M = .83, SD = .91$) than in the *unknown/other, settled science, uncertain science, political/ideological struggle, role of science, disaster/security, opportunity, and economics* frames. Additionally, the levels of anger were significantly different between frames, $F(11, 588) = 4.61, p < .001$. In particular, the expressions of anger were significantly more likely in the *political/ideological struggle* ($M = 1.15, SD = .67$) and *promotion/piggybacking* ($M = 1.50, SD = 1.03$) than in other frames. Lastly, there was no significant difference between levels of hope depending on the frame, $F(11, 588) = 1.13, p = .33$. However, hope did appear in response to the *disaster/security* frame more often ($M = .89, SD = 2.03$) than in *unknown/other, settled science, uncertain science,*

political/ideological struggle, and *words vs. actions*. Anger was more likely to appear in the discussion sections of *political/ideological struggle* posts ($M = 1.15$, $SD = .67$), than either hope ($M = .66$, $SD = .36$) or anxiety ($M = .29$, $SD = .22$). The second most popular frame, *promotion/piggybacking*, had the highest levels of anger ($M = 1.50$, $SD = 1.03$) than any other frame, and was more likely to display anger than anxiety ($M = .32$, $SD = .38$) and hope ($M = .67$, $SD = .51$). Other popular frames, such as *uncertain science* and *settle science*, also displayed higher levels of anger than anxiety and hope. *Uncertain science* posts displayed significantly more anger ($M = .87$, $SD = .58$) than either hope ($M = .53$, $SD = .37$) and anxiety ($M = .31$, $SD = .34$). Anger was also more prevalent in *settled science* ($M = .77$, $SD = 1.43$) than either hope ($M = .54$, $SD = .30$) or anxiety ($M = .32$, $SD = .35$).

A LSD post-hoc test was run to test the significant differences in emotional expression between frames. In anxiety, significant differences appeared between the *health* and *morality and ethics* frames and the rest of the frames. It is important to note that due to the small sample sizes in specific frames, the significant differences between the *health* and *morality and ethics* frame and the rest may be exaggerated. With respect to anger, the frames that varied significantly from the rest are *promotion/piggybacking* and *political ideological struggle*.

Table 5
Results for Emotion by Frame

Frame	Emotion					
	Anxiety		Anger		Hope	
	Mean	SD	Mean	SD	Mean	SD
Settled Science	.32	.35	.77	1.43	.54	.30
Uncertain Science	.31	.34	.87	.58	.53	.37
Political/Ideological Struggle	.29	.22	1.15	.67	.66	.36
Role of Science	.34	.31	.91	.57	.63	.28
Disaster/Security	.33	.40	.75	.69	.89	2.03
Morality and Ethics	.65	.62	1.18	.95	.69	.30
Opportunity	.27	.19	.71	.59	.77	.35
Economics	.44	.46	.85	.55	.66	.31

Table 5 Cont.
Results for Emotion by Frame

Frame	Emotion					
	Anxiety		Anger		Hope	
	Mean	SD	Mean	SD	Mean	SD
Health	.83	.91	1.35	.65	.49	.34
Promotion/Piggybacking	.32	.38	1.50	1.03	.67	.51
Words vs. Actions	.22	.15	1.13	.68	.58	.34
Unknown/Other	.34	.32	.97	.63	.59	.31

The final research question asks if key emotions differ depending on the subreddit (i.e., climate change believers, climate change skeptics, and neutral). The results indicate that the levels of anxiety varied significantly between subreddits, $F(2,597) = 3.73, p < .05$. The levels of anger in the discussion sections of posts also differed significantly between subreddits, $F(2,597) = 23.39, p < .001$. However, the levels of hope did not differ significantly between subreddits, $F(2,597) = 1.01, p = .36$. Table 6 shows the results of the LSD post-hoc tests. Subscripts represent significant differences across rows. The subscripts in the anger row represent a significance of $p < .001$, while subscripts in the anxiety row represent significance of $p < .05$ between climate skeptics and neutral subreddits and $p < .01$ between climate believer and neutral subreddits.

Anger was the most common emotion displayed in the comments. Significantly more anger was expressed in response to posts the neutral subreddit group ($M = 1.28, SD = .60$) and the climate skeptic group ($M = 1.19, SD = .79$) in comparison to the climate change believer group ($M = .65, SD = 1.01$). Anger levels in the neutral group ($M = 1.28, SD = .60$) were almost twice as high than anger in the climate believer group ($M = .65, SD = 1.01$), while anxiety and hope levels were similar in all groups. The climate believer subreddit displayed hope as their most common emotion ($M = .68, SD = 1.01$), with anger following closely ($M = .65, SD = 1.01$), and anxiety being least frequent emotion ($M = .35, SD = .41$). The climate skeptic group and the

neutral subreddit group displayed similar proportions of emotion, with high levels of anger, slightly lower levels of hope, and small amounts of anxiety.

Table 6
LSD Post-Hoc Results for Emotion by Subreddit Type

Emotion	Subreddit Type					
	Climate Believer		Climate Skeptic		Neutral	
	Mean	SD	Mean	SD	Mean	SD
Anxiety	.35 _a	.41	.35 _b	.36	.27 _{a,b}	.14
Anger	.65 _{a,b}	1.01	1.19 _a	.72	1.28 _b	.60
Hope	.68	1.01	.59	.38	.63	.19

Note. Shared subscripts represent statistically significant differences ($p < .05$)

Chapter 5

Discussion

The goal of this study was to investigate the prevalence of climate change frames appearing in Reddit posts and the emotional responses to these frames appearing in the discussion sections of the posts. Climate change frames have the potential to influence attitudes and behaviors towards climate change (Bord et al., 2000). Previous research on climate change frames has focused on traditional media messages (e.g., Stecula & Merkley, 2019) and more recently messages on social media platforms, particularly Twitter (e.g., Kim & Cooke, 2018; Roxburgh et al., 2019). However, little research has explored the climate change conversations appearing on other social media platforms. This study focuses on Reddit, a social media platform with a unique demographic and users who are engaged with the news. Reddit is an emerging site for climate change communication research.

The results of this study show that climate change was most often portrayed on Reddit as a *political/ideological struggle* or was used to *promote/piggyback* on tangential issues, such as the death of a billionaire celebrity or protests in the workplace. The results indicate that climate change frames varied significantly depending on the subreddit type (i.e., climate believer, climate skeptics, neutral). With respect to emotions, anger was the most expressed emotion appearing in the discussion sections of climate change posts. Emotional expression also varied significantly between climate change frames and between subreddit type. This discussion section elaborates on the study's findings, links the findings to current climate change and emotion research, and discusses the theoretical and practical implications of the findings. Then, the section discusses future research considerations and the study's limitations. Lastly, the conclusion elucidates on the importance of this research.

Climate Change Framing and Intermedia Contagion

This section focuses on the findings of the first two research questions, both of which focus on framing. First, the section discusses the importance of intermedia framing. Then, this section explores the results and the implications of the first two research questions about the frequency of frames and the relative appearance of frames in distinct subreddit types.

Climate change framing researchers focus on social media, as social media has the potential to disrupt traditional media's historically top-down approach to climate change communication where frames flow from the elite to the general public to create a two-way communication pathway (Jones-Jang et al., 2019). Research on the intermedia framing effect, or the flow of frames between traditional and social media, indicates that the relationship is more complex (e.g., Jang et al., 2016; Lo et al., 2019). Climate change frames initially flow from the elite (e.g., politicians, scientists, social media opinion leaders) to the general public, who partially use cues from traditional media to develop their opinions on climate change. After developing their initial opinions, members of the public often turn to social media and join polarized groups (Merkley & Stecula, 2018; Williams et al., 2015). Certain frames are reinforced by these polarized, homogenous groups that further entrench climate change beliefs within each community. Thus, the frames that appear most often in social media often represent the ones that are most salient in the climate change discussion in traditional media at a particular point in time. This study focused on one specific point in time – the time immediately before and after Greta Thunberg's speech at the 2019 UN Climate Action Summit.

Understanding the flow of stories from traditional media to social media is particularly important for this study, as this study focuses on the traditional media stories that appear on Reddit. The most popular Reddit communities in this study, /r/worldnews and /r/politics, rely

solely on news from outside sources for their posts. Both /r/worldnews and /r/politics also see more traffic than all of the other subreddits investigated in this study combined, with 22,138,787 and 5,411,256 subscribers, respectively. On the four other subreddits – /r/climate, /r/climatechange, /r/The_Donald, and /r/climateskeptics – the importance of outside sources was no less significant. Out of the 400 posts from the four subreddits sampled in this study, 345 of the posts included links to outside sources. Thus, what Reddit users believe is important in the traditional media conversation is what appears in these popular Reddit communities.

This study's findings for the first research question were like that of previous studies. Like O'Neill et al.'s (2015), Kim and Cooke's (2018), and Roxburgh et al.'s (2019) findings using a similar coding typology, Reddit users most often posted climate change stories that used the *political/ideological struggle* frame. Previous social media research has primarily investigated Twitter (e.g., Kim & Cooke, 2018; Roxburgh et al., 2019), a platform where politically homogenous groups form, so *political/ideological* frames are used often to put a "political spin on the public understanding" of climate change (Kim & Cooke, 2018, p. 16). Similarly, Reddit has subreddits where users can create communities to separate themselves into progressive and conservative groups as well as ideologically neutral communities that have no inherent political stance, such as /r/worldnews and /r/politics. Yet, within these last two communities there is a bias towards political news, as these subreddits only allow politically relevant articles from outside sources. Specifically, /r/politics' rules state that all posts must fall into one of two categories: 1) "information and opinions concerning the running of US governments, courts, public services and policy-making" or 2) "private political actions and stories such as demonstrations, lobbying, candidacies and funding and political movements, groups and donors." Also, it is likely that posts regarding climate change in that subreddit were

framed as *political/ideological struggle* since science journalism often relies on the conflict norm to attract readers (Dunwoody, 2014). Additionally, *political/ideological struggle* could be the most common frame because of the nature of the event. The 2019 UN Climate Action Summit was a gathering of political leaders from around the world. That a high number of stories on Reddit emphasized the conflict between these leaders or the political slant of climate change mitigation is unsurprising. Ultimately, the political framing of climate change is not only perpetuated by traditional media but is reinforced by politically engaged users making them the most frequent frame appearing in posts on Reddit.

After *political/ideological struggle* (24%), Reddit posts used relatively equal amounts of the *promotion/piggybacking* (13%), *unsettled science* (11%), and *settled science* (10%) frames. The *promotion/piggybacking* frame indicates that posts did not focus directly on climate change, but rather used climate change to discuss a range of tangential issues/people/events. For instance, a post that was discussing French President Macron's primary policy concerns discussed climate change briefly, but later focused on France's economy, public discontent, and religious extremism. Therefore, since the focus of the article was not Macron's attitudes towards climate change, the article was coded as *promotion/piggybacking*. The most common tangential events in the dataset being discussed were climate change protests and walk-outs. While related to climate change, posts discussing these events did not fit into any of the other categories and were thus delegated to the *promotion/piggybacking* frame. Future work should include a frame that involves community action or protests for climate change, as done by Painter et al. (2018), who included a *civil society protests* frame in their study. Finally, the *uncertain science* frame, which questions the realities of climate change, was the third most common frame, followed by *settled*

science. Since this study sampled from polarized subreddits, that the posts reflect the polarized debate of climate change is unsurprising.

While *political/ideological struggle* was the most common frame overall, the results of the second research question indicate there was a significant difference between how often the frames appeared in different subreddits. For instance, the *settled science* frame was used in 10% of all posts but appeared only in the climate believer and neutral subreddits. This suggests that individuals who frequent the subreddits selected to represent an ideologically neutral group are more likely accept what climate scientists are saying about climate change. There were no *settled science* posts in the climate skeptic subreddit. Similarly, *uncertain science* was used in 11% of all posts but appeared predominantly in the climate skeptic subreddit.

Similar to *settled science*, *disaster/security* and *health* frames appeared only in the climate believer and neutral subreddits. While it would be unlikely for individuals posting in climate skeptic communities to discuss the potential humanitarian consequences of a problem they do not believe to exist, the number of *disaster/security* and *health* frames even in the other subreddits were relatively low. While *disaster/security* frames appear commonly in traditional media, it is not as likely in social media (e.g., O'Neill et al., 2015) and the proportion of *disaster/security* posts found in this study is like previous findings on Twitter (e.g., Kim & Cooke, 2018). The *disaster/security* frame in traditional media “makes commercial sense” because it engages the public, but it may not appear in social media as often because it may also “actively disengage audience from feeling a sense of self-efficacy” (O'Neill et al., 2015, p. 383). Previous research shows that the proportion of *health* frames appearing in traditional and social media climate change conversations is relatively low (e.g., O'Neill et al., 2015; Painter et al.,

2018; Roxburgh et al., 2019) and thus people who are engaged in any subreddit, regardless of their beliefs, are unable to repost articles with that frame because they just do not exist.

While not a frame, nearly a fifth of posts were coded as *unknown/other*, which has important implications for this study. Coders were instructed to use this frame when the principal frame could not be determined with reasonable confidence due to a lack of context, the post did not align with any of the existing frames, or the post had a Reddit-specific purpose. In the first case, a post would be coded as *unknown/other* because too many parts of the post were previously deleted. Since the subreddit */r/The_Donald* was banned, many of the linked articles or the body of the posts did not exist, leaving many coders unsure of how to code only a two-word title of a post. This may be why most *unknown/other* posts were in the climate skeptic groups. Another common occurrence with the data set was that coders did not know how to code humor, as it did not clearly fall into any specific category of the coding typology. A few of the posts included comics or memes about Greta Thunberg which were difficult to code when using a coding typology designed for analyzing a serious political event. In a similar vein, coders were unable to code for posts that had a Reddit-specific purpose. For instance, a poster asking the */r/climate* community for advice about managing their anxiety or posts talking about Reddit moderators were coded as *unknown/other* since they did not fall into any of the coding categories. Ultimately, selecting a different subreddit and improving the coding typology should resolve these issues.

While many posts did not fit into the preexisting typology, by developing the new frame – *words vs. action* – this study was able to categorize over 5% of all posts. *Words vs. action* describes posts that emphasize hypocritical actions such as protesters at a climate change rally leaving heaps of trash at the rally location, or celebrities who advocate for climate change

mitigation policies but then fly their private jets to a climate change conference. Van Gorp (2007) states that there is a “stock of frames” that evolves with the culture of the time (p. 62). *Words vs. action* is a frame that is used in the public discourse today when individuals’ actions are hyperanalyzed. The *words vs. action* frame was found mostly in the climate skeptic group and was not found in the climate believer subreddits. It was used by the climate skeptics to point out the hypocritical nature in climate believers’ action and words, almost as an example of why climate change is a hoax and how it is being overly emphasized in the public sphere.

The next section discusses the findings of the final three research questions, which focus on the emotional responses to climate change stories on Reddit. The section begins with a brief overview of the findings of this study and then links this study’s findings to previous work. Lastly, implications are discussed.

Climate Change Posts and Emotion

Previous research on emotions has looked at individuals’ emotional response to news media about climate change impacts, actions, or both (e.g., Feldman & Hart, 2018). This study investigated the emotional responses to a more nuanced coding typology in a social media environment. This study investigated three research questions about the emotions appearing in the discussion sections of Reddit posts. First, this study asked which emotions were most expressed overall. Using LIWC, this study found that the most prevalent emotion expressed was anger, followed by hope. The least common emotion expressed was anxiety both in the overall sample and by subreddit. Second, this study investigated whether emotions expressed in the discussion sections differed based on the frames appearing in a post. Anger was the most frequently expressed emotion in all frames, except for *opportunity* and *disaster/security*, where greater amounts of hope were expressed. Lastly, this study analyzed which emotions appeared

most frequently in the distinct subreddit types – climate believer, climate skeptics, and ideologically neutral. Anger appeared more often in the climate skeptic and neutral subreddits, while hope was the most frequently expressed emotion in the climate believer subreddit. The following sections describe the findings for each emotion, link the findings to the theory, and finally discuss the implications.

Anger

Emotions play a key role in the perception of climate change risk, development of climate change beliefs, and ultimately mitigation policy support. By using appropriate frames, climate change stories can evoke emotions that can lead to greater concern, action, and support for policies, or that do the reverse. Anger, for instance, can reinforce existing opinions and lead to the greatest amount of polarization (Feldman & Hart, 2018). Anger discourages compromise and reinforces preexisting beliefs, so for individuals who do not support climate mitigation policies, anger is unlikely to increase support. However, for individuals who already support these policies, anger is likely to increase support.

In this study, anger was the most expressed emotion across most frames and was most frequently expressed in response to the *promotion/piggybacking* and *political/ideological struggle* frames. It was the most expressed emotion in the climate skeptics and the ideologically neutral subreddits and the least expressed in the climate believer subreddits.

These findings make sense considering previous research investigating climate change communities, emotion, and social media expression. In climate change discussions on Twitter, highly polarized individuals expressed greater negative sentiment (i.e., the expression of disagreement, disapproval, or criticism) towards the outgroup (Williams et al., 2015). In neutral subreddits, there is likely to be more interaction between individuals holding differing opinions

and thus, more anger expressed. Indeed, individuals in the neutral subreddits expressed significantly more anger than those posting in the climate believer group. However, individuals in the climate skeptic groups expressed nearly as much anger as those in the neutral group. Previous research has found no difference between the negative sentiments expressed by activist and skeptic groups (e.g., Williams et al., 2015). Because skeptics tend to interact more with members of the outgroup, they seem to be expressing more negative sentiments. However, overall, “they were not more negative than activists on a per-interaction basis” (Williams et al., 2015, p. 135). Thus, in this study, the climate skeptic communities may not be angry due to their interactions with others since they are in a homogenous community. Instead, the commenters’ anger could be in response to the frames that appear often in the climate skeptic group but not the climate believer subreddits, such as the *words vs. action* and *uncertain science* frames. In fact, the highest expression of anger in the /r/climateskeptic subreddit appeared in response to a post using the *words vs. action* frame describing climate change protesters leaving garbage at a rally site. Commentors responded to the situation with anger regarding the hypocrisy, saying that if they were to do something similar, they would be called out by these same protestors. In this study, climate believers may not be expressing as much anger because of the frames that appear more frequently in their subreddits such as *settled science*, *opportunity*, and *economics*. Ultimately, this study cannot determine what stimulus individuals are responding emotionally, the posts or others’ comments.

Emotional responses to climate change stories also may represent why the individuals are posting. Heiss (2020) notes that angry individuals are likely to participate in risk-seeking behavior (e.g., post on social media) because they feel that those in power are not adequately addressing social or political problems, such as climate change. Thus, the individuals in the

climate skeptic groups respond by posting when reading climate change stories about things that feel out of their control, such as political debates about climate change or the hypocrisy of the individuals in power. Individuals then turn to Reddit discussion sections as an emotional-coping method.

In the context of AIT (Marcus et al., 2000), emotional responses to posts on Reddit have important implications for attitudes towards climate change and ultimately, mitigation policy support. Angry individuals post more often and rely more on their pre-existing opinions. Thus, when posting on social media, angry individuals are either creating echo chambers that may or not be beneficial for climate change mitigation efforts or are engaging in discussions with individuals in the outgroup. Research has found that emotions on social media are contagious and can potentially affect off-line behavior (Kramer et al, 2014). Anger is correlated with greater support for climate change mitigation policies (Lu & Schuldt, 2016), but this may only be true in communities where support for mitigation efforts already exists. In the climate skeptic communities, anger may only lead to greater skepticism.

Hope

Overall, hope was the second most expressed emotion in the Reddit discussion posts. Hope was the most common in the *disaster/security* and *opportunity* frames and was the most frequently expressed emotion in the climate believer subreddit. The context of the 2019 UN Climate Action Summit could have stimulated the amount of hope present in the climate believer discussion sections. Some of the posts with the highest levels of hope were around the date of the event, such as a post about Scotland's "toughest climate change laws in the world" in which commentors praised the country's actions. Other posts introduced positive governmental actions, such as the state of Massachusetts suing Exxon over fraud and the Alaskan Supreme Court

hearing a climate change lawsuit. Overall, actions aiding the pro-environmental cause were viewed in a positive light in the climate believer groups and received hopeful comments.

Several other situations seemed to stimulate the expression of hope. A look at the Reddit dataset shows that a variety of posts had discussion sections where high levels of hope were expressed, sometimes sarcastically. For instance, one post where high levels of hope were expressed involved the mass levels of displacement that will occur because of climate change. The post stated that 150-300 million people worldwide would be displaced because of climate change and the comments were saying that the estimate was “optimistic.” LIWC categorized that emotion as hope, unable to catch the sarcasm. Also, hope was found in posts that discussed explicit actions taken by others. For example, some of the highest levels of hope were found in a post that included a video of a man addressing climate change protesters for blocking traffic. In this case, it could be that individuals are posting hopeful comments when they interact with content that they agree with or see individuals acting against the outgroup, be it the climate skeptics or climate believers. This is in line with Feldman and Hart’s (2018) finding that action-oriented text and images increase hope by offering “the promise of a desired outcome” (p. 587).

With regards to climate change, hope is strongly correlated with climate change mitigation policy support (Smith & Leiserowitz, 2014). Stories that focus on mitigating actions increase hope, which led to increased support of climate change mitigation policies for individuals along the political spectrum, but especially for conservatives (Feldman & Hart, 2018). “Conservatives, when feeling hopeful, are willing to moderate their opinion by increasing their support for policies that they otherwise may be reticent to accept” (Feldman & Hart, 2018, p. 599). Since liberals are likely to support these policies at the start, the effects of hope may not be as strong on them.

Anxiety

Anxiety was the least commonly expressed emotion in this study overall. It was also the least common emotion expressed in all frames, except for the *health* frame, and was the least common emotion expressed in all subreddit types.

Previous research has shown that climate change story frames can have a significant impact on readers' fear and anxiety levels and in turn, their response to climate change and potential offline behavior (e.g., Feldman & Hart, 2018). Although this study focused on anxiety, while fear and anxiety are "empirically distinguishable", they often co-occur in the climate change context (Clayton, 2020, p. 2). Hence, we draw on related research here. News stories that discuss mitigating actions individuals' might take can decrease fear and fear leads to the least amount of opinion polarization. When it comes to policy support, fear does not influence progressives but encourages support among those who were previously opposed to the policies (Feldman & Hart, 2018). However, emotions such as fear and anxiety can have a "boomerang effect" where too much leads to avoidance, denial, helplessness, and apathy (O'Neill & Nicholson-Cole, 2009; Taylor et al., 2014). Unfortunately, traditional media stories tend to focus on catastrophic consequences, increasing fear too much and decreasing individuals' concern for climate change (Hart & Nisbet, 2012; O'Neill & Nicholson-Cole, 2009).

The low levels of anxiety in this study were surprising but may be explained by previous research findings and AIT (Marcus et al., 2000). Anxious individuals are unlikely to post because they are more likely to avoid risk-seeking behaviors and may therefore remain as "lurkers" (Heiss, 2020), which may explain the low levels of anxiety appearing in the comments section of the posts. Another explanation for the relatively low expressions of anxiety is that anxiety often occurs in response to an uncertain threat (Lazarus, 2006). However, posts on

Reddit, particularly on the neutral subreddits where the lowest levels of anxiety were identified, are likely linked to outside articles. These articles may give the reader a direct target for their emotions, such as a political leader, meaning that the threat of uncertainty which might stimulate anxiety is no longer there.

Discrete emotions can have a substantial role in support for climate change policy (Smith & Leiserowitz, 2014). Individuals who feel anxious are not the individuals posting, for reasons outlined above. However, according to AIT (Marcus et al., 2000), anxious individuals activate their surveillance systems and participate in effortful processing of information. Since they are not relying on their habits and pre-existing beliefs, they are more likely to engage in political compromise. They seek out more information to deal with the threat and often show greater support for mitigation policies (Meijnders et al., 2001). Anxious individuals may be lurking on Reddit, seeking out additional information, but just not posting and expressing their anxiety and support for policies.

The following section will discuss Reddit as a research site. It will provide a brief justification for using Reddit, explore how using Reddit as a research site might influence the results, and delineate the benefits and limitations of the site.

Reddit

This study contributed to research by investigating Reddit interactions. In the climate change communication research, Twitter has been the most widely studied social media platform, while other platforms such as Reddit remain relatively ignored (Pearce et al., 2018). This study extended climate change communication research into Reddit since Reddit has higher engagement rates than most other social media sites, the demographics of Reddit users are unique, and it is a more textually oriented social media platform than platforms such as Twitter.

Research investigating the content in the Reddit discussion sections is nearly nonexistent (Straub-Cook, 2018). Because individuals can influence each other on social media, an analysis of the comments section is warranted (Kemp, 2019; Williams et al., 2015).

However, conducting a content analysis study on Reddit requires special considerations. In content analysis studies, researchers must decide on their population and take into consideration the fluid/dynamic nature of that population (Neuendorf, 2017). The fluid/dynamic nature of Reddit can be an obstacle to research. Comments and posts are constantly being added or deleted. Even after a post has been “archived” (meaning no further comments or vote changes can be made) posts and comments can be deleted by the user at any point (Weninger et al., 2013). In this study, thousands of comments were removed before the data collection occurred, meaning that those comments existed at some point but were not available in the analyzed conversation. Therefore, researchers should be careful when making any generalizations about the content (Amaya et al., 2019), and consider their data as cross-sectional in nature.

Finally, gatekeeping is an additional consideration to understand when using Reddit as a research site. Social media operate through second-level gatekeeping (Singer, 2014). The first level is held by the traditional media deciding which articles to publish, while the second level is held by social media users themselves by either upvoting or sharing posts to reach a wider audience. Since Reddit’s users represent a very specific demographic – liberal, white, young males – the information that reaches the front page is likely to represent their interests and opinions. Although this study sampled from a variety of subreddits, it is still likely that the sampled posts represent the views of the majority and the most active users.

Future research

This study is a first step to understanding the climate change conversation on a rarely studied social media platform, but much is left to be explored. Future researchers should continue to investigate the extent and type of climate change conversations that take place in the discussion sections in Reddit, where there is greater chance for textual analysis than other social media sites. Further emphasis should be placed on developing a more appropriate framing typology for researching climate change on Reddit. While O'Neill et al.'s (2015) climate change frames provided a solid foundation, 17% of posts were coded as *unknown/other* and the addition of *words vs. action* in the coding typology explained 5% of posts. That O'Neill et al.'s (2015) coding typology did not account for nearly a quarter of posts may be a result of using Reddit as a research site or of studying the 2019 UN Climate Action Summit. However, since most posts were linked from news media sources, it is likely that Reddit is not the reason that the posts did not align with the coding typology. O'Neill et al.'s (2015) coding typology was developed in consideration of both traditional and social media messages. It is more likely that it was the event itself that led to a quarter of the posts not fitting into the coding typology. O'Neill et al.'s (2015) coding typology was developed around the release of the IPCC report, a more climate science-centric event, rather than a global political meeting. Therefore, the types of conversation surrounding these events were not the same. Future research should include frames developed by Painter et al. (2018) in their coding typology for Reddit discussions on political events, as that study investigated the frames in web-based media surrounding the UN Climate Change Conference.

Additionally, further research should explore how posts and frames spread around Reddit to investigate peer influence. Williams et al. (2015) conducted a social network analysis study on

Twitter to understand the transmission of information and sentiment between subreddits. The study also examined the polarization of climate change conversations on Twitter. A similar study should be conducted on Reddit, to explore the posting and commenting patterns of individuals who subscribe to climate skeptic, believer and neutral subreddits.

When looking at the results related to emotions, it is important to consider how the use of LIWC as a computer-assisted textual analysis tool affected the study. In a study regarding LIWC's affect detection, McDonnell, Owen, and Bantum (2020) found that all LIWC versions, including the LIWC 2001 and LIWC 2015 dictionaries used in this study, were at least 80% accurate and highly sensitive when detecting emotion. However, although LIWC 2015 is good tool for detecting emotional responses, it was not built to understand the nuances of the shorthand text used in social media, such as emoticons (Tumasjan et al., 2011). Optimism, which was used as the measure for hope in this study, was removed from LIWC 2007 and LIWC 2015 versions because its emotional detection was poor (Pennebaker et al., 2015). Thus, the numbers for hope should be viewed with caution. Future research should consider use of an alternative linguistic analysis tool for social media content.

It is important to note that it cannot be determined to which part of the discussion individuals are emotionally responding. The textual analysis was conducted on all text in the discussion section at one time. Individuals could be responding to the content of the original Reddit post, to another comment in the discussion section, or to a completely unrelated issue. Future research could examine the difference in emotional responses in first-level comments, which are those that are posted in response to the story, and the emotions in deeper level comments, or those that are posted in response to other comments.

Anger was the most expressed emotion in the discussion sections of this study, which can lead to further entrenched opinions and polarization. Individuals who are expressing anger in their comments may be spreading anger among other users who read those posts and potentially affecting offline behaviors. Future research should explore if emotional contagion is occurring on Reddit and whether it is affecting individuals' offline behavior in the climate change context.

Limitations

This study had a few theoretical and methodological limitations that should be considered. First, conducting content analysis means understanding messages about a specific platform and time (Neuendorf, 2017). Therefore, this study of messages on Reddit surrounding the 2019 UN Climate Action Summit is not generalizable to other messages, social media platforms, time periods, or social media users (Amaya et al., 2019). However, this is potentially the case for all big data scraping research. "Big data are removed from human experience, so only gross summarizations of the outcomes of analyses can be comprehended, making the implications of findings on big data rather abstract and not always directly applicable to the human experience" (Neuendorf, 2017, p. 204). However, researchers have found that social media platforms are increasingly reflective of public opinion and sentiment (i.e., O'Connor et al., 2010; Shi et al., 2020). Therefore, although the generalizability of big data research is limited, the findings of this study may accurately portray public sentiment about climate change on Reddit immediately before and after the 2019 UN Climate Action Summit.

Methodologically, the limitations are worth noting. First, this study used the term "climate change" as the only criteria for selecting posts. Previous studies have shown that using the term "climate change" leads to a lot of false positives (e.g., Roxburgh et al., 2019). Therefore, a more comprehensive criteria selection as used by Roxburgh et al. (2019) could

provide a more relevant selection of climate change stories. An additional limitation involves the availability of the data. Because 100 out of the total 600 posts were from /r/The_Donald, a banned subreddit, coders came across many removed and deleted articles, images, posts, etc. For some of the posts, coders relied on the title of the post to make coding decisions because the full article/post was not available at the time of data collection. However, most posts were ultimately found by searching through the internet archives. This may have also affected the emotional results, as many comments from the /r/The_Donald were also deleted.

Conclusion

This study aimed to identify the most common climate change frames that appeared in response to the 2019 UN Climate Action Summit and to investigate the emotions that appeared in the discussion sections of these posts. Most climate change posts on Reddit focused on the political slant and users most often expressed anger in the discussion sections. While the study had a few important limitations, it begins elucidating on the climate change conversations being held on platforms other than Twitter. Future research should continue to explore Reddit, and other social media sites, to create a clearer picture of the climate change conversations taking place on social media. Reddit is neither a completely open forum where users consistently debate nor is it a completely isolated echo chamber and is thus a unique site to understand the ebb and flow of climate change discussions. Furthermore, emotion should continue to play a key role in climate change communication research. Nearly 50% of variance in climate change policy support is a result of emotional response to climate change (Smith & Leiserowitz, 2014). While emotions on Reddit, or other social media sites, may seem a small part of the conversation, understanding emotional responses in climate change discussions is the first step to creating an active and supportive public.

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Appendices

Appendix A

Codebook

Instructions for Coders

Always keep this document near you when coding, either the electronic version or a printed copy. Review the “Coding Guidebook” before each session you begin assigning frames.

To Begin:

- Open the Excel Sheet titled “Coding Sheet”
 - This document contains three tabs – training, individual posts, shared posts
 - Write your name and Coder ID at the top
 - You will use the “training” sheet only during group meetings
 - You will use individual and shared posts tabs when you code on your own
 - Individual posts are the posts which only you are responsible for coding
 - Shared posts are the posts which will be coded by every coder to determine intercoder reliability
- Open the Excel Sheet titled “Final Data”.
- The “Final Data” Excel Sheet will have two tabs – individual posts and shared posts.
 - For the posts in the “Individual posts” tab, your assigned posts will have your assigned coder ID next to them.
 - Each week you will be asked to code a subset of the “shared posts” in the “Shared posts” tab

To assign frames:

- After reviewing the “Coding Guidebook”, open the Excel Sheet “Final Data” to view your assigned posts for the week.
- For each post, take the “Post ID” from the “Final Data” Excel and transfer it to your “Coding Sheet” document. Make sure to pay attention to whether the post is from the individual tab or the shared tab. Place the post ID in the appropriate tab.
- Next, while on the “Final Data” Excel:
 - Read the title of the post
 - Read the body of the post
 - Read the article linked to the post (if applicable)
- All posts should be coded according to the coding schema attached
- Pay particular attention to the presence of:
 - Keywords, phrases, metaphors
 - Stories
 - Context (e.g. subreddit, title)
- Using the coding schema attached, identify the dominant frame of the post. Write the corresponding Frame Code (0-11) in each row in “Coding Sheet”.
 - Dominant Frame – look at the what the main point of the article is. If there are other frames included to support the dominant frame, only code for the dominant frame

- What is the intent of the poster? Think about subreddit, post title, and outside link when deciding.

Potential Scenarios:

- If the article does not have body or outside link, use N/A in the appropriate column (DO NOT WRITE N/A IN THE DOMINANT FRAME COLUMN)
- If you cannot **confidently** identify the frame, place the number “0” in the appropriate column.
- If a post is deleted, use the Wayback Machine (<https://archive.org/web/>) to access the post. You should also be able to access some outside links from this site.
- If the outside link is deleted, try Incognito mode first and then Outline.com. If you still cannot find it, then code using only the visible parts of the post.
- Even if only one part of the post is available, write the dominant frame.
- If you encounter a page with multiple stories, read only the one relevant to the post (i.e., they share a title).
- If you encounter a title that you do not understand, go back to title after reading article (e.g. “Great tits are on the verge of mass extinction”)

Consider

- What happens if multiple frames are present and I can’t decide which to choose?
 - Think about the intent of the post. Take into consideration the subreddit, title of post, and the outside article. What is the poster trying to get across?
 - If you had to summarize the post in one sentence what would it be?
 - If politicians are involved in a post, more likely than not, the post will be PIS (if their conversation is about climate change) most times.

Appendix B

Frame Typology

Frame	Frame Code	Description	Problem Definition	Keywords	Examples in Title	Example in Body	Example in External Link
Settled Science	1	Focus on the broad consensus of experts around the science of climate change. SS1: Affirming that the fundamental science of climate change is settled. SS2: Criticism of those promoting climate change skeptic views.	Emphasis on the science of climate change and human cause. Expert consensus on climate change Any uncertainty about reality of climate change (not extent of climate change) must be squashed If no mention of challenging uncertainty, then it is unsettled science (US) frame	‘settled science’ ‘unequivocal’ nature of climate change Reference to ‘scientific truths’ – how can others not act? Is happening Unnatural weather Global temperature rises Data supporting climate change Cause & effect of climate change	47 years ago, scientists predicted climate change Climate change isn’t a debate, it’s already here	Don’t we know this all already? And you’d be right.	The world is drifting steadily toward a climate catastrophe. For many of us, that’s been clear for a few years or maybe a decade or even a few decades.
Uncertain Science	2	Like Settled Science, this frame assumes a linear relationship between scientific evidence and policymaking –	Like Settled Science, this frame assumes a linear relationship between scientific evidence and policymaking –	‘not sure’ Scientists are in ‘hysteria’ or ‘puzzled’ ‘global warming believers’ Hoax	Climate chaos...will cause us all to die some day (maybe) Man made climate change is a hoax	Fake climate change predictions How can we take them seriously?	Discussion on previous periods when the earth was really warm

Frame	Frame Code	Description	Problem Definition	Keywords	Examples in Title	Example in Body	Example in External Link
Political/ Ideological Struggle	3	<p><i>but here there is (still) a lack of scientific evidence to justify action.</i></p> <p>A generic frame. Can lead to polarization of audiences if highly partisan. Political actors are the principal actors in the message; mentions of ideology (Republican vs. Democrat); political job assignment</p>	<p><i>but here there is (still) a lack of scientific evidence to justify action.</i></p> <p>A conflict over the way the world should work; over solutions or strategy to address climate change Does not include disagreements over scientific evidence. A battle for power (for example, between nations or personalities).</p>	<p>‘battle’ or ‘war’ Government is ‘confused’ Talk of climate change policy details (e.g. country plans at Climate Action Summit)</p>	Gov. Gavin Newson causes political firestorm		Climate change should be top priority for Boris Johnson
Role of Science	4	<p>This frame focuses on</p> <p>a) the institution of science and the role science and scientists play in society</p> <p>b) media reporting focused on the process of</p>	<p>Process or role of science in society (does not focus on actual climate change evidence, that is SS/US). Debate over transparency, funding, or awareness of science.</p>	<p>Manipulation of scientific information Peer reviewed articles Media bias False balance Amount of time given to discuss this issue on the media</p>	<p>Tweak algorithms to prioritize factual information Science is corrupted Media censorship</p>	<p>Climate scientists are like parasites. They survive on the reputation of result driven, truth seeking scientists that created rockets, computers and modern medicine.</p>	U.S. gives way too much time to air time to climate change deniers

Frame	Frame Code	Description	Problem Definition	Keywords	Examples in Title	Example in Body	Example in External Link
		conducting climate science. c) conversations about the public discussion of climate change, how to most effectively talk about climate	May include public opinion, understanding, and knowledge of science. If mention of political actor's role in manipulation, then PIS				
Disaster/ Security	5	Links impacts of climate/weather extremes on <i>people and environment</i> . A threat to human security. Could be energy, water or food security, or a threat to the nation state (for example, migration). Impacts on humans and animals	Impacts of climate change are dire. Vulnerable are impacted already. Threaten all aspects of life. Focus on overwhelming damage to <i>environment, animals, and humans</i> .	Frightening language Flooded homes Coral reefs in danger Scale is "overwhelming" Water security	Hundreds of reindeers starve to death Climate change could trigger a global food crisis Climate change could displace 150 to 300 million people	Unprecedented wildfires affecting humans	Worrisome climate records Entire ecosystems are collapsing If climate change is left unchecked, rising temperatures, extreme weather and land degradation could trigger a global food crisis
Morality and Ethics	6	An explicit and urgent moral, religious, or ethical call. ME1: for action. Strong mitigation, and	ME1: Strong mitigation and protection of the most vulnerable ME2: Scientific uncertainty	Ending world hunger' Moral responsibility Ethics God	ME1: Partnering to protect the vulnerable ME2: Climate change hysteria is amoral		Environmental injustices No community gets left behind Caring about the climate is the

Frame	Frame Code	Description	Problem Definition	Keywords	Examples in Title	Example in Body	Example in External Link
Opportunity	7	protection of the most vulnerable. ME2: for no action. Likely to discuss scientific uncertainty O1: Taking action in the face of climate change will give us an opportunity to create a better life moving forward. Talk of promising solutions O2: Climate change itself will improve the way we live, such as through CO2 fertilization for agriculture	Mention of God, ethics, and morals Climate change provides opportunities. Either O1: as a way to re-imagine how we live; for example, to further human development, to invest in co-benefits. O2: there will be beneficial impacts so no intervention is needed. Likely to mention uncertainty	O1: rich with opportunity, time for innovation, improve lives now O2: Opportunity to transform trade or resource extraction	O1: Scientists and entrepreneurs are working on some innovative solutions. O2: Climate change turns Arctic into economic hotspot		Christian thing to do You have a moral responsibility to stop climate change O1: Businessman and scientist working together O2: Oil, natural gas, and rare earth materials are waiting to be extracted once ice recedes
Economics	8	E1: Frame that focuses on economic analysis of climate change mitigation action, such as	Discusses growth, prosperity, investments, markets. Provides economic costs. Economics	E1: Economic damage if no action is taken E2: action will damage economic growth; killing industry,	E1: “Defund military” and spend it on climate change” E2: Climate change is all about killing capitalism and	E2: ‘Fixing’ climate change seem predicated on establishing left wing/socialist economies	E2: “Capitalism must be destroyed in order to save the planet”

Frame	Frame Code	Description	Problem Definition	Keywords	Examples in Title	Example in Body	Example in External Link
		divestment from fossil fuels E2: Economic justification for no climate change action (different than O1/O2 because E1/E2 includes talk of economic impact of (in)action)	implies either E1: Details potential economic actions (for example, divestment). E2: action is hugely expensive (or too costly in context of other priorities). Likely to mention uncertainty	imposing costly energy efficiency requirements	replacing it with socialism		
Health	9	Focuses on the health impacts of climate change on the individual human. D/S focuses on environmental effects while H focuses on effects on human body (i.e. D/S is crop failure and food supply, H is malnutrition).	Climate change poses a danger to human health (e.g. malnutrition, insect-borne diseases, air quality). Urgent mitigation action required.	Health, wellbeing, livelihoods, and survival are compromised Malnutrition Disease If D is present but emphasis is on effects on health, code for H.	Human body close to thermal limits Europe witnesses record heatwave, Netherland sees 15% increase in deaths		Australian Medical Association declaring climate change a health emergency Climate change could affect the spread of Ebola Climate change may be aiding a deadly fungus in infecting humans

Frame	Frame Code	Description	Problem Definition	Keywords	Examples in Title	Example in Body	Example in External Link
Promotion/ Piggybacking	10	CC/OA issues not addressed directly, emphasis is on self-promotion or promotion of a tangential issue/event/product (such as a walk-out/strike).	Is climate change the main topic of discussion? If not, then PP.		Notice how 'White Nationalist' is being used intentionally. The idea is to then lump nationalism into the same camp. Also ref: climate changing~manmade climate change		Billionaire David Koch, a key supporter of the climate change denial industry, is dead.
Words vs. Action	11	Focuses on the words and actions of climate change believers & skeptics. Used often by climate skeptics but may be used by believers to point out the discrepancy between words and actions/words.	Climate change believers or skeptics, celebrities, countries, etc. say one thing but their actions contradict their supposed beliefs.	Flying in private jets Buying oceanside mansions	Katy Perry attends Google summit in private jet Obama buys oceanside mansion Climate activists leave piles of trash	Bono's foundation is riddled with fraud	Global elites take to the skies to attend Google Summer Camp
Unknown/ Other	0	The principal frame cannot be determined with reasonable confidence or does not align	Lacking context Do not have enough information to make a judgment	e.g. Lists of resources w/o context or instructions e.g. Reddit specific posts			

Frame	Frame Code	Description	Problem Definition	Keywords	Examples in Title	Example in Body	Example in External Link
		with any of the above definitions.		such as surveys, talk about subreddit, etc.			