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The Perils and Promises of Using Online Survey Experiments to Study (Visual) Frames in Science Communication

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The Perils and Promises of Using Online Survey Experiments to Study (Visual) Frames in Science Communication

by

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ABSTRACT

It is important to identify methods for effectively communicating about the issue of climate change with the public. The inherent complexities of climate science, and existing partisan divisions and polarization on the issue makes finding ways to effectively communicate information with messaging that resonates with diverse audiences crucial for developing the public consensus needed to take the necessary actions, develop strategies, and support policies intended to address and mitigate the current and future threats posed by climate change. In this dissertation, I present the results of a 7-condition, two-wave survey experiment exploring the impact of textual and visual frames highlighting a geographically and socially proximate impact of climate change - projected coastal flooding that will occur in US coastal communities resulting from future sea level rise – on climate change beliefs. I show that exposure to these frames can influence individuals' climate change beliefs and opinions. Moreover, I present evidence that visual frames and imagery, which remain understudied in the literature, can produce treatment effects that are stronger than textual frames alone. Further, I provide an analysis of communication effects over time, showing that both the textual and visual frames can produce durable treatment effects that, while susceptible to decay, are able to persist over time. And finally, I provide a detailed discussion of the emerging issues of low quality and fraudulent data in the online surveys and survey experiments, including strategies for scholars to safeguard their studies, prevent problematic respondents, bolster data quality, and protect the validity of inference and social science research.

INDEX WORDS: Public opinion, Political communication, Science communication, Climate change, Political behavior, Framing theory, Emphasis frames

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DEDICATION

For Kristie and JB — Thank you.

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1 INTRODUCTION

In recent decades, a scientific consensus has emerged about the existence of climate change and evidence of anthropogenic causes. At the same time, there has been a growing awareness about the dangers that climate change poses to the environment and society. Global shifts in Earth's average weather patterns, rising temperatures, rising sea levels, ocean acidification, changing ecosystems, and other manifestations of climate change can have far reaching economic, environmental, national security, and social impacts that make addressing climate change an urgent political and policy priority. Despite the evidence about anthropogenic climate change and the need to take immediate action to address the issue, the public remains sharply divided about the existence of climate change, the nature of climate science, and the myriad of policies meant to mitigate its future effects.

Communicating effectively with the public is important for developing the understanding, consensus, and willingness to act required to address the collective action problems facing society. This is particularly true for the issue of climate change. For this reason, scholars have become increasingly interested in finding ways to effectively communicate about the issue of climate change with the public and identify messaging that resonates with diverse audiences. A growing literature examines how exposure to different *frames in communication* – words, phrases, images, symbols, presentation styles – that highlight specific considerations about an attitude object (e.g. a policy, candidate, issue, etc.) can influence climate change beliefs (Chong and Druckman, 2007; Druckman, 2001; 2011). Much of this existing work focuses on framing experiments that test how exposure to different *emphasis frames* highlighting different aspects of climate change – including the existence of a scientific consensus, the nature or state of climate science, and the variety of environmental, economic, national security, and social consequences

of its effects – can influence beliefs about the existence of climate change, perceptions of the risks and threats, concern about the impacts, and willingness to take personal action or support policy meant to mitigate its current and future effects (Kahan et al., 2012; Lewandowsky et al., 2013; O'Neill et al., 2015).

Existing work shows that emphasis frames highlighting different aspects of climate change have the potential to influence individual beliefs and opinions. However, partisan divisions, political polarization, and the inherent difficulties in communicating complex information like climate science leaves a pressing need to identify additional strategies for effectively communicating with the public about the issue of climate change.

1.1 Chapter Outlines

The purpose of this dissertation is to contribute to the literature on framing in political science, climate change communication, and science communication. In the chapters to follow, I present three essays on the use of survey experiments to test the effects of exposure to both textual *and* visual emphasis frames highlighting climate change and sea level rise on climate change opinions and beliefs. In doing so, I aim to make three contributions to the literature: (1) provide new insights into the effectiveness of visual frames in imagery that have received significantly less scholarly attention than textual emphasis frames to date, (2) move beyond the one-shot, cross sectional approach that is common across existing framing experiments and investigate the power and durability of both visual and textual framing effects over time, and (3) offer insights into the emerging threats to data quality in online surveys, and highlight practical solutions to safeguard data quality and study quality for scholars conducting online survey and survey experiments. I will now give a brief overview for each chapter.

Chapter 2 investigates the effects of exposure to visual frames and imagery, and a traditional textual frame, communicating climate change-induced sea level rise and the effects of subsequent coastal flooding on coastal communities in the United States on impact perceptions, concern for coastal communities, and broader beliefs in the existence of climate change. In this analysis, I build on the prior work of Bolsen et. al (2018) by both replicating and extending the authors' four condition experiment and administered a 7-condition survey experiment to an original sample of 1,050 respondents. I find that the textual frame, and the novel visual frames and imagery, effectively influence perceptions of the negative impacts, concern for these coastal communities, and belief that climate change is happening. Further, I find evidence that visual imagery may exert an effect that is independent over the textual frame alone.

In Chapter 3, I present an analysis of the power and persistence of these visual and textual framing effects over time. The analysis relies on data obtained from a follow up study to the survey presented in Chapter 2, in which participants were invited to complete a follow-up survey one week later. By incorporating an over-time component into the study design, I am able to use this data to investigate the differences and similarities in the duration and decay of textual and visual framing effects over time. Among the results, I find that the frames highlighting future inundation that will occur in US coastal communities resulting from climate change-induced sea level rise to be able to produce relatively durable framing effects. Further, the results suggest that, while there is some evidence of decay, frames were able to produce treatment effects capable of extending beyond the time of initial exposure. And finally, I report some preliminary findings that suggest there may be differences in the persistence and decay of visual and textual framing effects over time.

In Chapter 4, I discuss the increasingly common issue of low-quality and fraudulent data in online surveys and survey experiments, and the threat that these fraudulent data pose to inference and the integrity of studies in the social sciences. Specifically, I discuss the challenges conducting online surveys and survey experiments, with a focus on the different common drivers and sources of low-quality and fraudulent data in an online study. Following a description of these common sources of these data quality concerns, I present a series of practical and (relatively) easy to implement solutions using software commonly used by social science researchers. By detailing the common sources of low-quality and fraudulent data, and providing practical solutions that can be implemented by novices and experts alike, the essay contributes some practical knowledge for preventing and identifying low-quality and fraudulent data, and for protecting the power of study designs, validity of inference, and the legitimacy of social science research more broadly.

2 CHAPTER 2: THE IMPACT OF FRAMES HIGHLIGHTING COASTAL FLOODING IN THE USA ON CLIMATE CHANGE BELIEFS: A REPLICATION AND EXTENTION

2.1 Introduction

Scholars have become increasingly interested in understanding how to effectively communicate with the public about the issue of climate change. A large literature explores how messaging that highlights varying aspects of climate change – including the economic, environmental, national security, and more complicated considerations like the state of climate science and whether a scientific consensus exists – affects a range of beliefs about climate change, including perceptions of the existence and threat of climate change, feelings of personal efficacy, willingness to take personal action, or support policies intended to mitigate its future effects. Much of this existing work examines how exposure to different *frames in communication* that highlight specific considerations about the issue can influence people's climate change beliefs.

A large literature exists exploring how exposure to different "emphasis frames" influences beliefs about climate change, only recently, however, have scholars begun to study the effects of climate change imagery and visual frames on individuals' opinions and beliefs. In this research, I focus on a recent study in this area from Bolsen, Kingsland, and Palm (2018) and explore how textual and visual frames highlight future coastal flooding that will occur in US communities as global temperatures continue to rise influence climate change beliefs.

I developed and implemented a survey experiment that both replicates and extends the work of Bolsen et al. (2018) and find that exposure to both textual and visual frames highlighting the impacts of coastal flooding on coastal communities increases the perceived negative impact

on coastal communities, concern for these coastal communities, and belief climate change is happening. The results also offer evidence that, while both textual and visual frames are effective, visual imagery may have an independent effect over text alone.

2.2 Emphasis Framing and Climate Change

A growing body of research exists exploring how messaging influences beliefs about climate change. Much of the existing work in this area focuses on how exposure to different frames can affect individual opinions and beliefs about varying aspects of climate change. A frame in communication is defined as a word, phrases image, or presentation style that highlights a subset of potentially relevant considerations about a salient attitude object, for example, a political candidate, policy, or issue (Chong & Druckman, 2007, Druckman, 2001, 2011).

Framing theory describes an attitude about a given attitude object as a function of the salience and weight assigned to the different evaluative dimensions and considerations about the object (Chong & Druckman, 2007a, 2007b). Frames can influence opinion formation process by altering the "weight" assigned to a specific consideration; when an individual is exposed to a message or communication that highlights specific dimensions, considerations, or ways of thinking about an issue, this "frame" can become more salient and cognitively accessible. As a consequence, the specific dimensions or considerations emphasized can be privileged information that is relied upon more heavily (e.g. "carry more weight") in the opinion formation process than otherwise had the individual not been exposed to the communication. This is known as a framing effect or emphasis framing effect (Druckman 2001, 2011; Chong and Druckman 2007).

Frames can provide "interpretive storyline that set[s] a specific train of thought in motion, communicating why an issue might be a problem, who or what might be responsible for it, and

what should be done about it" (Nisbet, 2009 p. 15). Experimental studies show that frames emphasizing different aspects of climate change – such as the economic, environmental, national security, and public health risks, or other considerations regarding the science or the existence of a scientific consensus – can influence individuals' beliefs about the existence of climate change, concern about the risks and impacts, willingness to take personal action, and support public policies and strategies to mitigate its effects (Kahan et al. 2012; Myers, Nisbet, Maibach, and Leiserowitz, 2012; Lewandowsky, Gignac, & Vaughan, 2013; Nisbet 2009; O'Neill et al. 2015; Bolsen & Druckman, 2018; Bolsen, Kingsland, and Palm 2018). For example, Lewandowsky et al. (2013) examined how exposure to a frame highlighting that 97% of climate scientist believe in anthropogenic climate change influenced beliefs. The authors found that exposure to the frame emphasizing this scientific consensus increased beliefs that a scientific consensus exists, acting as a gateway belief that impacts support for action and other fundamental beliefs.

2.3 Visual Imagery and Framing Climate Change

While a robust literature exists examining emphasis frames and climate change beliefs, studies investigating the effects of climate change imagery on citizens' opinions and behaviors are fewer in number (Bolsen et al. 2019, 2018; Hart and Feldman 2016; Leiserowitz 2006; Myers et al. 2012; O'Neill 2013; O'Neill, Boykoff, Niemeyer, & Day, 2013; O'Neill & Nicholson-Cole,2009; Sheppard 2005). Existing research in this area shows that the visual presentation of information can improve engagement and information retention versus text alone (Graber, 1990; Powell, Boomgaarden, De Swert, & de Vreese, 2015). This increased engagement is, in part, due to the unique characteristics of visual imagery over text-based information. O'Neill and Smith (2014) explain that "images have several qualities that aid in information exchange: they can

draw viewers in through vivid and emotive portrayals, they aid in remembering information, and… they can transcend linguistic and geographical barriers" (p. 73).

Effective visualization of climate change data can reduce difficulty in comprehension, limit misconceptions, and potentially improve climate change communications (Harold, Lorenzoni, Shipley, and Coventry, 2016). Moreover, visual frames and imagery often pair well with text-based information, often producing stronger framing effects (e.g. Feldman & Hart, 2018; Graber, 1996; Powell et al., 2015). For example, Hart and Feldman (2016) found that exposure to images of solar panels accompanied by a call-to-action increased feelings of personal efficacy, as well as indirect effects on measures of individual behavior change including intentions to engage in energy conservation. In another study, Van der Linden et al. (2014) found that combining simple visual frames with textual information can increase belief that a scientific consensus exists.

Visuals that highlight specific aspects of climate change can affect engagement with the issue and influence individuals' beliefs and behaviors (Hart and Feldman 2016; O'Neill and Nicholson-Cole 2009; O'Neill et al. 2013; O'Neill and Smith 2014; Bolsen et al. 2018; Bolsen et al. 2019). Imagery can influence perceptions about the people and places that may be at risk from climate change impacts. Existing research shows that common media depictions of climate change include images that highlight socially or spatially distant locations - such as pictures of polar bears, melting glaciers, industrial smokestacks, or political considerations (Feldman et al. 2015; Lorenzoni et al. 2006) – that can contribute to a "psychological distancing effect." This psychological distancing can lead individuals to perceive climate change as something that will predominantly affect future generations and occur in distant locations instead of in familiar and

local communities (Lorenzoni et al. 2007; Pidgeon and Fischoff 2011; Scannell and Gifford 2013).

One strategy to reduce this psychological distance and promote engagement is to communicate about the local and regional effects of climate change on familiar people and places (Bolsen, Kingsland, and Palm 2018; Bolsen, Palm, and Kingsland 2019; Bolsen & Shapiro, 2018; Leiserowitz, 2007; Spence, Poortinga, & Pidgeon, 2012; Scannell and Gifford 2013; Sheppard 2005). For example, Scannell and Gifford (2013) exposed respondents to information about a general global impact of climate change, or detailed information about the impacts of climate change on the respondents' local area. The authors found that exposure to the detailed information on the local impacts of climate change significantly increased levels of climate engagement relative to the control group, while the information on general global impacts did not have a significant effect.

In this area, scholars have incorporated visual frames communicating the local impacts of natural disasters caused by climate change - such as maps showing coastal flooding resulting from sea-level rise and heat waves contributing to extreme droughts - and found that maps highlighting these future impacts may be an effective means of shifting people's risk perceptions and beliefs. For example, Retchless (2017) found that exposure to interactive maps showing the impact of coastal flooding in Florida shifted risk perceptions among respondents that were initially uncertain or doubtful about climate change. In another study, Bolsen et al. (2018) exposed respondents to frames containing animated maps highlighting the effects of coastal flooding resulting from sea-level rise on two U.S. cities (Boston and Miami) and found that individuals increased perceptions that climate change will have a negative impact on U.S. coastal cities, expressed greater concern about the effects of climate change on U.S. communities, and

increased their belief that global warming is occurring. Following this line of research, Bolsen et al. (2019) manipulated text frames and visual imagery using two environmental hazards associated with climate change – sea level rise with associated coastal flooding and increasing heatwaves with associated drought and wildfire – and found that visual imagery was not only able to shift risk perceptions and beliefs, but also counteract the negative effects of politicization on these beliefs.

Taken together, there is a growing literature that examines how exposure to different emphasis frames can influence individuals' perceptions and beliefs about climate change. Yet, much of this body of work focuses on experiments examining the effects of exposure to different textual frames and interventions, and only recently have scholars begun to examine the impact of visual frames and climate change imagery on individuals' opinions and behaviors. The existing studies in this nascent area of research suggest that use of visual imagery can potentially enhance communications with the public about the climate change and shift people's risk perceptions and beliefs about the issue. Further, prior experiments show that maps highlighting the projected coastal flooding resulting from climate change induced sea level rise may be a particularly effective way of communicating with audiences. However, the existing experiments are few and have not been replicated on different samples, leaving "their potential for engaging audiences remains largely unevaluated" (Retchless 2017, pg.6).

2.4 Previous Study

In prior research, Bolsen, Kingsland, and Palm (2018) examine how exposure to text-based and visual frames highlighting the impact coastal flooding resulting from temperature induced sea-level rise on US coastal cities individuals' climate change beliefs. Respondents (n = 729) were recruited using Amazon's Mechanical Turk in May 2017 and randomly assigned to

one of four experimental conditions. The treatment conditions included a text frame emphasizing the effects of sea-level induced coastal flooding, and two additional treatments incorporating a set of animated maps showing the localized effects of projected coastal flooding in Boston and Miami.[1] In their analysis of the experimental data, Bolsen et. al (2018) found that exposure to the text only and visual frames significantly increased, relative to the control group, respondents' perceptions of the negative impact of coastal flooding, concern for coastal communities, and belief that global warming is occurring.[2]

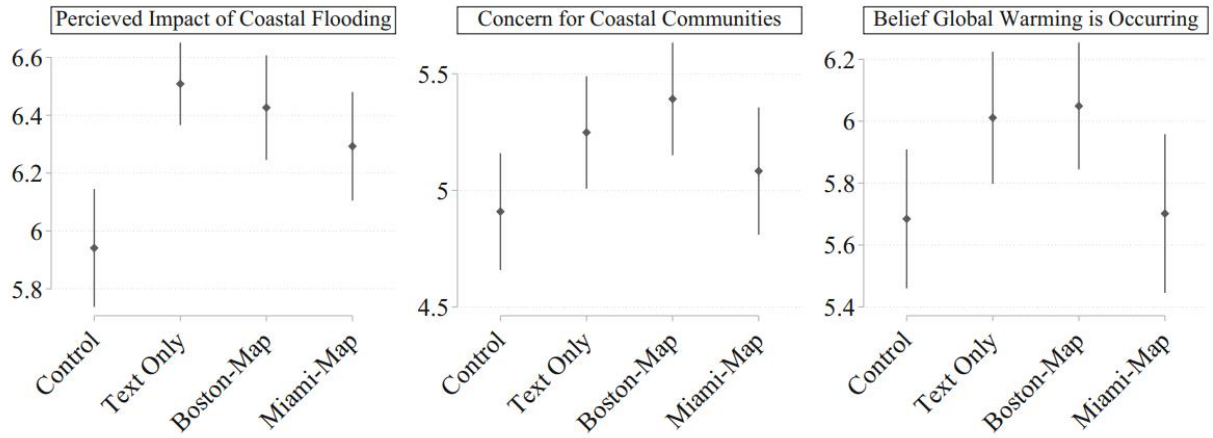

Fig. 1 Experimental treatment effects on dependent measures. Dots represent estimated group means, with error bars representing a 95% confidence interval

Figure 1: Experimental Treatment Effects from Bolsen et. al (2018)

Among the central findings, the results of the analysis show that exposure to a textual frame highlighting the impacts of sea level rise on US coastal cities, and frames including the animated maps emphasizing projected flooding in Boston and Miami, increased perceptions that sea level rise will negatively impact coastal communities in the United States relative to the control group (Text Only v. Control, diff. = 0.57, $p < .01$; Text + Boston Map v. Control, diff. =

[1] Animated maps were created with flood projection images produced by Climate Central's "Surging Seas: Seeing Choices" tools. Available at: https://sealevel.climatecentral.org/
[2] Presented in Figure 1, taken from Bolsen, Kingsland, and Palm (2018)

0.49, $p < .01$; Text + Miami Map v. Control, diff. = 0.35, $p < .01$). Respondents exposed to the text only and Boston map frames also expressed increased concern about the effects of climate change on coastal communities (Text Only v. Control, diff. = 0.34, $p < .10$); Text + Boston Map v. Control, diff. = 0.48, $p < .01$) and increased belief that climate change is occurring (Text Only v. Control, diff. = 0.33, $p < .05$; Text + Boston Map v. Control, diff. = 0.37, $p < .05$) relative to the control group. Interestingly, the animated map of Miami did not have a significant effect on concern (Text + Miami Map v. Control, diff. = 0.17, p =ns) and belief that climate change is occurring (Text + Miami Map v. Control, diff. = 0.02, p =ns) relative to the control, and was less effective than the Boston map (Text + Boston Map v. Text + Miami Map, diff. = .31, $p < .10$) in increasing concern and belief climate change is happening (Text + Boston Map v. Text + Miami Map, diff. = .35, $p < .10$).

On the effects of the textual and visual treatments, the authors found "[e]xposure to the textual frame highlighting sea level rise and coastal flooding in the USA as a result of polar ice melt appears to be a strong and impactful communication frame," and note that "[w]hile we do not find that the animated map produces any significant effect on any of the dependent variables beyond exposure to the textual frame alone, individuals in the Boston map condition reported slightly, but not significantly, higher levels of concern and belief in the existence of global warming relative to the textual frame alone" (Bolsen et al., 2018 p. 364).

2.5 Motivation and Research Questions

The experiment and conclusions from Bolsen et al. (2018) raise additional questions about the effects of textual and visual frames on climate change beliefs that warrant investigation. In their work, the authors find that exposure to the textual and visual frames emphasizing the effects of sea level rise and coastal flooding on the US, Boston, and Miami

influence risk and impact perceptions, concern, and belief that climate change is occurring. Yet, this experiment has not been replicated. Will the results replicate on different on a different sample at a different time?

Further, the results of the analysis indicate that the maps were generally impactful, however, exposure to the Boston map was more effective at generating concern and increasing belief that climate change is occurring than the Miami map. The authors explain, "we can only speculate about why the animated map of Boston had a greater impact than that of Miami" on responses (p. 366) and question whether unique characteristics of the selected locations – such as the novelty of flooding in Boston compared to more familiarity with (often hurricane-related) flooding in Miami – might explain the differential impacts of the Boston and Miami maps. The selection of two coastal cities and evidence of differential impacts raises additional questions. Are the results of the 2018 regarding the impact of the visual imagery of Boston and Miami consistent when replicated in a different sample at a different time? Will visual imagery (in the form of similar animated maps) of projected flooding in different US coastal cities be similarly effective at influencing perceptions of impact, concern, and belief that climate change is occurring? And finally, to what extent does location matter? Will exposure to additional coastal cities in different geographic areas show additional evidence of location-specific effects?

In the current study, I will investigate these questions and seek to build on this prior work by replicating and extending the experiment from Bolsen et al. (2018). In doing so, this research will contribute a true replication attempt of a prior experiment in the literature on emphasis frames - including textual and (the less often studies) visual frames, in climate communication. Replication attempts of previous experiments are valuable. Attempts at replication can indicate whether the existing literature may understate or overstate effects (e.g. Busby and Druckman

2010), and offer additional evidence on the effects of text based and visual emphasis frames on climate change beliefs. This study will also contribute to the literature on visual imagery and emphasis frames by extending the experiment from Bolsen et al (2018) to include additional treatment exposing respondents to visual frames highlighting the impacts of sea level rise on different geographic locations. By replicating and extending the original experiment, this research will offer additional insights into the influence s of emphasis frames – including textual frames *and* understudied visual frames highlighting the impacts of climate change in geographically proximate and socially familiar places - in climate communications. And finally, previous studies show that interactive maps showing sea level rise may be an effective way of engaging with audiences and communicating about detailed, local of effects of climate change on US communities. This research will offer additional understanding about the potential for this method of depicting the impacts of climate change to influence climate change behaviors and beliefs.

2.6 Survey Experiment

In this research, I developed and fielded a survey experiment on an original sample. The survey experiment mirrors the experimental design and stimuli from the original study from Bolsen et al. (2018) with the (1) Pure Control, (2) Text Only, (3) Text + Boston Map, and (4) Text + Miami Map conditions, and serves as a direct attempt at replicating the previous experiment. The design builds from the original study with the inclusion of several additional conditions that (1) present animated maps showing the projected coastal flooding that will occur as a result of sea-level rise in additional coastal locations in Virginia Beach, VA and New Orleans, LA, and (2) exposes respondents to flood maps from two coastal cities concurrently.

These additional conditions provide three notable extensions from our prior work. First, the use of maps showing projected coastal flooding in additional coastal cities will give insights into the extent to which the previous findings extend to locations beyond Boston and Miami. Further, including additional maps of different geographic locations provides the opportunity to investigate the extent to which the effects from exposure to imagery is consistent or possibly dependent on location and geographic context. gives this study more leverage to assess the extent to which effects of frames and imagery are uniform as opposed to being location or context dependent. Finally, incorporating a condition that includes exposure to maps from multiple locations (as opposed to a single city) allows for a unique test of whether exposure to additional imagery showing projected coastal flooding in a second location results in can enhance or depress treatment effects on the dependent measures.

A summary of the experimental design and stimuli are presented in the Appendix.

2.7 Hypotheses

Drawing from the extant literature on emphasis framing and prior research on visual frames in climate change communication, I expect that exposure to frames highlighting the negative effects of coastal flooding that will result from future sea-level rise will increase belief that sea-level rise will have a *negative impact* on coastal communities, increase *concern* about the impact of this sea-level rise on coastal communities, and increase belief that global warming is *occurring*.

Hypothesis 1: Exposure to frames highlighting coastal flooding that will result from future sea level rise will increase individuals' belief that sea-level rise will have a negative impact on coastal communities.

Hypothesis 2: Exposure to frames highlighting coastal flooding that will result from future seal level rise will increase individuals' concern about the impact of sea-level rise on coastal communities.

Hypothesis 3: Exposure to frames highlighting coastal flooding that will result from future seal level rise will increase individuals' belief that global warming is occurring.

2.8 Design and Methods

To test the proposed hypotheses, I rely on data from a seven-condition survey experiment fielded in February of 2021. A total of 1,082 respondents were recruited to participate using Amazon's Mechanical Turk.[3] The MTurk platform is a tool for recruiting participants in social science research and is more accessible than traditional random probability, nationally representative samples. And while nationally representative, random probability samples are the gold standard for inference and generalization, existing research shows that MTurk samples are a viable tool for inference and generalization beyond the study sample in experimental contexts (Mullinix et al. 2015; Levay et al. 2016; Berinsky et al. 2012; Druckman and Kam 2011).

Upon entering the survey, participants were randomly assigned to either a (1) pure control group or one of six treatment conditions. Each of the treatment conditions are based on, and closely mirror the stimuli detailed by Bolsen et al. (2018). Respondents in the (2) *Text Only* condition were presented with a short article with the headline "Rising Sea Levels Will Threaten US Coastal Cities" along with the following paragraph (see Bolsen et al, 2018) updated to reflect the current year:

[3] A nationally representative, random probability sample is the gold standard for inference and generalization beyond the study sample. However, MTurk samples are shown to allow for generalizations beyond the sample in the contexts of experimental designs (Mullinix et al. 2015; Levay et al. 2016; Berinsky et al. 2012; Druckman and Kam 2011).

"Earth's polar ice is melting faster than climate scientists had previously thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean level to rise by 10 to 15 ft, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just 1 in. of sea level rise equates to about an 8- to 10-ft loss of beach."

Respondents assigned to the (3) *Boston Map*, (4) *Miami Map,* (5) *Virginia Beach Map,* (6) *New Orleans Map* conditions were shown the text from the *Text Only* treatment, in addition to an animated map showing the projected future flooding and inundation that will occur in each city resulting from a 15-ft increase in sea-level following a 3.5 degree Fahrenheit (2.0 degree Celsius) increase in Earths average temperature. A brief description was presented alongside the map that reads:

"Please look carefully at the animated map below of (city name). It shows the projected amount of coastal flooding that will occur in (city name) as a result of a 15-foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US."

Finally, respondents assigned to the (7) *Multiple Maps* condition were shown the same stimuli with an additional map showing the projected flooding that will occur in a second coastal location. Respondents in the *Multiple Map* condition received the following text alongside the animated maps:

"Please look carefully at the animated maps below of (first city) and (second city). The maps show the projected amount of coastal flooding that will occur in (first city) and (second city) as a result of a 15-foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US."

2.8.1 Dependent Measures

Immediately following condition assignment, I measured how exposure to these frames affected individuals' beliefs about (1) the perceived impact of climate change on US coastal communities, (2) concern about the effects of rising sea levels will have on coastal communities, (3) belief that climate change is occurring. *Impact* was measured using a 7-point scale with response options ranging from (1) Extremely positive to (7) Extremely negative. *Concern* was measured using a 7-point scale with response options ranging from (1) Extremely unconcerned to (7) Extremely concerned. *Occurring* was measured using a 7-point scale with response options ranging from (1) Definitely is not occurring to (7) Definitely is occurring.

In addition to the dependent measures, respondents were asked to answer a variety of questions capturing traditional demographic characteristics. After dropping responses that were missing data on key variables, a total of 1,050 observations are included in the analysis. A complete list of survey questions and measures is available in the Appendix.

2.8.2 Summary of Survey Experiment

The current survey experiment mirrors the experimental design and stimuli from the original study from Bolsen et al. (2018) with the (1) *Pure Control*, (2) *Text Only*, (3) *Text + Boston Map*, and (4) *Text + Miami Map* conditions, and thus serves as a direct attempt at

replicating our previous analyses and findings assessing the impact of a textual frame and visual imagery showing the projected impacts of coastal flooding resulting from sea-level rise in Boston and Miami on climate change beliefs. And further, this design builds from the original study with the inclusion of several additional conditions that (1) present animated maps showing the projected coastal flooding that will occur as a result of sea-level rise in additional coastal locations in Virginia Beach, VA and New Orleans, LA, and (2) exposes respondents to flood maps from more than one coastal location concurrently.

These additional conditions provide three notable extensions from the prior study. First, the use of maps showing projected coastal flooding in additional coastal cities will give insights into whether, and to what degree, our previous findings extend to locations beyond Boston and Miami. Second, including additional maps gives this study more leverage to assess the extent to which effects of frames and imagery are uniform as opposed to being location or context dependent. Finally, incorporating a condition that includes exposure to maps from multiple locations (as opposed to a single city) allows for a unique test of whether additional imagery can enhance or diminish treatment effects on the dependent measures. A summary of the experimental design and stimuli are presented in the Appendix.

2.9 Results

To evaluate the effect of condition assignment on the perceived negative impacts, concern about the effects of sea level rise on coastal communities, and belief that climate change is occurring, I estimated a series of OLS models regressing each dependent variable on indicators for the experimental conditions. In each model the *Control* group is excluded as the reference

category.[4] The table cells contain OLS coefficient estimates with robust standard errors in parentheses below. Each coefficient estimate represents the estimated difference-in-means between the experimental condition and the *Control* reference group.

Table 1: Main Treatment Effects

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.625***	0.000	0.263*	0.056	0.099	0.261
	(0.14)		(0.17)		(0.15)	
Boston Map	0.513***	0.001	0.359**	0.015	0.264*	0.054
	(0.16)		(0.17)		(0.16)	
Miami Map	0.584***	0.000	-0.051	0.387	-0.030	0.426
	(0.15)		(0.18)		(0.16)	
Virginia Map	0.614***	0.000	0.230*	0.087	0.214*	0.083
	(0.15)		(0.17)		(0.15)	
New Orleans Map	0.568***	0.000	0.267*	0.062	0.396***	0.005
	(0.16)		(0.17)		(0.15)	
Multiple Map	0.410***	0.005	0.054	0.382	0.197	0.103
	(0.16)		(0.18)		(0.16)	
Constant (Control)	5.552***	0.000	4.868***	0.000	5.346***	0.000
	(0.14)		(0.16)		(0.15)	
N	1050		1050		1050	
AIC	3554.2		3883.7		3606.5	
BIC	3608.7		3938.2		3661.0	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition and the Control group baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test.
* *p<0.10,* ** *p<0.05,* *** *p<0.01*

[4] Covariates for party identification and ideology are included in the model estimates for theoretical and empirical reasons. First, party identification and political ideology are theoretically meaningful and known predictors of climate attitudes, and therefore relevant for inclusion (Hamilton, 2011; Kahan, 2015: Kahan et al., 2012). Second, and more important for the purposes of this analysis, I chose to include these additional covariates in the models to adjust for imbalances detected in party identification and political ideology across the experimental conditions post-randomization. The inclusion of these covariates does not change the substantive interpretation of the models; however, model efficiency does improve. Additional analyses were conducted in which treatment effects were estimated without party identification and political ideology and are available in the Appendix.

2.9.1 Impact

Model 1 reports the effects of condition assignment on perceived negative impact. In support of Hypothesis 1, exposure to frames highlighting coastal flooding that will result from future sea level rise increased belief that sea level rise will have a negative impact on coastal communities, relative to the control group. The frames were substantively and statistically significant across all treatment conditions. Exposure to the textual frame increased perceptions of the negative impact of coastal flooding on coastal communities (Text Only v. Control, b=0.625, p<0.01). Similarly, respondents exposed to visual frames containing imagery of projected flooding in specific coastal cities reported increased perceptions of negative impact relative to the control group. The effects of the visual imagery were positive and consistent across each of treatments, regardless of the geographic location and city highlighted (Boston Map v. Control, b=0.513, p<0.01; Miami Map v. Control, b=0.584, p<0.01; Virginia Map v. Control, b=0.614, p<0.01; New Orleans Map v. Control, b=0.568, p<0.01), and also when respondents were exposed to maps of multiple locations (Text Only v. Control, b=0.415, p<0.01).

2.9.2 Concern

Model 2 reports the impact of the experimental conditions on *Concern.* The results support Hypothesis 2. Exposure to the textual frame (Text Only v. Control, b=0.263, p=0.056) increased concern about the impact of sea level rise on coastal communities relative to the control group. A similar increase in concern occurred in several of the experimental conditions containing visual frames. Exposure to text in conjunction with maps showing projected inundation and coastal flooding in Boston (Boston Map v. Control, b=0.359, p=0.015), Virginia Beach (Virginia Map v. Control, b=0.230, p=0.087), and New Orleans (New Orleans Map v. Control, b=0.267, p=0.062) significantly increased levels of concern expressed for coastal

communities relative to the *Control* group. Interestingly, the Miami Map and Multiple Map conditions did not have a significant effect on concern. Consistent with Bolsen et al.'s (2018) findings, exposure to imagery highlighting the projected flooding that will occur in Miami did not increase individuals' concern, and in this analysis, was also incorrectly signed (Miami Map v. Control, b=-0.051, p=0.387). And while exposure to maps of individual cities (Boston, Virginia Beach, and New Orleans) increased feelings of concern, the treatment containing projected flood maps occurring in multiple cities did not achieve statistical significance (Multiple Map v. Control, b=0.054, p=0.382).

2.9.3 Occurring

Model 3 reports the effects of condition assignment on belief that global warming is occurring. The results provide general support for Hypothesis 3, exposure to frames highlighting costal flooding that will result from future sea level rise increased individuals' belief that global warming is occurring relative to the control group. However, there are several notable differences in the impact of the frames varies across experimental conditions. Respondents exposed to visual frames highlighting flooding in Boston (Boston Map v. Control, b=0.264, p=0.054), Virginia Beach (Virginia Map v. Control, b=0.214, p=0.083), and New Orleans (New Orleans Map v. Control, b=0.396, p<0.01) expressed increased belief that global warming is occurring relative to the pure control group. The Multiple Map treatment was also positively signed, indicating higher levels of belief that climate change is happening, though it falls short of reaching statistical significance at conventional levels (Multiple Map v. Control, b=0.197, p=0.103). Next, exposure to the Miami Map treatment failed to have a meaningful impact on beliefs that global warming is occurring and was again incorrectly signed and statistically insignificant (Miami Map v. Control, b=-0.03, p=0.426). Finally, while several experimental

conditions including visual frames significantly increased belief that climate change is happening, exposure to the textual frame (Text Only v. Control, b=0.099, p=0.261) alone did not have a meaningful effect. This finding diverges from the results of Bolsen et al.'s analysis, which shows a positive and significant effect of the text only frame on this belief and offers evidence suggesting an independent effect of visual imagery on climate beliefs.

2.10 Discussion

In this research, I replicate and extend the work of Bolsen et al. (2018) and examine the effects of textual and visual frames highlighting coastal flooding in the United States on climate change beliefs. The results of the analysis, presented in Figure 1, offer several notable findings, and raise additional questions that have implications for effective communication of climate change with the public.

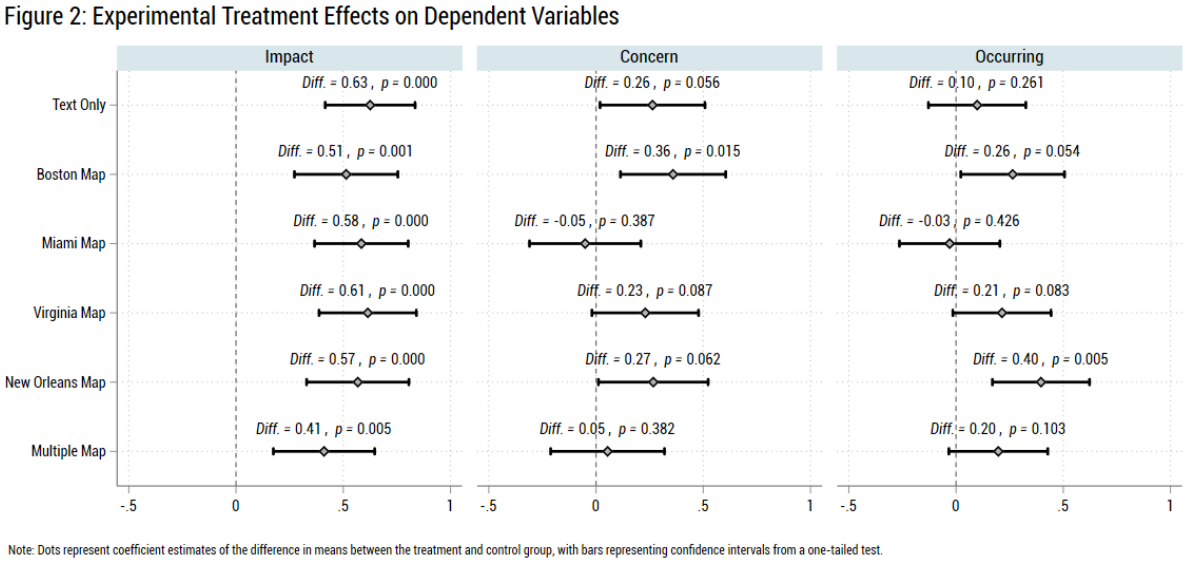

Figure 2: Experimental Treatment Effects on Dependent Variables

First, the analysis provides additional evidence that communicating about the impacts of climate change on geographically proximate and socially familiar places can be an effective

strategy for communicating with the public and influencing people's climate change beliefs. This experiment finds that communicating about a specific impact of climate change - in the form of coastal flooding resulting from future sea level rise, on familiar places and people – had a meaningful effect on negative impact perceptions, concern for communities, and broader beliefs that climate change is occurring. In prior work, scholars have shown communicating about the local impacts of climate change to be an effective way to engage audiences. The results of this analysis fit well in this body work, offering an additional test and further evidence of the utility of this approach in climate communication.

Second, this study examines the effects of exposure to one type of visual imagery, animated maps showing projected coastal flooding on US cities, on climate change beliefs. While few in number, scholars have shown in previous experiments that "using interactive maps showing sea level rise may be an effective "frame" for engaging skeptical audiences" (Retchless, 2017 p. 6; see also, Bolsen et al 2018, 2019). The analysis here further supports this thinking. Exposure to visuals and imagery showing projected flooding in different US – including Boston, Miami, Virginia Beach, and New Orleans – significantly increased perceptions of the negative impact of coastal flooding on coastal communities, concern about the effects of sea level rise on these communities, and belief that climate is occurring.

While the findings show that, consistent with prior work, animated maps are an effective way to engage audiences, there are a few caveats for future research. Analyzing the effects of condition assignment in this experiment shows differential effects based on the geography and specific coastal city that was highlighted. Specifically, imagery highlighting the projected inundation that will occur in Boston, Virginia, and New Orleans significantly increased perceived negative impact, concern, and belief that climate change is happening. Yet, the Miami

map failed to meaningfully influence concern or belief that climate change is occurring. This finding is consistent with Bolsen et al.'s (2018) analysis and suggests that there may be location-specific considerations that can moderate the effects of this imagery. As noted by Bolsen et al. (2018), it is possible that the maps of Boston, Virginia, and New Orleans were more impactful because flooding in these locations may be relatively novel when compared to the more familiar hurricane-related flooding that occurs in Miami. And further, while there is evidence that exposure to these visual frames is effective for shaping thoughts and beliefs about climate change, there did not appear to be any effect of exposure to an *additional* map showing impacts on a second coastal community. More research is needed that further explores how connectivity and familiarity may condition or complicate effects. Similarly, further research is needed to further understand whether, and to what extent, exposure to additional stimuli yields diminishing returns, or even the potential for back-fire in individuals' responses.

Finally, a large literature explores how exposure to different emphasis frames can influence beliefs and opinions about climate change. Experiments testing the effects of a wide variety of different textual frames compose much of this work, while studies exploring the effects of *visual frames* are much fewer in number. In this study, I contribute another analysis of the effectiveness of both textual and visual emphasis frames, through the replication and extension of Bolsen et al.'s (2018) study and find that both textual stimuli and those incorporating visual imagery can influence climate change beliefs. The results not only replicated in an original sample at a different point in time, but also generalized to additional experimental treatments highlighting different geographic locations. However, the results of this study diverge from Bolsen et al.'s in one meaningful respect. The authors explain that "while we do not find that the animated map produces any significant effect on any of the dependent

variables beyond exposure to the textual frame alone, individuals in the Boston map condition reported slightly, but not significantly, higher levels of concern and belief in the existence of global warming relative to the textual frame alone" (Bolsen et al., 2018 p.364). The results of this analysis similarly show both the textual and visual frames to be effective across the dependent variables. However, I find evidence of an individual effect of the visual frames versus the textual frame alone. Exposure to the text only frame did not significantly influence beliefs that climate change is occurring, however, exposure to the visual frames highlighting flooding in Boston, Virginia, and New Orleans (and with exposure to multiple maps just missing statistical significance) *did* have a significant effect on this important core belief.

The reported findings provide some preliminary evidence that the use of visual imagery might not only serve to "enhance" textual frames, but rather, visual frames may be effective when textual frames are not. A considerable amount of further research is needed on this front, and the literature on emphasis framing in climate communication will benefit from further understanding the differences between textual frames, and visual frames and imagery.

3 THE IMPACTS OF FRAMES HIGHLIGHTING COASTAL FLOODING ON CLIMATE CHANGE BELIEFS: POWER AND PERSISTENCE OF VISUAL AND TEXTUAL FRAMING EFFECTS OVER TIME

3.1 Introduction

Communicating with the public about complicated issues, and the pursuit of the consensus needed to effectively act on these matters, can be inherently challenging. This is particularly true when dealing with the issue of climate change, which involves the difficulty of communicating with the public about the complexities of climate science amidst the growing political polarization and divisions on the subject. There is a pressing need to find methods of communicating the public about the issue of climate change so that consensus can develop, and action can be taken to address the current acceleration and effects of climate change, as well mitigate its future impacts.

A large literature exists that explores how messaging that emphasizes varying aspects of climate change, "emphasis frames," can influence climate change beliefs. Much of this work focuses on how exposure to *frames* highlighting a variety of considerations about climate change – including complicated considerations like the current state of climate science or the existence of a scientific consensus, or the economic, environmental, social, and national security impacts – can influence beliefs about existence of climate change, perceptions of threats posed by the effects, feelings of personal or government efficacy, willingness to take personal action, or support for policies intended to mitigate or address future impacts.

While this topic has been the focus of significant scholarly attention, and prior work shows evidence that various emphasis frames are effective in influencing various climate beliefs, much of existing research focuses on applications of messaging relying on textual information

and occurs in a cross-sectional experimental context. As a result, the communication potential and utility of frames that incorporate and communicate using visual imagery, or *visual frames*, remains understudied. And similarly, the "one shot," cross-sectional nature of most existing work in this area has left the duration, persistence, durability, and decay of framing effects over time largely unstudied.

In this research, I aim to contribute to these understudied areas and investigate the effects of textual and visual frames, and how framing effects function over time. In doing so, I developed and implemented a two-wave survey experiment that used both textual and visual frames highlighting the impacts of coastal flooding resulting from sea-level rise on coastal communities in the US, and measured how exposure to these treatments influenced perceived negative impacts, concern for coastal communities, and belief in the existence of climate change after initial exposure, and again at a later point in time (7 days).

Using this data, I investigate the duration and persistence of framing effects resulting from exposure to these textual and visual frames. And further, prior research suggests that visual frames and imagery are unique in both characteristics and strength compared to textual frames alone. The inclusion of both textual and visual frames, along with incorporation of "time," into the survey experiment allows for a humble first attempt at exploring whether, and to what degree, there are difference in the persistence, durability, and decay of visual and textual framing effects over time.

I find that, in some instances, framing effects exhibit signs of decay over time, however, this decay is not necessarily uniform. The results of the analysis also provide some initial evidence that the unique characteristics and "strength" of visual frames compared to textual frames may have impacts that extend beyond the time of initial exposure. I report some

preliminary findings that hint that there may be differences in the persistence, durability, and decay of visual and textual framing effects over time.

3.2 Emphasis Frames in the Communicating Climate Change

A growing body of research exists exploring how messaging influences beliefs about climate change. Much of the existing work in this area focuses on how exposure to different *frames* can affect individual opinions and beliefs about varying aspects of climate change. A *frame in communication* is defined as a word, phrases image, or presentation style that highlights a subset of potentially relevant considerations about a salient attitude object, for example, a political candidate, policy, or issue (Chong & Druckman, 2007a; Druckman, 2001, 2011).

Framing theory describes an attitude about a given attitude object as a function of the salience and weight assigned to the different evaluative dimensions and considerations about the object (Chong & Druckman, 2007a, 2007b). Frames can influence opinion formation process by altering the "weight" assigned to a specific consideration; when an individual is exposed to a message or communication that highlights specific dimensions, considerations, or ways of thinking about an issue, this "frame" can become more salient and cognitively accessible. As a consequence, the specific dimensions or considerations emphasized can be privileged information that is relied upon more heavily (e.g. "carry more weight") in the opinion formation process than otherwise had the individual not been exposed to the communication. This is known as a *framing effect* or *emphasis framing effect* (Druckman 2001, 2011; Chong and Druckman 2007a).

Frames can provide "interpretive storyline that set[s] a specific train of thought in motion, communicating why an issue might be a problem, who or what might be responsible for it, and what should be done about it" (Nisbet, 2009 p. 15). Experimental studies show that frames

emphasizing different aspects of climate change – such as the economic, environmental, national security, and public health risks, or other considerations regarding the science or the existence of a scientific consensus – can influence individuals' beliefs about the existence of climate change, concern about the risks and impacts, willingness to take personal action, and support public policies and strategies to mitigate its effects (Kahan et al. 2012; Myers, Nisbet, Maibach, and Leiserowitz, 2012; Lewandowsky, Gignac, & Vaughan, 2013; Nisbet 2009; O'Neill et al. 2015; Bolsen & Druckman, 2018; Bolsen, Kingsland, and Palm 2018). For example, Lewandowsky et al. (2013) examined how exposure to a frame highlighting that 97% of climate scientist believe in anthropogenic climate change influenced beliefs. The authors found that exposure to the frame emphasizing this scientific consensus increased beliefs that a scientific consensus exists, acting as a gateway belief that impacts support for action and other fundamental beliefs.

3.3 Visual Frames and Imagery in Communicating Climate Change

While a robust literature exists examining emphasis frames and climate change beliefs, studies investigating the effects of climate change imagery on citizens' opinions and behaviors are fewer in number (Bolsen et al. 2019, 2018; Hart and Feldman 2016; Leiserowitz 2006; Myers et al. 2012; O'Neill 2013; O'Neill, Boykoff, Niemeyer, & Day, 2013; O'Neill & Nicholson-Cole,2009; Sheppard 2005). Existing research in this area shows that the visual presentation of information can improve engagement and information retention versus text alone (Graber, 1990, 1996; Powell, Boomgaarden, De Swert, & de Vreese, 2015). This increased engagement is, in part, due to the unique characteristics of visual imagery over text-based information. O'Neill and Smith (2014) explain that "images have several qualities that aid in information exchange: they can draw viewers in through vivid and emotive portrayals, they aid in remembering information, and… they can transcend linguistic and geographical barriers" (p. 73).

Effective visualization of climate change data can and reduce difficulty in comprehension, limit misconceptions, and potentially improve climate change communications (Harold, Lorenzoni, Shipley, and Coventry, 2016). Moreover, visual frames and imagery often pair well with text-based information, often producing stronger framing effects (e.g. Feldman & Hart, 2018; Graber, 1996; Powell et al., 2015). For example, Hart and Feldman (2016) found that exposure to images of solar panels accompanied by a call-to-action increased feelings of personal efficacy, as well as indirect effects on measures of individual behavior change including intentions to engage in energy conservation. In another study, Van der Linden et al. (2014) found that combining simple visual frames with textual information can increase belief that a scientific consensus exists.

Visuals that highlight specific aspects of climate change can affect engagement with the issue and influence individuals' beliefs and behaviors (Hart and Feldman, 2016; O'Neill, 2017; O'Neill and Nicholson-Cole, 2009; O'Neill et al., 2013; O'Neill and Smith, 2014; Bolsen et al., 2018; Bolsen et al., 2019). Imagery can influence perceptions about the people and places that may be at risk from climate change impacts. Existing research shows that common media depictions of climate change include images that highlight socially or spatially distant locations - such as pictures of polar bears, melting glaciers, industrial smokestacks, or political considerations (Feldman et al. 2015; Lorenzoni et al. 2006) – that can contribute to a "psychological distancing effect." This psychological distancing can lead individuals to perceive climate change as something that will predominantly affect future generations and occur in distant locations instead of in familiar and local communities (Lorenzoni et al. 2007; Pidgeon and Fischoff 2011; Scannell and Gifford 2013).

One strategy to reduce this psychological distance and promote engagement is to communicate about the local and regional effects of climate change on familiar people and places (Bolsen, Kingsland, and Palm 2018; Bolsen, Palm, and Kingsland 2019; Bolsen & Shapiro, 2018; Leiserowitz, 2007; Spence, Poortinga, & Pidgeon, 2012; Scannell and Gifford 2013; Sheppard 2005). For example, Scannell and Gifford (2013) exposed respondents to information about a general global impact of climate change, or detailed information about the impacts of climate change on the respondents' local area. The authors found that exposure to the detailed information on the local impacts of climate change significantly increased levels of climate engagement relative to the control group, while the information on general global impacts did not have a significant effect.

In this area, scholars have incorporated visual frames communicating the local impacts of natural disasters caused by climate change - such as maps showing coastal flooding resulting from sea-level rise and heat waves contributing to extreme droughts - and found that maps highlighting these future impacts may be an effective means of shifting people's risk perceptions and beliefs. For example, Retchless (2017) found that exposure to interactive maps showing the impact of coastal flooding in Florida shifted risk perceptions among respondents that were initially uncertain or doubtful about climate change. In another study, Bolsen et al. (2018) exposed respondents to frames containing animated maps highlighting the effects of coastal flooding resulting from sea-level rise on two U.S. cities (Boston and Miami) and found that individuals increased perceptions that climate change will have a negative impact on U.S. coastal cities, expressed greater concern about the effects of climate change on U.S. communities, and increased their belief that global warming is occurring. Following this line of research, Bolsen et al. (2019) manipulated text frames and visual imagery using two environmental hazards

associated with climate change – sea level rise with associated coastal flooding and increasing heatwaves with associated drought and wildfire – and found that visual imagery was not only able to shift risk perceptions and beliefs, but also counteract the negative effects of politicization on these beliefs.

Taken together, there is a growing literature that examines how exposure to different emphasis frames can influence individuals' perceptions and beliefs about climate change. Yet, much of this body of work focuses on experiments examining the effects of exposure to different textual frames and interventions, and only recently have scholars begun to examine the impact of visual frames and climate change imagery on individuals' opinions and behaviors. The existing studies in this nascent area of research suggests that use of visual imagery can potentially enhance communications with the public about the climate change and shift people's risk perceptions and beliefs about the issue. Further, prior experiments show that maps highlighting the projected coastal flooding resulting from climate change induced sea level rise may be a particularly effective way of communicating with audiences. However, the existing experiments are few and have not been replicated on different samples, leaving "their potential for engaging audiences remains largely unevaluated" (Retchless 2017, pg.6).

3.4 Duration and Persistence of Framing Effects Over Time

Applications of framing theory and studies of emphasis frames in communication have provided ample empirical evidence of the existence of framing effects. And while evidence of framing effects has been shown using a variety of messaging frames and issue domains, most framing studies rely on experiments embedded in cross-sectional surveys that measure opinions and beliefs immediately following exposure to a frame, and as a result, less is known about the

persistence or duration of framing effects over time (Gaines, Kuklinski, and Quirk, 2007; Lecheler and de Vreese 2011; Busby, Flynn, and Druckman, 2018).

Investigating the extent to which framing effects endure, and the conditions or factors that influence persistence, requires the incorporation of time in the study design. This typically involves exposing individuals to a frame, immediately measuring an opinion, and remeasuring the same opinion again at a future point in time. A small number of experimental studies have incorporated time in this way. And generally, existing duration studies have shown that treatment effects decay over time (Tewksbury et al. 2000; Chong and Druckman 2008, 2010; Lecheler and de Vreese, 2011, 2012, 2013). Some studies suggest that this decay can happen quickly. For example, Druckman and Nelson (2003) found that framing effects diminished 10 days following exposure. Similarly, Tewksbury et al. (2000) and de Vreese (2004) found diminished, and even muted, effects in 2 to 3 weeks following exposure. And in another study, Mutz and Reeves (2005) found that exposure to uncivil political debates reduced reported levels of trust from respondents. After approximately 3 weeks since initial exposure, the researchers reported that there were no longer significant differences between experimental conditions (Mutz and Reeves, 2005).

While generally prone to decay, scholars have identified some conditions and frame-level factors that can promote endurance of framing effects over time. One of these factors is repeated exposure. Framing works by altering the accessibility, salience, or "weight" of specific considerations about an attitude object. In the context of duration studies, repeated exposure at a later point in time can work to further increase the accessibility of a consideration, and as a result, promote the duration and persistence of framing effects over time (Chong and Druckman 2010, 2013; Lecheler and de Vreese 2016; Moons, Mackie, and Garcia-Marques, 2009).

However, repeated exposure may not always serve to increase the longevity of framing effects. In some conditions, exposure to additional messaging can reduce or mitigates effects from initial exposure to a frame, particularly in competitive messaging environments or in the presence of counter-framing (Chong and Druckman 2007; see also Jerit, 2009; Sniderman and Theriault, 2004).

In addition to repeated exposure, other frame-level and individual level factors can influence the duration of framing effects. For example, research shows that the negative or positive tone of a frame can influence persistence. Negative frames (e.g. frames emphasizing losses, "cons," or downsides) can induce longer lasting framing effects than positive frames (e.g. frames emphasizing gains, "pros," or successes) (Busby, Flynn, and Druckman, 2018; Lecheler and de Vreese, 2016; Ledgerwood and Boydstun, 2014). Other research shows that individual level factors, such as political knowledge, can influence the endurance of framing effects after initial exposure. For example, Lecheler and de Vreese (2011) find increased persistence of framing effects among individuals with moderate levels of political knowledge over time and suggest that these individuals may be more able and likely to commit frames to long-term memory.

Duration studies are few in number, and, as described by Lecheler and de Vreese (2016), the existing work on "over-time experimental designs in framing research is in its infancy" (pg. 4). There is a need for further research investigating the conditions and frame-level factors that shape persistence and duration of framing effects over time. As Gains et al. (2007) state, "determining the rates of decay of various treatment effects and deriving the political implications could be one of the most informative tasks that users of survey experiments undertake in the future" (pg. 6).

3.5 Research Questions

Much of the existing research on emphasis framing in climate communication relies on one-shot experimental designs exposing respondents to *textual* frames, and opinions (framing effects) measured immediately following exposure. However, *visual* frames and the persistence of framing effects over time remain understudied. In this research, I will contribute to this body of work by investigating the effects of exposure to both *textual* and *visual* frames highlighting projected coastal flooding in coastal communities resulting from sea-level and examine how framing effects from exposure to these text and visual frames persist over time. In doing so, I will explore two primary research questions:

RQ1: Will exposure to textual and visual frames using animated maps highlighting projected coastal flooding in coastal communities resulting from sea-level rise produce durable treatment effects that will persist over time?

RQ2: Are framing effects from exposure to visual frames different (or similar) in persistence and decay when compared those from exposure to textual frames?

When taken together, the research on visual frames and duration of framing effects can yield nuanced, divergent expectations. First, previous duration studies show that framing effects decay over time, and this is particularly prevalent in the absence of repeated exposure over time. Based on the existing research, it would be expected that exposure to both textual and visual frames highlighting projected coastal flooding in U.S. coastal communities resulting from sea-level rise would show evidence of treatment effects following initial exposure (Time 1), but

evidence of decay (either diminished, or entirely muted) at the time of the follow up (Time 2, which is 7 days after initial exposure in this study). Similar evidence of decay would be expected between the text frame and visual frame conditions.

However, it is possible that the persistence or decay of framing effects may differ based on exposure to either a text based or visual frame. Existing duration studies suggests that some frame-level characteristics or factors can influence the durability of framing effects over time. Frames that are novel, accessible, and promote higher levels of engagement with the message may produce more durable framing effects. Busby et al. (2018) state "framing effects are more likely to endure when people are induced to form stronger, more effortful opinions upon initial exposure to the frame" (pg. 22). In another area, research textual and visual frames shows that the unique characteristics of visual frames imagery - including the novelty and accessibility of imagery - can increase levels of engagement and effectiveness of information when compared to textual frames alone. Considering this prior work, I propose an alternative expectation: Based on existing research showing that visual frames and imagery are novel, increase accessibility and engagement, and produce stronger effects than text-based treatments alone, I expect the exposure to visual frames to yield durable, more persistent framing effects compared to the text-based alternative.

3.6 Research Design

To probe the similarities and differences in persistence of framing effects resulting from exposure to visual and textual frames, I designed a two-wave survey experiment based on prior work from Bolsen, Kingsland, and Palm (2018), which will be described in detail below. In their 2018 research, Bolsen et al. conducted a survey-experiment to test how exposure to textual and visual frames highlighting coastal flooding that will occur in U.S. coastal communities (Boston

and Miami) resulting from future sea-level rise influenced individuals' perceptions about the effects on coastal communities, concern for these communities, and belief in the existence of climate change. The authors find that exposure to both textual frames and visual frames including animated maps showing projected levels of future coastal flooding that will occur in Boston and Miami significantly increases individuals' perceptions of the negative impacts, concern for coastal communities, and beliefs in the existence of climate change (Bolsen, Kingsland, and Palm 2018).[5]

Building from the experiment and framework implemented by Bolsen et al. (2018) offers several advantages to this current study and the investigation of the duration and decay of framing effects over time. First, the authors explored the impact of a novel, understudied, and impactful frame highlighting the impact of coastal flooding resulting from sea-level rise on physically and socially proximate locations. Second, the experiment incorporated both a text-based frame, and visual frames containing animated imagery of future flooding that would occur in two US cities. Third, the results of the analysis show that both the textual frame and the visual frames and imagery accentuating future coastal flooding resulting from sea-level rise were effective frames, and both the textual and visual frames influenced individuals' beliefs about coastal flooding and climate change following exposure. And finally, the cross-sectional design and visual frames focusing on two cities (Boston and Miami) offer an opportunity for an extension to the experimental framework to include visual frames highlighting different geographic locations and incorporates an over-time component. By having textual frames, additional visual frames, and a follow-up survey, the extension to the Bolsen et al. (2018) experiment will provide three valuable pieces of data for examining durability and decay in

[5] Animated maps were created with flood projection images produced by Climate Central's "Surging Seas: Seeing Choices" tools. Available at: https://sealevel.climatecentral.org/

framing effects resulting from exposure to visual and textual frames: (1) estimates of treatment effects resulting from exposure to a textual frame; (2) estimates of treatment effects following exposure to a visual frame; and (3) estimates of treatment effects at a later point in time.

3.7 Survey Experiment

In this research, I developed and fielded a survey experiment on an original sample. The survey experiment mirrors the experimental design and stimuli from the original study from Bolsen et al. (2018) with the (1) Pure Control, (2) Text Only, (3) Text + Boston Map, and (4) Text + Miami Map conditions, but includes several extensions. The design builds from the original study with the inclusion of several additional conditions that (1) present animated maps showing the projected coastal flooding that will occur as a result of sea-level rise in additional coastal locations in Virginia Beach, VA and New Orleans, LA, and (2) exposes respondents to flood maps from two coastal cities concurrently.

Additionally, to investigate the persistence of treatment effects on perceptions of negative impacts, concern for coastal communities, and belief in the existence of climate change, I incorporated "time" as an element in the design by implementing a follow-up survey administered to respondents seven days after completing the initial survey.

A summary of the experimental design and stimuli are presented in the Appendix.

3.8 Design and Methods

Data for this analysis come from a seven-condition survey experiment fielded in February of 2021. A total of 1,082 respondents were recruited to participate using Amazon's Mechanical Turk.[6] The MTurk platform is a tool for recruiting participants in social science research and is

[6] A nationally representative, random probability sample is the gold standard for inference and generalization beyond the study sample. However, MTurk samples are shown to allow for generalizations beyond the sample in

more accessible than traditional random probability, nationally representative samples. And while nationally representative, random probability samples are the gold standard for inference and generalization, existing research shows that MTurk samples are a viable tool for inference and generalization beyond the study sample in experimental contexts (Mullinix et al. 2015; Levay et al. 2016; Berinsky et al. 2012; Druckman and Kam 2011).

Upon entering the survey, participants were randomly assigned to either a (1) pure control group or one of six treatment conditions. Each of the treatment conditions are based on, and closely mirror the stimuli detailed by Bolsen et al. (2018). Respondents in the (2) Text Only condition were presented with a short article with the headline "Rising Sea Levels Will Threaten US Coastal Cities" along with the following paragraph (see Bolsen et al, 2018) updated to reflect the current year:

"Earth's polar ice is melting faster than climate scientists had previously thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean level to rise by 10 to 15 ft, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just 1 in. of sea level rise equates to about an 8- to 10-ft loss of beach."

Respondents assigned to the (3) Boston Map, (4) Miami Map, (5) Virginia Beach Map, (6) New Orleans Map conditions were shown the text from the Text Only treatment, in addition to an animated map showing the projected future flooding and inundation that will occur in each city resulting from a 15-ft increase in sea-level following a 3.5 degree Fahrenheit (2.0 degree

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the contexts of experimental designs (Mullinix et al. 2015; Levay et al. 2016; Berinsky et al. 2012; Druckman and Kam 2011).

Celsius) increase in Earths average temperature. A brief description was presented alongside the map that reads:

"Please look carefully at the animated map below of (city name). It shows the projected amount of coastal flooding that will occur in (city name) as a result of a 15-foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US."

Finally, respondents assigned to the (7) Multiple Maps condition were shown the same stimuli with an additional map showing the projected flooding that will occur in a second coastal location. Respondents in the Multiple Map condition received the following text alongside the animated maps:

"Please look carefully at the animated maps below of (first city) and (second city). The maps show the projected amount of coastal flooding that will occur in (first city) and (second city) as a result of a 15-foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US."

3.8.1 Dependent Measures

Immediately following condition assignment, I measured how exposure to these frames affected individuals' beliefs about (1) the perceived impact of climate change on US coastal communities, (2) concern about the effects of rising sea levels will have on coastal communities, (3) belief that climate change is occurring. Impact was measured using a 7-point scale with response options ranging from (1) Extremely positive to (7) Extremely negative. Concern was

measured using a 7-point scale with response options ranging from (1) Extremely unconcerned to (7) Extremely concerned. Occurring was measured using a 7-point scale with response options ranging from (1) Definitely is not occurring to (7) Definitely is occurring.

3.8.2 Follow-up Procedure

In addition to the dependent measures, respondents were asked to answer a variety of questions capturing traditional demographic characteristics. After dropping responses that were missing data on key variables, a total of 1,050 respondents that participated in the initial wave of the survey (Time 1) are included in the analysis.

Respondents that participated in the initial wave of the survey were contacted 7 days after completion using their MTurk worker ID. The message included an invitation to participate in the brief follow-up study, and a link to the survey. Upon entering the survey, the respondents were asked to answer the same dependent measures and an additional question used for identification. The data for the follow-up survey (Time 2) includes 786 respondents from the treatment groups and wave-one control group that were not missing data on any key measures.

A complete list of survey questions and measures is available in the Appendix.

3.8.3 Hypotheses

This study is motivated by a primary research question: Are framing effects from exposure to visual frames different (or similar) in persistence and decay when compared to framing effects from exposure to a textual frame?

In the context of this survey experiment and drawing from prior research on the durability of framing effects over time, and emphasis frames and visual frames in climate communication, I develop a set of empirical expectations.

The first empirical expectation concerns the durability and decay of treatment effects over time in the absence of repeated exposure. Based on prior research on emphasis framing and visual frames in climate communication, I expect that exposure to frames highlighting the negative effects of coastal flooding that will result from future sea-level rise will increase belief that sea-level rise will have a *negative impact* on coastal communities, increase *concern* about the impact of this sea-level rise on coastal communities, and increase belief that global warming is *occurring* immediately following exposure (Time 1). However, prior research on the durability of treatment effects suggests framing effects decay over time. This decay (or muting) of treatment effects can occur relatively quickly (e.g. in a matter of days or a few weeks), particularly in the absence of repetition or repeated exposure. Based on this prior work, evidence of decay (reduction), or muting altogether, of treatment effects from exposure to visual *and* textual frames between initial exposure (Time 1) and the follow-up (Time 2) could be expected.

Alternatively, prior research shows that frame-level characteristics may influence the durability of framing effects over-time. And prior work on visual frames and imagery (and textual frames) suggests that visual frames have unique characteristics – including their novelty, increased accessibility and engagement, and strength - that may result in produce stronger effects than text-based treatments alone. It seems possible that the unique characteristics of visual frames, and the relative strength of their treatment effects, could produce framing effects that are less susceptible to decay than text-based frames. Considering this, I propose an alternative expectation: exposure to *visual* frames including maps highlighting coastal flooding resulting from sea-level rise that is projected to occur in US coastal communities to result in framing effects that are more persistent and durable than framing effects from the textual frame. Stated otherwise, it is possible that framing effects from exposure to the visual framing conditions will

exhibit less decay (e.g. reduction in magnitude or muting of the treatment effect) between the initial survey (Time 1) and the follow up (Time 2) compared to the textual frame condition.

3.8.4 Analytical Approach

To evaluate the persistence and decay of framing effects from exposure to the textual and visual frames on perceived negative impacts of coastal flooding, concern about the impacts on coastal communities, and belief that climate change is occurring, I estimated a series of OLS models regressing each dependent variable on the condition indicators for each experimental condition.

Model estimates for the Time 1 data exclude the *Control* group as the reference category. Coefficient estimates for the Time 1 models represent the estimated difference-in-means between the textual and visual frame conditions and the *Control* group in the initial survey. In the Time 2 model estimates, coefficients represent the estimated difference-in-means between the textual and visual framing conditions at the time of the follow-up survey (Time 2) and the *Control* group from Time 1.[7]

Estimates for initial framing effects are reported here, however, they are not the focus of this study. This research is primarily concerned with evaluating changes in the magnitude (persistence or decay) or significance of the initial framing effects over time. The estimates for

[7] Other strategies for looking at differences in treatment effects over time may be appropriate. This might include analyses of within-individual or within-group changes in the dependent measures over time. However, due to limitations in data - including respondents missing data on key dependent measures, potential complications from selection or non-random attrition, loss of power, among others – I chose to instead focus on a between-groups analysis instead of a within-individual level analysis or within-group strategy. With this strategy, the analysis provides a reasonable view of changes in the strength of framing effects over time.

treatment effects measured immediately after exposure serve as a reference point for evaluating changes in the magnitude or significance of the framing effects when measured at Time 2.[8]

3.9 Results

All model estimates for both the Time 1 (initial main effects) and Time 2 (treatment effects at the time of the follow-up) are displayed graphically to ease interpretation and presentation of the results. Figure 1 includes plots illustrating the difference-in-means between the experimental condition and the *Control* group baseline for each of the dependent variables, at both Time 1 and Time 2. Dots represent the coefficient estimate, with error bars representing the 95% confidence interval. The regression coefficients, along with *p*-values are displayed above each point estimate. All models estimated for this analysis and reported in Figure 1 are available in tables located in the Appendix.

3.9.1 Impact

Looking at the Time 1 estimates, exposure to the textual and visual frames significantly increased individuals' belief that that sea-level rise and associated coastal flooding will have negative impacts on US coastal communities. This effect was consistent across all experimental conditions. The textual frame (*Text Only*) and each of the visual framing conditions (*Boston Map, Miami Map, Virginia Map, New Orleans Map,* and *Multiple Map*) resulted in substantively large (and statistically significant) shifts in perceived negative impacts, with effects ranging from 0.41 to 0.63 point increases relative to the control group.

An aggregate view of the Time 1 estimates shows that the frames, both the text only frames and those with visual imagery, were impactful. Turning to the Time 2 estimates, we see

[8] Complete model estimates are available in the Appendix, and more comprehensive reporting of the initial treatment effects is available in Study 1.

that the framing effects did persist over time. Each of the experimental conditions continued to report higher levels of perceived negative impacts of coastal flooding resulting from sea-level rise than the *Control*, and estimated treatment effects for all conditions remained statistically significant at conventional ($p<0.05$ and $p<0.1$) levels. However, results also provide evidence of decaying framing effects over the time. The effects of the textual frame at Time 2 were roughly half compared to Time 1. And this was not limited to the *Text Only* condition. Each of the visual framing conditions show similar reductions in effects between the initial and follow-up surveys.

The effects of condition assignment on *Impact* are offer interesting conclusions. Neither the textual nor visual frames resulted in treatment effects that were immune to decay. However, even after decay the effects of both the text-based treatment and visual frames and imagery continue to be substantively meaningful, with the treatment conditions reporting levels of perceived negative impact that range from 0.26 to 0.41 points higher than the control baseline. This suggests that both the textual and visual frames were able to produce relatively durable

treatment effects on levels of perceived negative impacts over time.

Figure 1: Experimental Treatment Effects Over Time

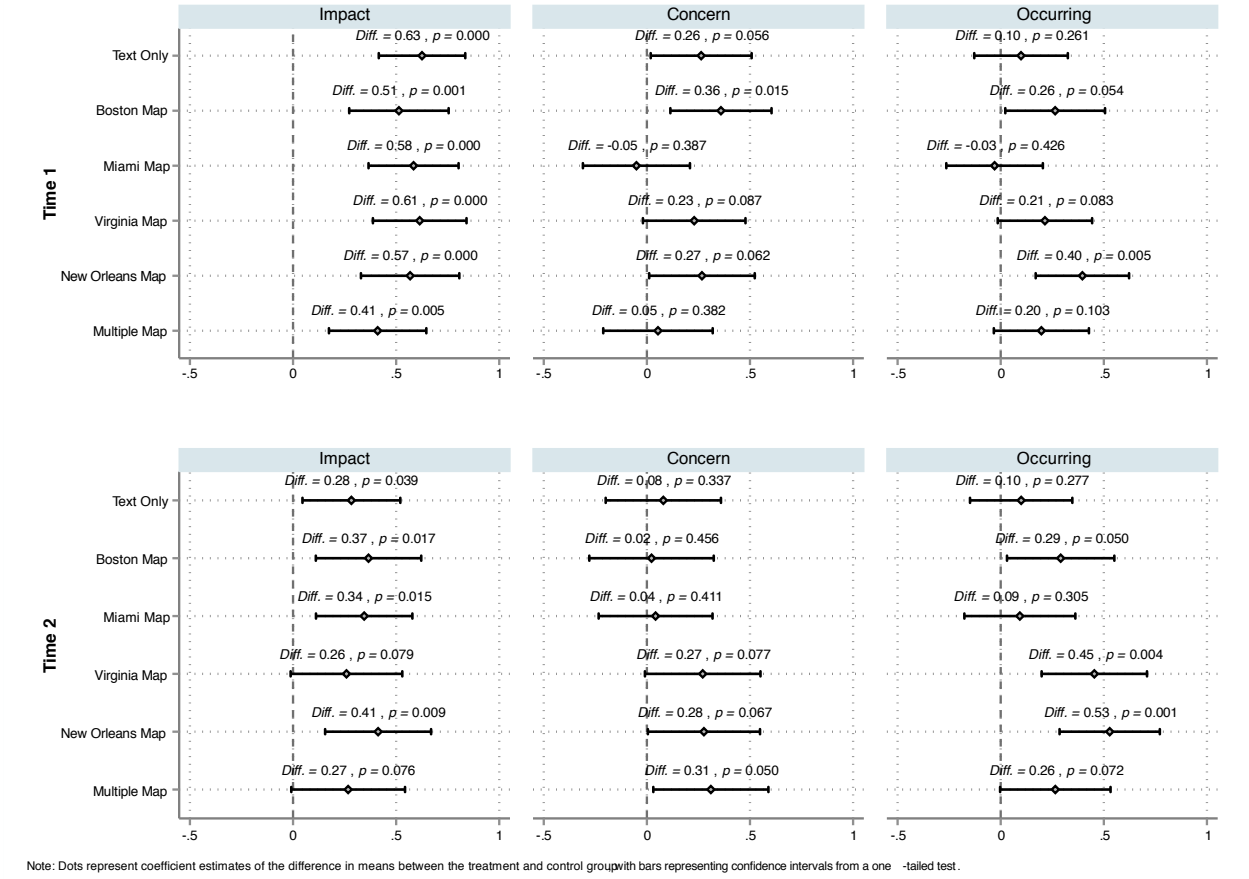

Figure 3: Experimental Treatment Effects Over Time

3.9.2 Concern

Next, the model estimates for the effect of the experimental conditions of levels of concern for coastal communities show that, on aggregate, the textual and visual frames increased *Concern*. However, the effects are less uniform. After initial exposure, the *Text Only* increased expressed concern, along with visual frames highlighting projected flooding that will occur in Boston, Virginia, and New Orleans. The *Miami Map* and *Multiple Map* treatments did not have a meaningful impact on concern at Time 1.

Moving to estimates for Time 2, there is some initial evidence of differences in the durability of framing effects from the textual and visual frames. Beginning with the *Text Only* condition, we see a meaningful change in the framing effect between Time 1 and Time 2. The textual frame increased *Concern* by 0.26 points at the time of the initial survey. At the time of the follow-up 7 days later, the substantive effect had not only decayed considerably (Diff. = 0.08, $p = 0.337$), but was muted all together with no evidence of a statistically significant difference relative to the control group. Similarly, the effects of exposure to the *Boston Map* treatment dissipated over time. The effect of the Boston treatment was almost entirely muted at the time of the follow-up, and no longer significantly differed from the control.

A notable difference emerges when considering the other visual frame conditions. The visual frames showing projected flooding that will occur in Virginia and New Orleans significantly increased concern at Time 1. At the time of the follow-up, the framing effects from initial exposure persisted. Not only is there no evidence of muting (e.g. both the Virginia and New Orleans conditions remain significantly different from the control group), the visual framing effects show considerable durability and remain virtually identical (even increasingly slightly) over time. It is worth noting that the Multiple Map treatment did not have a substantive or statistically significantly impact reported levels of concern in the initial survey (Time 1), however, the Multiple Map condition shows higher levels of concern at the time of the follow-up (Time 2). While interesting, there is no realistic explanation for this finding, and generally consider it to be an artifact.[9]

[9] It is possible that the observed difference between the Multiple Map condition and the control group at Time 2 is due to differences in the sample caused by attrition that affected this condition. A larger sample size and increased control over the study environment at the time of the follow up (e.g. in a lab setting) would allow for this result to be investigated more thoroughly.

Together, the model estimates for the effects of the experimental treatments on *Concern* suggest differences in decay between the text-based frame and the visual frames and imagery. The findings offer some initial evidence of visual framing effects being more persistent and durable over time compared to the effects induced by the textual frame.

3.9.3 Occurring

The last set of models shows the estimated effects of the textual and visual frames on the belief that climate change is occurring. At Time 1, the results show that the textual frame did not have a significant impact on belief in the occurrence of climate change, yet exposure to the visual frames did increase belief relative to the control group.

Given the null effects of the *Text Only* frame at Time 1, there is not much insight to be gained from looking at the relative decay of treatment effects from the textual frame over time. On the other hand, the results from the visual framing conditions are more interesting. Initial exposure to the *Boston Map* condition significantly increased belief in climate change (Diff. = 0.26, p = 0.054) relative to the control group. This effect shows no sign of decay at Time 2. Instead, the effect for the *Boston Map* condition remains substantively unchanged (Diff. = 0.29, p = 0.050). Similarly, the *Virginia Map* frame increased belief in climate change at Time 1 (Diff. = 0.21, p = 0.083), and persistent (and even increased) over time at the follow-up (Diff. = 0.45, p = 0.004). Next, the framing effects from exposure to the *New Orleans Map* treatment appear resistant to decay, increasing belief at Time 1 relative to the control group (Diff. = 0.40, p = 0.005), and continuing to report significantly higher levels at the time of the follow up (Diff. = 0.53, p = 0.001). And finally, exposure to the *Multiple Map* frame marginally increased belief in climate change at Time 1 (Diff. = 0.20, $p = 0.103$), and the effect appears durable and persists at Time 2 (Diff. = 00.26, $p = 0.072$).

3.10 Conclusion

The literature on framing in the climate communication is well established, and the large number of studies using framing experiments have provided ample empirical evidence of the effectiveness of a variety of different emphasis frames on communicating climate change and influencing individuals' beliefs about climate change. Less established, however, are the bodies of research exploring the impact of visual frames and analyses of the durability of framing effects over time. Much of the existing work in this area focuses on various textual frames and assesses framing effects immediately following exposure at a single point in time. This prior work contributes valuable information about the utility of frames in communication, and textual emphasis frames specifically, in influencing climate beliefs. Yet, there is a need for further research because: (1) visual frames and imagery can provide an effective method of communicating with the public about the issue of climate change and may be stronger or more impactful textual frames alone; and (2) understanding the true impact of different messaging requires further understanding about the extent to which the communication effects persist over time.

In this study, I contribute to these understudied areas of the literature with an analysis of the impact of both textual and visual frames on climate beliefs, and the durability of these framing effects over time. Specifically, I developed and implemented a 7-condition survey experiment that exposed individuals to either a textual frame accentuating projected coastal flooding in the US, or a visual frame that includes additional animated imagery of projected coastal flooding that will impact several US coastal communities resulting from future sea-level rise. I measured the effect of these frames on perceptions of negative impacts, concern for

coastal communities, and belief in the existence of climate change immediately following exposure and again 7 days later. Using this data, I explore two primary research questions: (1) will exposure to textual frames, and visual frames with imagery, highlighting projected coastal flooding that will occur in US coastal communities resulting from sea-level rise produce durable treatment effects that will persist over time?; and (2) are framing effects resulting from exposure to visual frames different (or similar) in persistence or decay compared to those resulting from exposure to textual frames alone?

I find that individuals exposed to these frames perceived the impacts of coastal flooding to be more severe, reported higher levels of concern for coastal communities in the US that will experience future flooding from sea-level rise, and increased their belief in the existence of climate change. This finding provides further evidence of the effectiveness of visual frames and imagery, and messaging emphasizing the impacts of climate change on geographically and socially proximate places, for influencing climate beliefs.

Further, I find that these framing effects were (relatively) persistent, if not durable, over time. Exposure to the text only, Boston Map, Miami Map, Virginia Map, New Orleans Map, and Multiple Map treatments increased perceptions of negative impacts at Time 1. There was some decay in the size of the treatment effects over time, however, all the experimental treatments remained substantively and statistically different from the control group at Time 2. And for the other dependent measures, some interesting results begin to emerge. Exposure to the Text Only, Boston Map, Virginia Map, and New Orleans Map increased reported levels of concern at Time 1. At the time of the follow-up, the treatment effects for both the Text Only and Boston Map conditions not only decayed but had become muted all together. However, the visual frames showing imagery of flooding that will occur in Virginia or New Orleans were found to be

uniquely durable. The treatment effects for the Virginia Map and New Orleans Map conditions showed no evidence of decay, and instead remained substantively unchanged and significantly different from the control at Time 2.

Finally, the results indicate that the visual frames accentuating flooding that will occur in Boston, Virginia, New Orleans, and multiple US cities increased belief in the existence of climate change immediately following exposure. And interestingly, these treatment effects were both persistent and durable over time. Each of these experimental conditions showed little-to-no evidence of decay or muting, suggesting these visual frames were able to meaningful and lasting shifts in climate change beliefs.

The results of this analysis have several implications. First, while there is some evidence of decay, the empirical models show that both textual and visual frames highlighting projected coastal flooding that will occur in US communities are persuasive and can result in persistent and durable framing effects over time, even in the absence of reintervention or repeated exposure. Second, the results provide some initial, albeit interesting, evidence that the unique characteristics and "strength" of visual frames compared to text-based frames may not be limited to measurement immediately following exposure, and instead extend over time. This study offers some preliminary findings suggesting that there may be differences in the persistence, decay, and durability of visual and textual framing effects in an over-time environment. And these results hint that visual frames and imagery may not just be uniquely powerful at influencing beliefs at a single point in time, but rather uniquely able to produce meaningful and lasting opinion shifts over time when compared to text frames alone.

Further research investigating duration and persistence of framing effects following exposure to visual and textual frames is needed. This study reports the results of a preliminary

investigation of the durability of visual and textual framing effects over time and has several limitations. A larger number of survey participants and tighter control over the follow-up procedure would improve the statistical power and reliability of the analysis. Additionally, while the results show that the visual frames including animated flood maps were impactful, the maps highlighting flooding in some US cities (Virginia and New Orleans) were particularly effective compared to others (like Miami). Future research that investigates how geography of specific cities, as well as factors such as familiarity, knowledge, or attachment to specific locations, may moderate the impact of this type of visual imagery.

Finally, this study explores the impact of textual and visual frames highlighting coastal flooding in US communities resulting from sea-level rise on climate change beliefs over time. Future research on visual and textual frames would benefit from exploring additional types of frames and imagery, such as imagery showing destruction to homes and infrastructure, droughts, wildfires, or other impacts occurring in geographically and socially familiar places. And further, this study design relied on a 7-day delay between initial exposure and follow-up. Additional work that tests visual and textual framing effects over additional lengths of time, and studies including re-exposure or reintervention with counter-frames, would be valuable.

4 DATA COLLECTION FOR ONLINE SURVEY EXPERIMENTS: PROMISE, PERILS, AND SOLUTIONS

4.1 Introduction

Online data collection for surveys and survey experiments has become increasingly prevalent in the social sciences and is particularly common in the field of political science and the study of public opinion, political communication, and political behavior. Random probability, nationally representative samples remain the gold standard for statistical inference. However, declining telephone and mail survey response rates (Kennedy and Hartig 2019; Stedman, Connelly, Heberlein, Decker, & Allred, 2019), logistical demands (particularly in lab-based or in person collection), challenges in implementation and fielding, and the high cost of these samples leaves this gold standard often inaccessible to researchers. Online sample recruitment platforms, and the online administration of surveys and survey experiments, have grown increasingly popular among scholars in the social sciences. These platforms have the advantages of being accessible, allow for easy access to respondents and (comparatively) fast data collection, and more cost-effective source for experimental data and samples that are viable for inference (Coppock, Leeper, and Mullinix, 2018; Mullinix et al. 2015; Levay et al. 2016; Berinsky et al. 2012; Druckman and Kam 2011).

While online data collection for surveys and survey experiments offers the promises of quick recruitment of participants, approachable sources of data for researchers, and a cost-effective alternative for samples, there are perils in the collecting data online that can pose threats to statistical inference and validity of social science research. Perhaps the most important of these perils is data quality, and specifically, low quality data resulting from the rise of "bots,"

inattentive or insincere respondents, and other fraudulent data in the online recruitment of samples.

The issues posed by low quality data, whether caused by "bots," inattentive respondents, insincere or mischievous respondents, or other drivers of fraudulent data, are significant and have implications for political and social science research that cannot be overstated. Online surveys and survey experiments produce findings that can have impacts beyond academia, including influencing and informing public policy, making the accuracy and reliability of survey data and results an issue of great importance. This paper aims to explore the challenges associated with low quality data from online surveys and survey experiments in political science research and highlight a variety of practical solutions that researchers can employ to safeguard against these issues.

This analysis will begin by delving into the common mechanisms through which "bots," inattentive and insincere respondents, and other drivers of low-quality data can emerge and impact online surveys, including the potential problems and biases they introduce for political science research. Further, this paper will present a variety of recommendations and best practices that can be used to detect and mitigate these issues - including several practical and relatively easy to implement strategies using tools commonly used for online survey research, Qualtrics survey software and Stata statistical software – allowing researchers to better safeguard their survey data.

As scholars increasingly rely on online tools and platforms to field surveys and survey experiments, access samples and recruit participants, it is important to address the issues of low-quality data. By highlighting these challenges and providing insights into effective

countermeasures, this paper contributes to the ongoing effort to ensure and promote the validity and credibility of online surveys and survey experiments in political science research.

4.2 Common Sources of Low-Quality Data in Online Surveys

Several online platforms exist that allow scholars to collect survey data and perform survey experiments with relative ease. Researchers in the field of political science, and in the social sciences more broadly, have increasingly used crowdsourcing platforms including Amazon's Mechanical Turk (commonly referred to as MTurk) and Prolific Academic, among others, as well as commercial market research and opt-in survey panel providers like Lucid, Qualtrics, Survey Monkey, Google Surveys, and Facebook to collect survey data and conduct survey experiments online. These online platforms are a valuable tool for researchers as they allow for (relatively) quick recruitment of study participants, require fewer staff for data collection (Griffin et al. 2021; Das et al. 2018; McMaster et al. 2017) and are generally more accessible and cost-effective when compared to more traditional alternatives (Newmane et al., 2021; Zhang & Gearhart, 2020; Kennedy et al., 2020; Berinsky et al. 2012). And further, while these samples are not the nationally representative, random probability samples that serve as the gold standard, prior research has shown these samples to be more representative than other traditional convenience samples, and a viable source of quality data that can often replicate experimental findings and observational results from nationally representative samples (see, for example: Berinsky et al. 2012; Mullinix et al. 2015; Levay et al. 2016).

While online for surveys and survey experiments offers many advantages to scholars conducting political and social science research, researchers have expressed concerns about the quality of data obtained from various online data collection platforms (Douglas, Ewell, & Brauer, 2023; Smith, Roster, Golden, & Albaum, 2016). In perhaps the most well-known

example, scholars began noticing a marked decline in data quality beginning in 2018 using Amazon's Mechanical Turk, a popular platform for data collection among social scientists (Chmielewski & Kucker, 2019). The rising rates of inattentive and fraudulent responses found in data collected using the platform led many researchers to question the validity of empirical studies relying on MTurk data (Kennedy et al. 2020; Chmielewski & Kucker, 2019). Importantly, declining data quality was not a concern limited to the MTurk platform. Instead, researchers have found ample evidence of declining data quality in online surveys and survey experiments in samples sourced from a variety of professional and commercial panel providers (Kennedy et al., 2020; Zhang and Gearhart, 2020; Douglas, Ewell, and Brauer, 2023).

Generally, low quality data from online surveys and survey experiments can be attributed to a several common sources, each posing a threat to the validity of data and empirical findings: (1) software used to automate the completion of online surveys, or "bots"; (2) inattentive, acquiescent, careless, or satisficing respondents (e.g. Berisnky et al., 2014; Meade and Craig, 2012; Oppenheimer et al., 2012; Krosnick 1991; Groves, 1987) ; and (3) intentionally deceptive, dishonest, or "mischievous" participants (Browning, Satterfield, and Lloyd-Richardson, 2023; Perkel, 2020; Lopez and Hillygus, 2018).[10]

4.2.1 Automated and Assisted Survey Completion, or "Bots"

Online surveys are vulnerable to low quality and fraudulent responses caused by automated, programmatically generated responses from "bots." A "bot" in this context is a piece of software or a script that either assists individuals to programmatically and quickly complete

[10] This is not meant to be an exhaustive list of potential threats to data quality in survey and survey experiment research. Instead, the focus here is on a select list of common sources of low-quality data that affect online surveys and survey experiments and, unlike issues from poor question wording or study design, tend to fall beyond the researcher's control.

responses or automates the completion of surveys without human intervention all together (Griffin et al., 2021; Storozuk et al., 2020; Dreyfus et al., 2018; Stokel-Walker, 2018). The use of software or bots to complete surveys has received considerable attention from scholars focusing on specific online platforms, most often MTurk, but bots are relatively common to encounter in any situation where there are financial incentives for completion of surveys. Put simply, bots are most often used by individuals looking to quickly find and complete surveys in exchange for some financial reward. This financial reward may come in the form of direct monetary compensation (e.g. a $2.00 reward paid to the respondent for participation and completion of a survey) or by being entered into a "lottery" that will select a winner from the pool of participants.

Bots can engage in "ballot box stuffing," or repeated, duplicate responses to a survey to increase compensation they may receive, or to improve the odds of being selected in lottery style systems. And further, a bot may provide a single completion meant to achieve the financial reward as quickly as possible. These programmatic, duplicate responses have important consequences for research. Importantly, these bot responses are notoriously low-quality, and often provide incoherent, inconsistent data that contribute statistical noise that may threaten the validity of inference by contributing to confounding and the accentuation or attenuation of observed effects (Peer et al., 2022; Huang and DeSimone, 2021; Chandler, Sisso, and Shapiro, 2020; Buchanon and Scofield, 2018; Huang, Liu, and Bowling, 2015). And further, bots have important resource related consequence for research. Compensation paid to fraudulent bot respondents, and the time spent by researchers monitoring and checking for evidence of bot activity drains valuable research funds and research time.

4.2.2 Inattentive, Acquiescent, or Satisficing Respondents

Another source of low-quality data that often impacts online surveys and survey experiments are inattentive, acquiescent, satisficing, or otherwise careless respondents (see, for example: Krosnik, 1991; Krosnick et al., 1996; Oppenheimer et al., 2009). Inattentive or careless respondents may skim through survey questions and experimental treatments, fail to follow directions, fail manipulation checks, provide answers that do not correctly reflect the nature of questions, engage in "straight lining," and generally contribute to sub-optimal data quality.

Inattention and satisficing are not unique to online surveys. In earlier work, before the spread of online surveys, Krosnik (1991) theorized that the cognitive demands of surveys may lead individuals to give the first acceptable response that comes to mind from a list of alternatives to reduce cognitive demands. This can ultimately lead to a respondent arbitrarily selecting an answer that appears to match the question (which may or may not be the "best" answer), or even random answering of survey items. Surveys and survey experiments administered online are vulnerable to these effects of cognitive demands and survey fatigue. Yet, online survey data are particularly prone to issues of inattentive respondents (Berinsky et al., 2014). Individuals participating in online surveys may be distracted by other stimuli on their devices, engage in multitasking (e.g., listening to music, watching videos, etc.) and other activities that may limit their focus on the survey task (Drody, Pereira, and Smilek, 2023; Ternovski et al., 2022; Zwarun and Hall, 2014). And further, respondents may engage in survey speeding or "straight lining" to quickly receive a financial incentive offered for the completion of a survey.

Inattentive and careless responses are problematic in the collection survey data online. These respondents can be difficult to identify, and subsequently difficult to remedy.

Additionally, the inconsistent, random, or low-effort responses can contribute additional noise that can compromise the statistical power, utility, and validity of a dataset. As Oppenheimer et al. (2009) explain, these participants can "decrease the signal to noise ratio of a data set, and can substantially lower the power of an experiment" (pg. 867). This additional noise can contribute to Type 1 and Type 2 errors, as the additional noise, error, and effects on power can either accentuate or attenuate the relationships between variables.

4.2.3 Intentionally Deceptive, Insincere, or "Mischievous" Respondents

Mischievous respondents, individuals that are intentionally deceptive or insincere, are another concern for data quality from online surveys and survey experiments. Deceptive or mischievous behavior can take different forms including, among other things, misrepresentation of personal characteristics, "cheating" or looking up survey questions, or even giving satirical or "troll" responses to survey questions (Browning et al., 2023; Clifford and Jerit, 2016; Lopez and Hillygus, 2018).

Individuals may misrepresent personal characteristics or answer insincerely due to financial motivations. For example, if a researcher was interested in targeting a sample of homeowners, a mischievous respondent (that is not a homeowner) may answer screening questions or otherwise present themselves as a homeowner to become eligible to participate in the study and earn the financial reward for completion of the survey. Similarly, a researcher interested in surveying adults in the United States may have issues with respondents outside of the US attempting to participate in the survey by misrepresenting their location in screening questions, or by circumventing location restrictions by using VPNs, VPS servers, or other advanced methods (Kennedy et al., 2020).

Additionally, respondents may offer insincere responses to survey questions due to survey fatigue, acquiescence-response bias, demand effects and trying to answer in a way they believe the researcher wants them to answer, or even cheating on survey questions. For example, Clifford and Jerit (2016) found evidence of online survey participants cheating on political knowledge questions included in surveys by looking up the correct answers to these questions online. Other research shows that respondents may give insincere answers due to acquiescence bias, described by Krosnick as a propensity to agree or "endorse any assertion made in a question, regardless of its content" (pg. 552), or due to social desirability bias, or the "overreporting of admirable attitudes and behaviors and underreporting those that are not socially respected" (pg. 545). This insincerity and misrepresentation of beliefs can have important impacts on scholarly understanding of important social and political topics. In a recent study, for example, Hill and Roberts (2023) find that acquiescence-response bias can lead to significant overinflation of estimates (by upwards of 50%) of political misperceptions and conspiratorial beliefs in the United States. And finally, respondents may participate in "survey trolling" and give low-quality and insincere responses to be humorous or inflammatory (Lopez and Hillygus, 2018).

Mischievous respondents can result in low quality data that can have several negative consequences for the quality of samples, datasets and survey and survey experimental research. Through misrepresenting personal characteristics, including the manipulation of geographic location information, to gain access to surveys, these respondents deplete research funds and prevent researchers from accurately sampling their target audience. Further, respondents that give insincere responses as a result through acquiescence or social desirability bias can lead to overstated or understated conclusions about the relationships between variables. And as a result,

these data can have important implications for our understanding of political and social matters of importance and affect the integrity and validity of political science and social science research.

4.3 Data Quality in Online Surveys: Practical Strategies and Solutions

Online data collection for surveys and survey experiments offers many promising advantages to political scientists and social science research more broadly. Accessibility, easy access to respondents, quick and timely data collection, and cost-effectiveness make online surveys a valuable tool for researchers in the social sciences. However, as discussed above, online surveys are susceptible to issues with data quality and low-quality data that stem from inattentive, fraudulent, or otherwise problematic respondents being able to access and complete these studies across various online platforms. These low-quality data can negatively impact political and social science research in important ways, including (but not limited to) affecting statistical power of study designs, understating or overstating relationship between variables (Type 1 and Type 2 errors), compromising the validity of datasets and empirical findings, and threatening the integrity of political science research more broadly. And given the risks posed by low-quality and fraudulent data to statistical inference and political science research, it is important that researchers take steps to proactively prevent low-quality and fraudulent responses, and to identify and address problematic data after data collection has occurred.

The purpose of this essay is to offer a host of (relatively) easy to implement strategies that researchers can use to identify and address low quality data from online surveys, and more importantly, highlight several approaches that will help to prevent fraudulent responses from occurring all together. In the following section, I will give a brief walkthrough of different prevention and mitigation strategies to decrease the occurrence of fraudulent responses and

promote data quality within Qualtrics – a well-known survey building platform and software that is widely used by academics in political and social sciences. And further, I will explain some useful approaches for identifying or detecting problematic, low-quality responses in a dataset *after data collection* with examples in Stata, a commonly used statistical software in the field of political science.[11]

4.4 Preventing Low-Quality Responses in Qualtrics

An important first step for identifying and addressing low-quality data and fraudulent responses in surveys is to prevent these problematic respondents from entering and completing the survey. However, no approach will successfully prevent all fraudulent respondents, and to aid in identification and mitigation of problematic responses that do emerge in the data collected, available data and information needs to be leveraged in a way that enables researchers to effectively investigate and process their survey data. There are several tools, settings, and recommendations for survey design that can be configured prior to data collection that can help prevent fraudulent responses and offer valuable indicators of data quality that can assist researchers for detecting and investigating data quality.

Qualtrics is a popular platform used by scholars to build, distribute, and collect data for online surveys and survey experiments. Despite the widespread use of the platform, there are many settings, questions, and valuable "embedded data" that remain relatively unknown and

[11] I focus on examples in Qualtrics and Stata for 3 reasons. First, these are the tools that I am most familiar from my experiences conducting online survey experiments. Second, Qualtrics is a platform that many academics have access to and commonly use, and the platform is used widely to the point that virtually all online data collection platforms are configured to interface or integrate with Qualtrics when scholars are conducting studies. And finally, while I focus on Qualtrics and Stata in these examples, these approaches can similarly be applied/implemented using different platforms or statistical software depending on a researcher's access and preference.

underused when conducting survey research. In the following sections I will describe some of the utilities that are particularly helpful for preventing and detecting fraudulent survey responses, as well as detail the strengths of each for protecting data quality.

4.4.1 Survey Settings for the Prevention of Bots

Qualtrics has built-in bot detection and fraud prevention tools that are effective in the detection and prevention of fraudulent respondents. It is important to note, these functions are not enabled by default and must be enabled and activated prior to data being collected to be effective. To find and enable these tools, navigate to the "Survey options" and select the "Security" tab.

The first setting to enable is the "Prevent multiple submissions" option. Enabling this option will help to prevent automated survey attempts from relatively simple bots or automated scripts and prevent "ballot box stuffing" or repeated submissions from individual respondents. Automated survey responses and ballot box stuffing are common when survey respondents are offered financial incentives for participation and completion. After enabling this setting, data collected by Qualtrics, like IP addresses, are used to prevent individuals that have completed the survey once from accessing or completing the survey again.

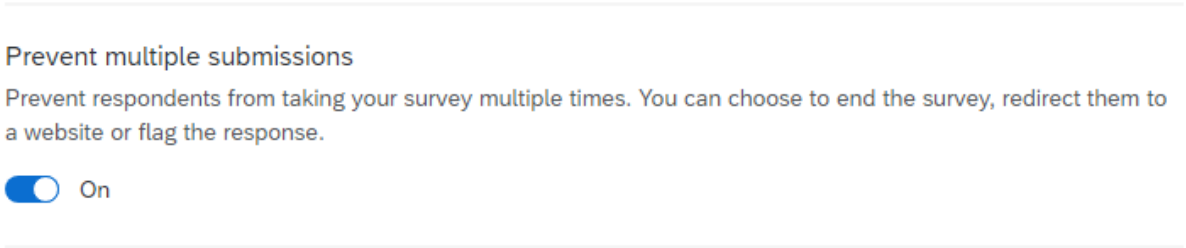

Figure 4: Preventing Multiple Submissions (Ballot Box Stuffing)

Additional options are available for how to process respondents that are blocked for making multiple submissions, including terminating or flagging the response. Flagging the respondent would allow the individual to proceed to and complete the survey while being marked with an indicator in the final data, whereas termination simply ends the survey session and prevents the attempt completely. Flagging is a useful utility in many situations, but for the prevention of multiple submissions it is best to terminate the responses immediately.

Further, the "RelevantID" setting, which appears on the same security page, should be enabled. The RelevantID setting shares a lot of overlap with the "Prevent multiple submissions" utility by detecting repeated submissions, but also uses a variety of additional device, location, and browser data to develop and assign a fraud score. [12]

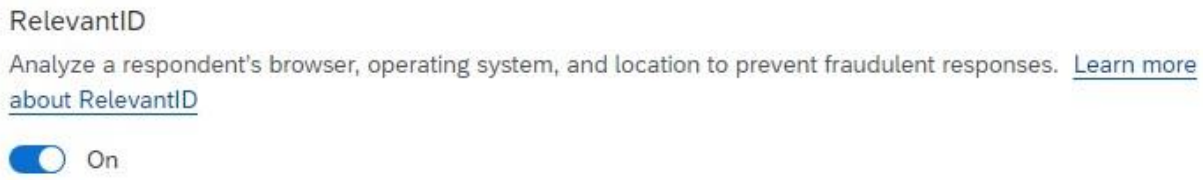

Figure 5: Enabling RelevantID for Fraud Detection

Enabling the "RelevantID" setting will create several embedded data variables that can be used to identify, filter, or terminate fraudulent responses. For addressing problematic respondents, the "Q_RelevantIDDuplicateScore" and "Q_RelevantIDFraudScore" variables provide useful information. The former is an indicator of RelevantID's confidence that a response is a duplicate (where values from 75-100 indicate high confidence), while the later is an indicator containing a fraud score (where values over 30 meaning a response is likely to be a bot).

[12] Qualtrics uses Imperium's RelevantID technology to develop the individual fraud scores. More information can about RelevantID can be found here: https://www.imperium.com/relevantid/

Indicators for RelevantID will appear in the survey data file as a variable for identification or processing in statistical software, but these embedded data fields can also be used to create a binary indicator that "flags" a respondent for suspect or failing scores across several measures. This binary indicator collapsed multiple data into a single, easy to interpret indicator, ultimately saving time spent by researchers combing through the data. Creating this binary indicator is relatively easy and can be done in the "survey flow" using branching logic. Figure 3 demonstrates the creation of a flagging indicator that I named "flagRelevantID," which codes a respondent with a value of 1 based on scoring above or below certain thresholds on the different scoring indicators.

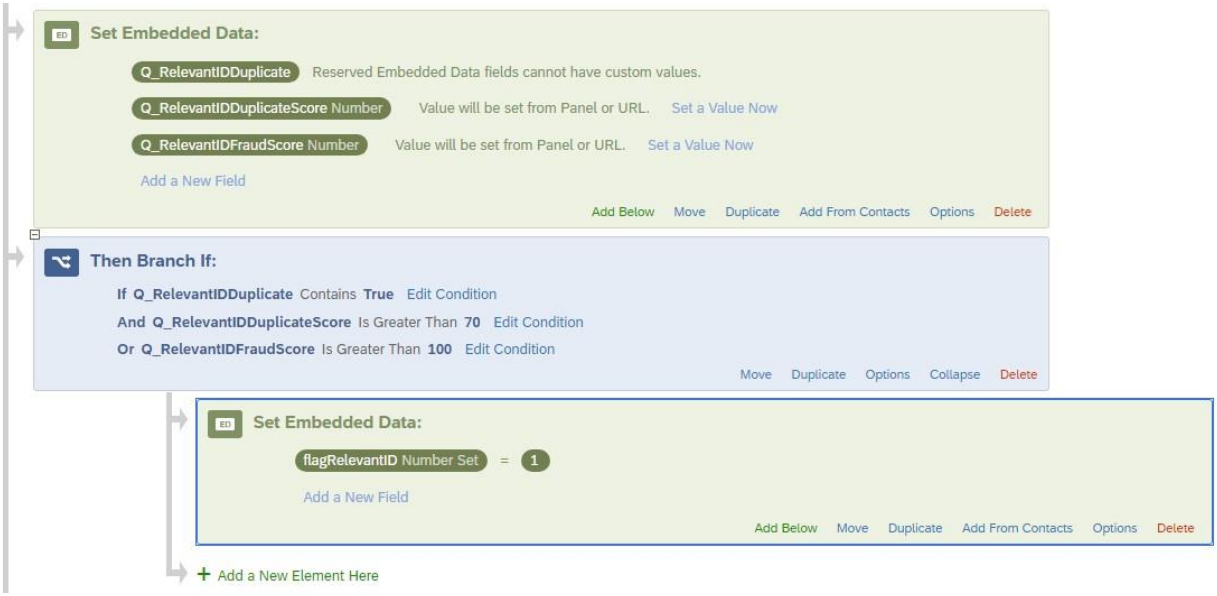

Figure 6: Creating a Flagging Indicator for RelevantID Fraud Scores

Next, Qualtrics uses Google's reCaptcha technology to assign a score for each respondent indicating the likelihood that that the respondent was a human or a bot (Qualtrics, 2023). To make use of this capability, the "Bot detection" setting should be enabled within the survey settings and can be found on the same "Security" tab previously discussed.

Figure 7: Enabling bot detection and reCaptcha

After the bot detection setting has been enabled, a measure called "Q_RecaptchaScore" is created as an embedded data field within the survey and assigned a value that ranges between 0 and 1 indicating the likelihood of a response being fraudulent. Qualtrics explains that scores above 0.5 indicate that a respondent was likely a human, while a score of less than 0.5 indicate a higher likelihood that the respondent was a bot.[13] This data will appear in the data and analysis section of Qualtrics and will also appear as a variable in the final survey data file when downloading and exporting the dataset after data collection has completed. Using the embedded data and branching logic, a binary indicator flagging respondents for suspect reCaptcha scores can be constructed.

[13] The Qualtrics help and support pages provide detailed explanations of the various embedded data fields along with the interpretation of their values. https://www.qualtrics.com/support/survey-platform/survey-module/survey-checker/fraud-detection/

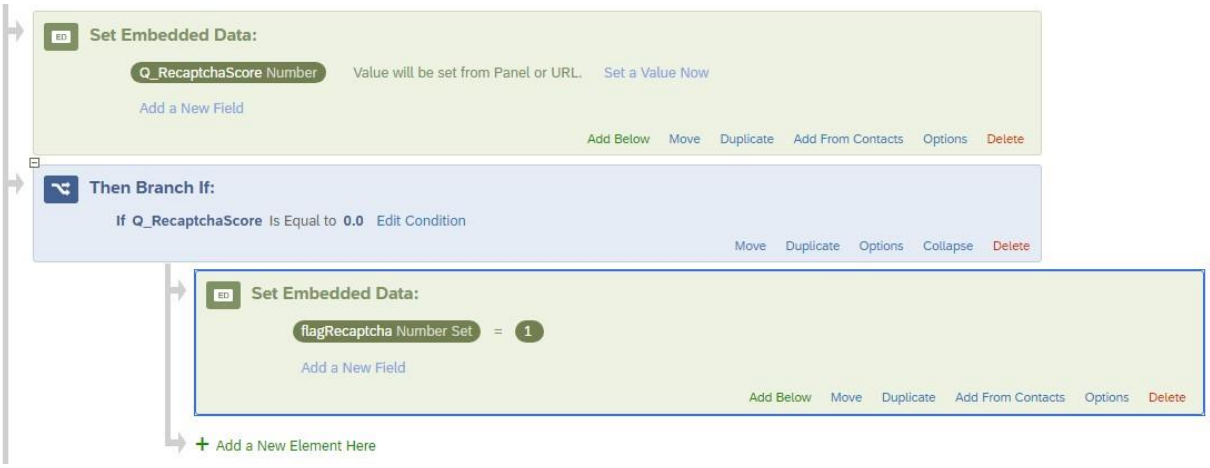

Figure 8:Creating a Flag Indicator for Suspect reCaptcha Scores

Together, these three settings provide a significant amount of protection from fraudulent responses and low-quality data that results from bots and individuals attempting to "stuff the ballot box" by preventing multiple submissions, but also providing helpful indicators that can be used to detect problematic responses that are not caught and appear in the final data.

4.4.2 Geolocation and Location Restrictions

As discussed earlier in this paper, dishonesty and misrepresentation from respondents are a common source of low-quality data in online surveys and survey experiments. Misrepresentation or dishonesty about location or country of origin often occurs when collecting survey data online and is usually due to an individual attempting to be granted access to complete the survey and receive a financial reward.

Respondents misrepresenting their locations can be problematic for researchers attempting to target the relevant samples for their studies. For example, if trying to sample

registered voters in Florida to gauge government approval in the state, respondents from other states or other countries entirely can compromise the quality of a sample.

Location restrictions can be used to mitigate this type of problematic response. Specifically, Qualtrics' GeoLocation data can be used to construct location-based restrictions that effectively screen out respondents that are not from specific geographic locations. Within the survey flow, branching logic and the embedded geolocation data can be used to terminate a survey. Figure 6 provides an example of using the geolocation embedded data to create a binary indicator flagging non-US respondents, and terminating a survey attempt if the respondent was outside of the United States.

Figure 9: Creating Geographic Restrictions in Qualtrics

4.4.3 Inattentive and Careless Respondents

As described earlier, inattentive and careless respondents are a prevalent source of low-quality survey data, and these responses can contribute reduce statistical power and contribute statistical noise that can accentuate or attenuate the relationships between variables in the data. These types of respondents are particularly problematic because they can be difficult to detect.

However, various timing data and attention check measures can be used to flag and identify speeding, careless, or inattentive respondents.

4.4.4 Flagging Failed Attention Checks

Including attention check measures in a survey instrument is a recommended best practice. A robust literature exists on attention checks exploring the utility of attention checks along with different measures used and their relative merits. The number and types of attention checks that should be used is not the interest here. Instead, the goal is to explain how to use an attention check to identify and address low-quality responses more effectively. This can be done easily using an attention check item in the survey and branching logic with embedded data in the survey flow to quickly create flagging indicator for respondents failing attention checks.

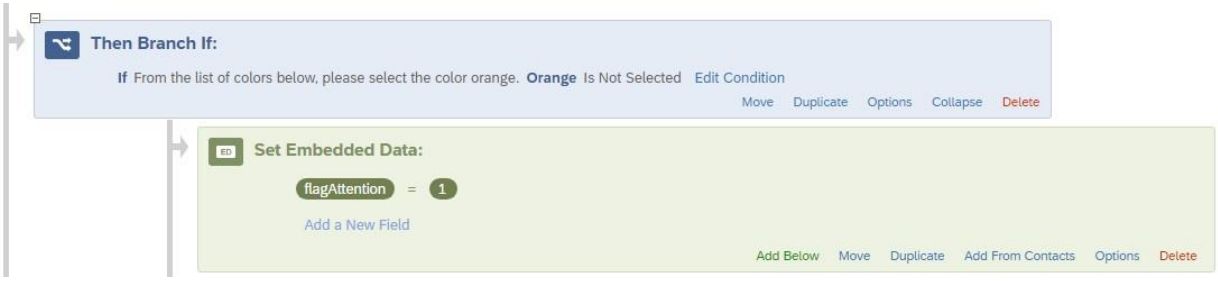

Figure 10: Flagging Failed Attention Checks

As an example, consider an attention check item in the survey that instructs respondents "from the list of colors below, please select the color orange," we can use the response to this measure to create an indicator flagging a respondent that did not select orange from the list for failing the attention check. Figure 7 demonstrates the branching logic and embedded data used to construct the "flagAttention" quality indicator. Just like the other indicators for flagging data

quality, this attention check flag makes the identification, sorting, exclusion, and investigation of these problematic responses more efficient. Alternatively, there may instances in which a researcher wants to go beyond flagging an inattentive respondent and terminate the attempt and prevent the respondent from completing the rest of the survey. A slight change to the survey logic, shown in Figure 8, will terminate the inattentive respondent.

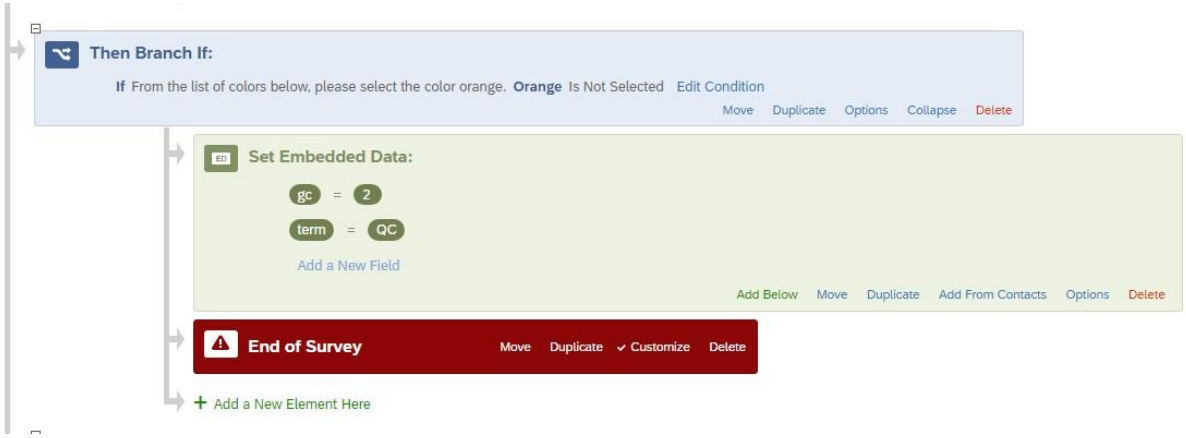

Figure 11: Terminating Respondents that Fail Attention Checks

4.4.5 Timing and Identifying Speeders

Speeders are innatentive respondents that can contribute to data quality issues when collecting survey data online. There are two features that can be implemented within Qualtrics surveys that can help to identify survey speeders. First, Qualtrics measures the total time spent by a respondent comlpeting the survey as stores this as an embedded data variable. In the survey flow, this total survey duration can be accessed and used to either flag problematic speeders or terminate these responses. Figure 9 demonstrates how to use branching logic and embedded data to create a variable named “flagSpeeder” that indicates a respondent was speeding through the survey.

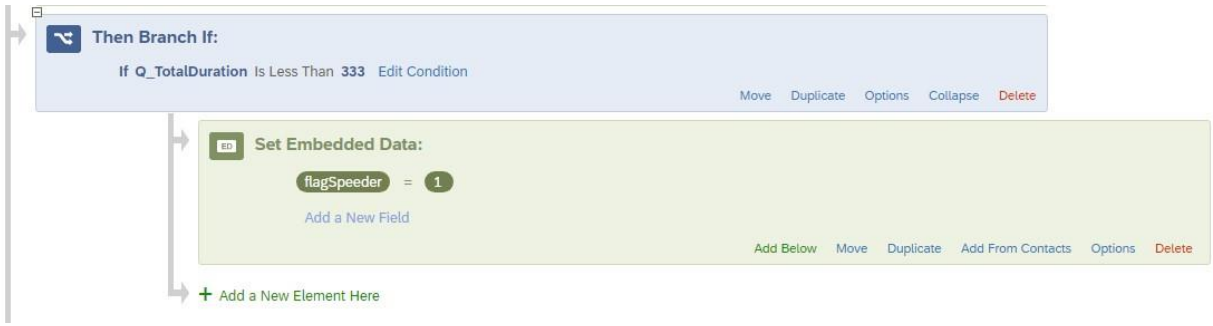

Figure 12: Flagging Survey Speeders

The time threshold used to classify a respondent as a speeder can vary from survey to survey and should be decided based on estimated completion times from the development stage and initial pilot testing. However, a good starting point to consider would be flagging respondents that spend less than 1/3rd of the median completion time for the survey. And with a small change to the survey logic, displayed in Figure 10, these responses can be terminated and removed from the data set.

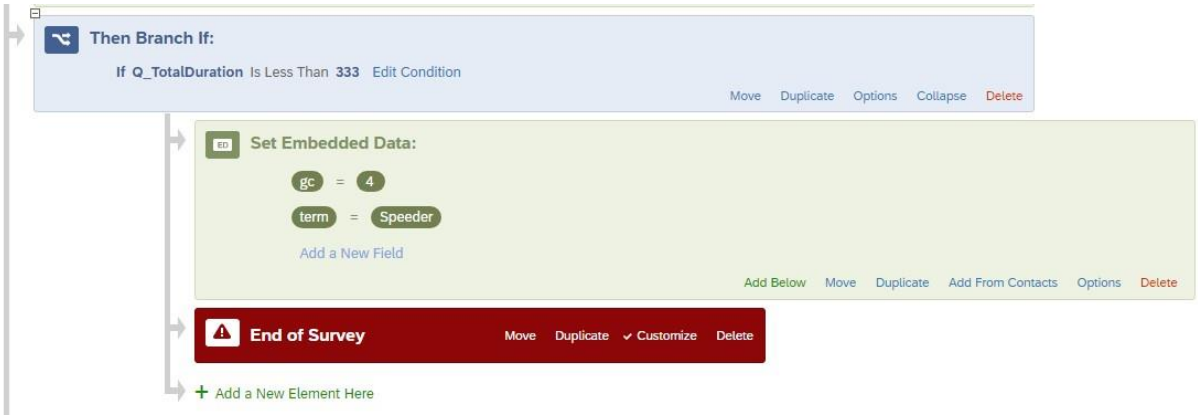

Figure 13: Terminating Survey Speeders

4.4.6 Individual question timers

The second timing utility that is effective for identifying inattentive speeders is using the timing question in Qualtrics. Once a timing question has been added to the survey, it will measure the amount of time the respondent spent on that specific page. Figure 11 demonstrates the use of the timing question to capture time spent reading a news article used as a treatment condition in a survey experiment.

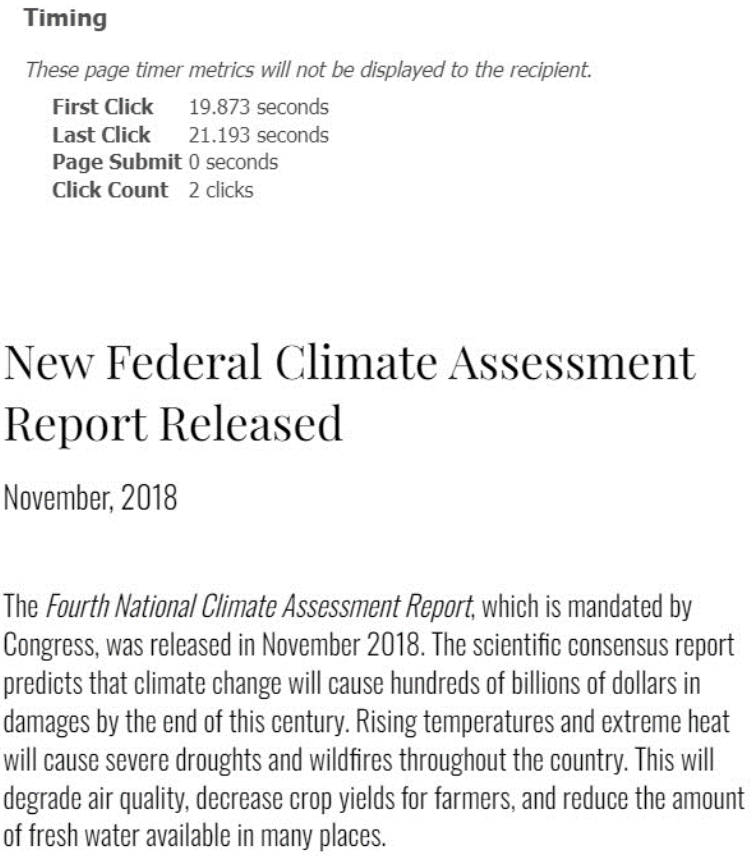

Figure 14:Measuring Time Spent on Treatment

Timing questions are particularly effective for survey experiments exploring the effects of exposure to a treatment on subsequent attitudes and beliefs, as they offer insights into the

extent to which a respondent engaged with or was attentive to the stimuli presented. Like the other examples presented here, this question timing data can be accessed within survey logic to flag suspected speeders for further investigation, or if preferred, terminate these respondents all together. Figure 12 uses an example of using question timer functions in six experimental treatment conditions to terminate respondents that spent less than 5 seconds on the treatment page.

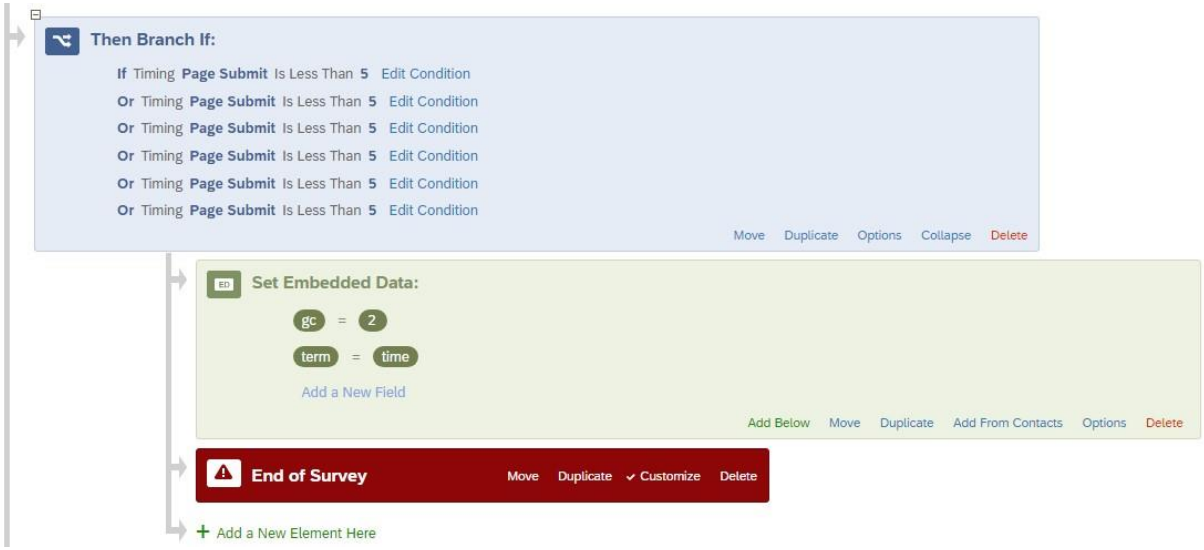

Figure 15: Example Survey Logic to Terminate Speeders in Experimental Conditions

4.4.7 Open Response Questions

Finally, open response questions are a valuable tool for researchers in identifying and addressing problematic responses in survey data. Including one or two open response questions in the survey offers researchers the chance to capture additional data to use in investigating suspect respondents and can be particularly effective for catching fraudulent responses and other low-quality data that was able to slip through the safeguards presented in this essay.

While open response questions may not prevent fraudulent responses from ending up in your data set, they do have the advantage of making identification much easier when processing and investigating data further in statistical software. Bot responses, insincere respondents, "survey trolls" and other sources of low-quality survey data are often easy to spot in the text provided while answering open response items. Mischievous respondents will often enter incoherent, and often random gibberish that is relatively straight forward to identify at first glance.

4.5 Post-Collection Strategies for Identifying Low-Quality Data

Each of the strategies for improving data quality when conducting online surveys and survey experiments discussed in the previous section serve to (1) prevent fraudulent, low-quality responses from infiltrating a survey, and (2) offer additional data quality indicators that can be used to further identify, investigate, and process suspect respondents that make it past the other safeguards.

After exporting a dataset from Qualtrics, all of the survey responses and embedded data variables will be present, and these can be used to develop additional measures of data quality, like flagging indicators for straight lining, inconsistent answers, and incoherent or gibberish open response entries.

Identifying Straight lining and Satisficing

Satisficing, straight lining, and response non-differentiation are another source of low-quality data encountered in surveys and survey experiments. Unlike speeders and inattentive respondents, which can be detected using timing and attention check questions that are relatively

easy to implement, additional challenges exist for identifying and addressing straight lining or satisficing.

First, there is not an easy to implement approach for flagging respondents suspected of straightening in as the respondent progresses through the survey. This results in most straight lining needing to be investigated after the data has been collected and is being processed or cleaned in statistical software.

And second, satisficing and straight lining is not as effective as other indicators for data quality in online surveys. Mischievous respondents that contribute fraudulent or low-quality responses aim to avoid detection, and straight lining is a relatively easy way for survey completions rejected and financial compensation withheld. Because of this, problematic respondents try to avoid consistent straight lining on survey questionnaires.

Despite these challenges, identification of straight liners does offer another indicator of data quality and can be done quickly using the “respdiff” command in Stata. Figure 15 presents an example of Stata code using the “respdiff” command to construct binary indicator variables that are coded as 1 if the respondent engaged in straight lining across two different sets of dependent variables. The first line of code creates a variable named “itstraightline” that takes a value of 1 if there was non-differentiation, or identifical responses across the dependent variables it1-it6. The second example uses the dependent variables cons1-cons5 to create the same measure of non-differentiation named “conspstraightline.”

```
// generating variable indicating whether or not the respondent
  // straightlined the 6 IT items
  respdiff itstraightline= nondiff( it1 it2 it3 it4 it5 it6 )
  label var itstraightline "Straighlined IT Items"
  tab itstraightline

  // generating variable indicating whether or not the
  // respondent straightlined
  // the consp items
  respdiff conspstraightline= nondiff( cons1 cons2 cons3 cons4 cons5)
  label var conspstraightline "Straightlined Consp Battery"
  tab conspstraightline
```

Figure 16: Flagging Straight-liners in Stata

4.5.1 Inconsistent Responses – example of party ID and Ideology

The final source of low-quality data that is commonly encountered in online data collection for surveys is respondents offering inconsistent, low effort responses. There are a handful of strategies that can be used to identify inconsistent responses, including asking a question and then asking the identical question again at a later point in the survey. This is an effective method, but one that I usually avoid out of not wanting to add additional measures that bloat the number of questions, time required, and energy required to complete a survey.

An alternative approach is to calculate a measure of inconsistency using existing measures in the survey that are expected to be relatively congruent. Figure 14 displays some example Stata code that can be helpful for flagging suspect, inconsistent responses using party identification and political ideology variables for demonstration. Given that all the online surveys I have conducted are centered in political science, respondents' party identification and political ideology are always measured, and some level of consistency or congruence is expected

between the two, these measures can be used to uncover inconsistency in responses relatively easily.

```
// Detecting inconsistent respondents using Party ID and Ideology

//  generate variable that is the absolute value
//  of the difference between Party ID and Ideo reported
//  larger values indicate an inconsistency
// e.g. selecting "Extreme Republican" for pid
// and "Extremely Liberal" for ideo
  gen pidideo= abs(pid-ideo)
  tab pidideo
  label var pidideo "PID vs Ideo Diff"
  tab pidideo


//Indicator coded as 1 if respondent has a large reported difference

  gen flagpidideo=(pidideo>4)
  label var flagpidideo "Flag - pidideo > 4"
  tab flagpidideo
```

Figure 17: Identifying Inconsistent Responses in Stata

In the example code in the figure, a variable is generated that is equal to the absolute value of the difference between the respondents reported party identification and political ideology (both measured on 7-point scales). The resulting variable has higher values representing greater response inconsistency (e.g. A respondent identifying as a “Strong Republican” but answering “Extremely Liberal” when asked their political ideology). In the later part of the code, this measure of inconsistency is then used to construct a simple flagging indicator that identifies

a respondent as being suspected for inconsistency. This example is just to demonstrate a strategy for detecting response inconsistency that I have used in numerous surveys, but the general approach will work with different measures and survey items easily.

4.5.2 Investigating Open Responses

In an earlier section, open response items were suggested as a valuable tool for identifying and addressing low quality and fraudulent response. These open response items are very simple to implement by just adding the questions to the survey, but working with the response data is, unfortunately, more time intensive and demanding.

Open response items do not offer a way to prevent or screen out problematic responses as they occur. They do, however, offer additional evidence to use for investigating and addressing suspect responses after data collection has concluded. A practical approach for making use of open response variables that does not require manually pouring through hundreds, if not thousands, of responses looking for suspect entries is to instead use the open responses when making determinations to exclude a respondent from analyses or remove them from the dataset altogether. Unsurprisingly, completely bogus, incoherent, gibberish responses often come from respondents (or bots) that will have been flagged on several of the data quality indicators highlighted in this paper.

openresponsedv
Yes
Dhdh dhdukdjd jesus is jxj his
Uhhhhhh sbsb
Shhvcc.ghahahah.
very good very good very good very good very good
L
Hishsgisihdhodhiduihihodhkdhodhidgidhiduidhodhodhdhodhidhiihdgidgid.
vary good.
Opinion
Llil
Yeah I wanna know how much I love y'all. Yeah I t
good interesting message
uhhh idk- spongebob
None
Bob hahahah
Hey I'm going on my insta was a little fun I just got to work I got my dad a text I got a call back from my dad I got to call him bye call now bye love ya mama
Vgh
Ok I'll get a good gr8from you can get detailed in town to me
nerd strength
Jnbbnnjemsnz. She sks sks am and d dnd
2
Good service
Bxsjbzjs shznznsnsjss
Ooo ya girl lol lol y'all ya lol lol. Hey sis I hope y'all are doing too much yayyyyy
need to find out the trute right l
Really cool game but it would have been better if you could add more games to play with this game is a great game for kids
Hxjxhdhdhshdhehdjejheheeheudhshsjdjjsjsjsjdjsjsjsjsjsjdhdhdhdh
Fuj so he jjjg Josie him like some in Josie and cost consider crucial certain in Grafton Justin call I've done cool could
Snd
Hh
Shsnnsnsnddn
I'm so sorry glad I didn't get hit by the app I was really
Hgtuy hfhy height utuh. Cumin gthh no fun

Figure 18: Example Open Responses from Fraudulent and Mischievous Respondents

A sample of open response entries from fraudulent survey respondents is presented in Figure 15. These data are "real" and come from respondents that were recruited by a very large, well-known sample panel provider that was under contract to administer a survey experiment to sample of over 2,000 respondents recruited in the United States. Even more concerning than this quality of these responses is that these highlighted examples constituted only a portion of the total fraudulent responses that were present in the initial soft launch data of only a couple of hundred participants.

I chose to include this anecdote, and the example data presented in Figure 15, to highlight and reinforce the main points underlying this essay: (1) bots and mischievous, inattentive,

careless, and otherwise problematic respondents pose sincere threats to data quality in online surveys and survey experiments; (2) low-quality responses can infiltrate and compromise data quality in all online surveys, regardless if data is being collected on crowdsourcing platforms, or through expensive, well-known commercial panel providers; and (3) given the consequences and prevalence of threats to data quality in online surveys, it is important to take steps to prevent, identify, and address the common sources of these issues.

4.6 Conclusion

Online data collection for surveys and survey experiments offers many promises to political scientists and scholars conducting social science research. Online surveys are an accessible, cost-effective alternative to more traditional methods and allow for quick access to participants and collection of data. For these reasons, online surveys have become the preferred tool for researchers conducting survey experiments and observational survey research in the political and social sciences. However, the promises of online surveys do not come without challenges, the most pressing being the growing concern about the prevalence of low-quality and fraudulent data.

Low-quality data from bots, inattentive, insincere, and other mischievous respondents pose sincere threats to political science research that cannot be understated. These mischievous responses can contribute noise that weakens statistical power, can result in overstated and understanded effects or relationships between variables, drain resources, and otherwise threaten statistical inference and the validity of political science research.

In this paper, I explore these issues of low-quality data in online surveys and survey experiments, describe and discuss the most common sources of fraudulent data in online surveys, and present a variety of relatively easy-to-implement strategies to prevent, identify, and address

problematic responses and better safeguard data. Addressing the issues of data quality in online surveys is important. And in detailing the scale and nature of these challenges and providing accessible, effective strategies for mitigating these issues, this paper aims to increase awareness of these issues and contribute to the ongoing effort to improve and ensure the validity of online surveys and survey experiments in political science and social science research.

5 CONCLUSION

Communicating effectively with the public is vital for developing the consensus necessary to take necessary action and pursue policy to address collective action problems. Climate change is one of the most pressing challenges facing society today. Global warming, sea level rise, ocean acidification, and other manifestations of Earth's changing global weather patterns have severe economic, environmental, national security, and social consequences that society must address and face. However, the inherent complexity of climate science and growing partisan divisions and polarization on the issue pose a threat to the effective communication of climate change with the public and the development of consensus needed to take action to mitigate the future effects. Because of this, there is a need to find messaging and methods for communicating with the public that resonate with different audiences.

In this dissertation, I contribute to the body of work in political communication, climate change communication, and science communication by investigating the effects of emphasis frames on climate change beliefs. Building from prior work, I designed and implemented a 7-condition, two-wave survey experiment to test the effects of exposure to a novel set of frames, both textual and incorporating visual frames and imagery, that highlight the impact of sea level rise and coastal flooding in US communities on climate change beliefs. I find that these textual and visual frames effectively influence beliefs about climate change, including perceptions of negative impacts, concern for affected communities, and belief that climate change is happening. Further, I find that these frames can produce durable treatment effects that persist over time. And finally, I offer some preliminary insights into the similarities and differences in visual and textual framing effects in an over-time environment.

The literature on emphasis framing and climate change communication is extensive and received significant scholarly attention. Prior work using framing experiments to test the effects of exposure to different emphasis frames have provided solid empirical evidence that frames highlighting different aspects of climate change have the ability influence peoples' opinions and beliefs about climate change. While well-established, and having solid theoretical and empirical grounding, the existing research on emphasis frames in climate communication does have two important limitations that are the subject of this dissertation: (1) much of the prior work uses framing experiments to study the effects of exposure to different *textual* frames on climate change beliefs, while studies of *visual* frames and imagery are significantly fewer in number; and (2) most of the existing work on emphasis framing in political communication employ one-shot, cross sectional experimental designs measuring treatment effects immediately following exposure, leaving the body of work on the duration of communication effects over time comparatively underdeveloped. The empirical studies presented in this dissertation contribute to these areas of the literature by providing an examination of (understudied) visual frames and imagery in climate communication, an analysis of both textual and visual framing effects, and an empirical test of the durability and decay of these framing effects in an over-time communication environment.

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APPENDICES

Appendix A

Alternative model specifications, including model estimates with additional covariates, are presented in the tables included in Appendix A.1 below. The second section of the Appendix contains the survey instrument, including all treatments and dependent measures.

Appendix A.1

Table 2:Main Treatment Effects with Demographic Covariates

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.625***	0.000	0.263*	0.056	0.099	0.261
	(0.14)		(0.17)		(0.15)	
Boston Map	0.513***	0.001	0.359**	0.015	0.264*	0.054
	(0.16)		(0.17)		(0.16)	
Miami Map	0.584***	0.000	-0.051	0.387	-0.030	0.426
	(0.15)		(0.18)		(0.16)	
Virginia Map	0.614***	0.000	0.230*	0.087	0.214*	0.083
	(0.15)		(0.17)		(0.15)	
New Orleans Map	0.568***	0.000	0.267*	0.062	0.396***	0.005
	(0.16)		(0.17)		(0.15)	
Multiple Map	0.410***	0.005	0.054	0.382	0.197	0.103
	(0.16)		(0.18)		(0.16)	
Republican	-0.095	0.288	0.009	0.481	-0.098	0.287
	(0.17)		(0.19)		(0.18)	
Democrat	0.237**	0.036	0.509***	0.000	0.446***	0.000
	(0.13)		(0.15)		(0.13)	
Liberal	0.309***	0.010	0.452***	0.001	0.648***	0.000
	(0.13)		(0.14)		(0.13)	
Conservative	-0.119	0.242	-0.643***	0.000	-0.702***	0.000
	(0.17)		(0.19)		(0.17)	
Constant (Control)	5.552***	0.000	4.868***	0.000	5.346***	0.000
	(0.14)		(0.16)		(0.15)	
N	1050		1050		1050	
AIC	3554.2		3883.7		3606.5	
BIC	3608.7		3938.2		3661.0	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition and the Control group baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test.
* *p<0.10,* ** *p<0.05,* *** *p<0.01*

Table 3: Unadjusted Treatment Effects

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.625***	0.000	0.251*	0.078	0.096	0.297
	(0.15)		(0.18)		(0.18)	
Boston Map	0.455***	0.004	0.244*	0.092	0.129	0.247
	(0.17)		(0.18)		(0.19)	
Miami Map	0.600***	0.000	-0.037	0.424	-0.015	0.469
	(0.15)		(0.20)		(0.19)	
Virginia Map	0.625***	0.000	0.244*	0.097	0.229	0.101
	(0.16)		(0.19)		(0.18)	
New Orleans Map	0.593***	0.000	0.309*	0.052	0.455***	0.005
	(0.17)		(0.19)		(0.18)	
Multiple Map	0.427***	0.005	0.092	0.319	0.238*	0.095
	(0.17)		(0.19)		(0.18)	
Constant (Control)	5.729***	0.000	5.103***	0.000	5.587***	0.000
	(0.12)		(0.13)		(0.13)	
N	1050		1050		1050	
AIC	3609.1		4063.4		3916.2	
BIC	3643.8		4098.1		3950.9	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition and the Control group baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test.
* *p<0.10*, ** *p<0.05*, *** *p<0.01*

Appendix A.2

Survey Design - Experimental Conditions

Control

We will begin by asking about your beliefs regarding coastal flooding and climate change.

Text Only

You will now read a short article. Please read the article carefully, as we will ask you several related questions later in the survey.

Rising Sea Levels Will Threaten US Coastal Cities

Earth's polar ice is melting faster than climate scientists had previous thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean to rise by 10 to 15 feet, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just one inch of sea level rise equates to about an 8-to 10- feet loss of beach.

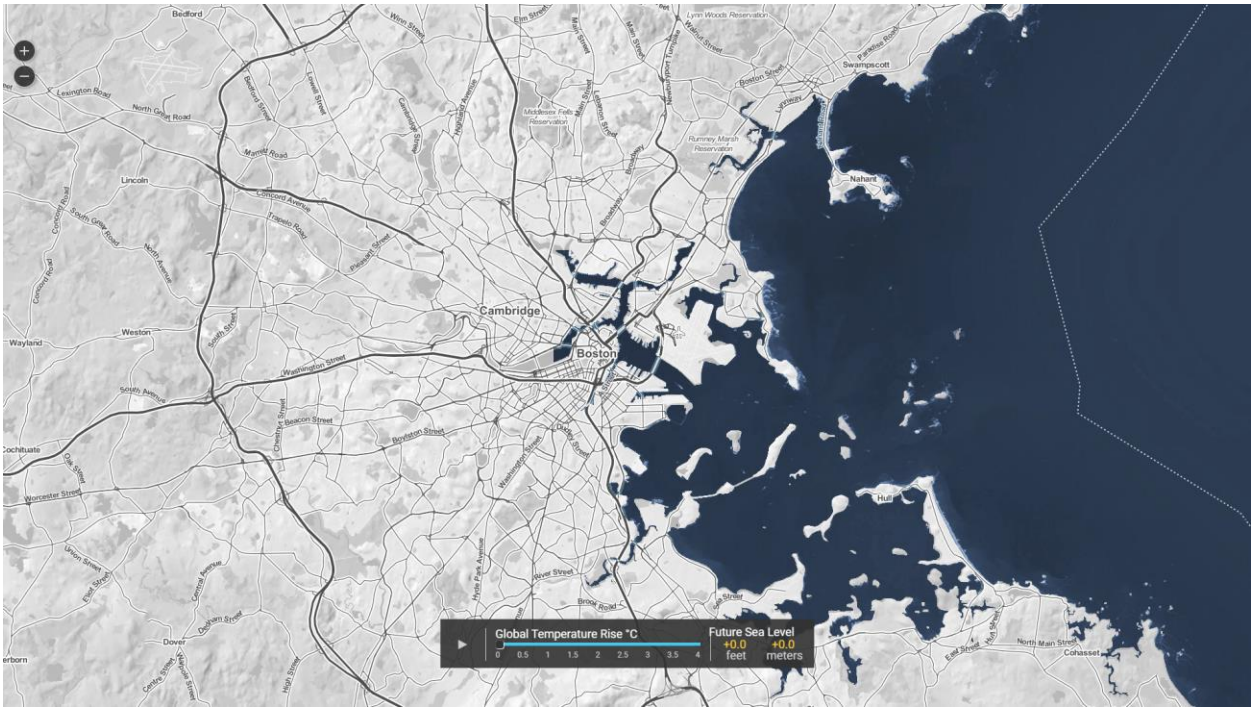
Text + Boston Map

You will now read a short article. Please read the article carefully, as we will ask you several related questions later in the survey.

Rising Sea Levels Will Threaten US Coastal Cities

Earth's polar ice is melting faster than climate scientists had previous thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean to rise by 10 to 15 feet, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just one inch of sea level rise equates to about an 8-to 10- feet loss of beach.

Please look carefully at the animated map below of Boston. It shows the projected amount of coastal flooding that will occur in Boston as a result of a 15 foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US.



Note: The areas shaded in blue represent the portions of land that will be permanently flooded as a result of the change in sea-level.

Text + Miami Map

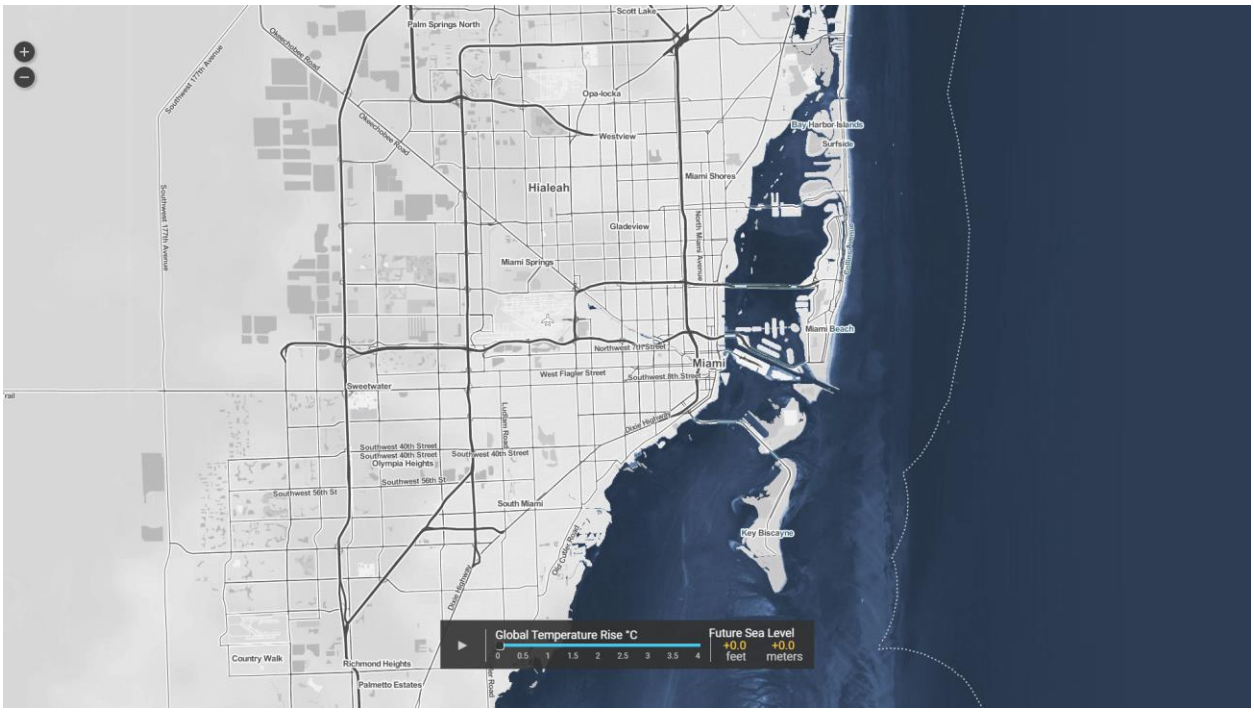
You will now read a short article. Please read the article carefully, as we will ask you several related questions later in the survey.

Rising Sea Levels Will Threaten US Coastal Cities

Earth's polar ice is melting faster than climate scientists had previous thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean to rise by 10 to 15 feet, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just one inch of sea level rise equates to about an 8-to 10- feet loss of beach.

Please look carefully at the animated map below of Miami. It shows the projected amount of coastal flooding that will occur in Boston as a result of a 15 foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-

level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US.



Note: The areas shaded in blue represent the portions of land that will be permanently flooded as a result of the change in sea-level.

Text + Virginia Beach Map

You will now read a short article. Please read the article carefully, as we will ask you several related questions later in the survey.

Rising Sea Levels Will Threaten US Coastal Cities

Earth's polar ice is melting faster than climate scientists had previous thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean to rise by 10 to 15 feet, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just one inch of sea level rise equates to about an 8-to 10- feet loss of beach.

Please look carefully at the animated map below of Virginia Beach. It shows the projected amount of coastal flooding that will occur in Boston as a result of a 15 foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US.

Note: The areas shaded in blue represent the portions of land that will be permanently flooded as a result of the change in sea-level.

Text + New Orleans Map

You will now read a short article. Please read the article carefully, as we will ask you several related questions later in the survey.

Rising Sea Levels Will Threaten US Coastal Cities

Earth's polar ice is melting faster than climate scientists had previous thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean to rise by 10 to 15 feet, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just one inch of sea level rise equates to about an 8-to 10- feet loss of beach.

Please look carefully at the animated map below of New Orleans. It shows the projected amount of coastal flooding that will occur in Boston as a result of a 15 foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US.

Note: The areas shaded in blue represent the portions of land that will be permanently flooded as a result of the change in sea-level.

Text + Multiple Maps

You will now read a short article. Please read the article carefully, as we will ask you several related questions later in the survey.

Rising Sea Levels Will Threaten US Coastal Cities

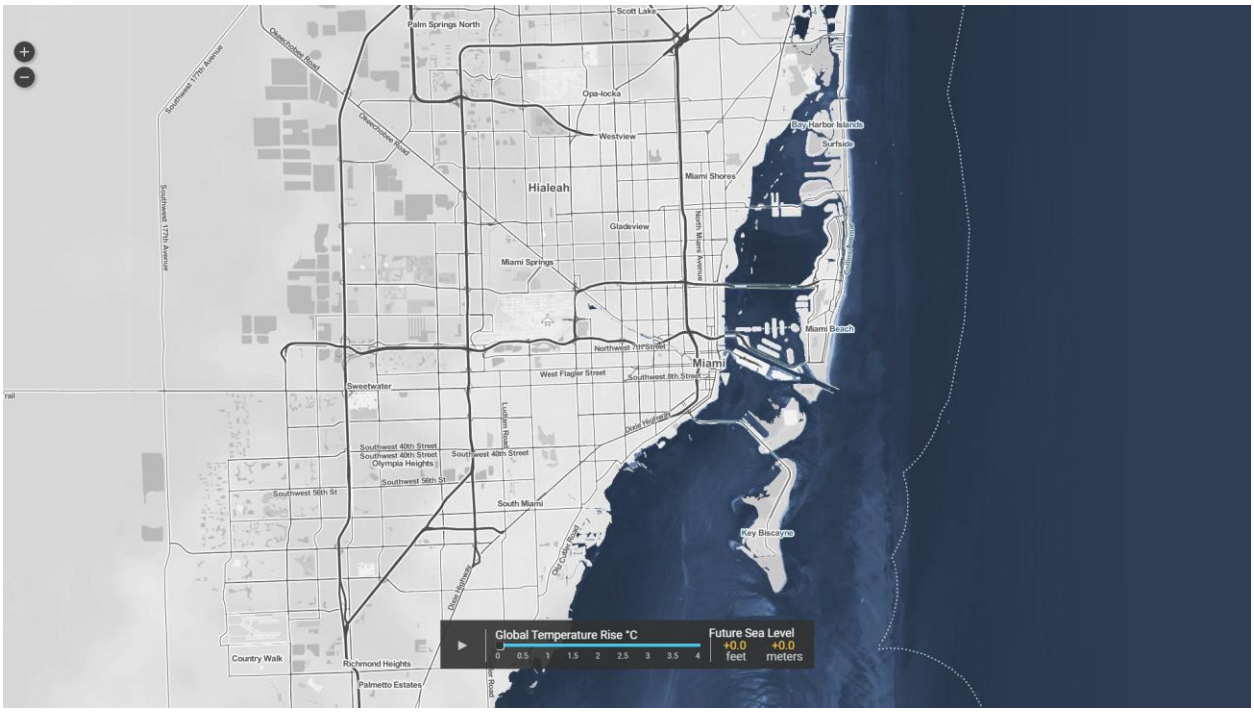
Earth's polar ice is melting faster than climate scientists had previous thought because of rising global temperatures. Sea levels rose around the globe in 2020 because of a record low amount of Arctic sea ice. A reduction in ice in Greenland and Antarctica could cause the ocean to rise by 10 to 15 feet, causing major flooding of coastal cities. In turn, this would result in the loss of many homes and roads, and even the abandonment of entire coastal communities. Even smaller amounts of sea rise could devastate many US coastal cities. For example, just one inch of sea level rise equates to about an 8-to 10- feet loss of beach.

Please look carefully at the animated maps below of Virginia Beach and Miami. The maps show the projected amount of coastal flooding that will occur in Virginia Beach and Miami as a result of a 15 foot increase in the sea-level due to an increase of Earth's average temperature of only 3.5 degrees Fahrenheit. This rise in sea-level would cause significant damage. Such a rise in sea level would have similar effects on coastal communities across the US.

Virginia Beach

Note: The areas shaded in blue represent the portions of land that will be permanently flooded as a result of the change in sea-level.

Miami



Note: The areas shaded in blue represent the portions of land that will be permanently flooded as a result of the change in sea-level.

Study One – Measures

Perceived impact

Do you think rising ocean levels will have positive or negative impacts on US coastal cities?

Extremely positive (1)

Moderately positive (2)

Slightly positive (3)

Neither positive nor negative (4)

Slightly negative (5)

Moderately negative (6)

Extremely negative (7)

Concern

How concerned are you about the effects that rising sea levels will have on US coastal communities?

Extremely unconcerned (1)

Very unconcerned (2)

Somewhat unconcerned (3)

Neither unconcerned nor concerned (4)

Somewhat concerned (5)

Very concerned (6)

Extremely concerned (7)

Occurring

Global warming refers to the idea that the Earth's average temperature has been increasing over the past 150 years and may be increasing more in the future. What do you think? Do you think that global warming is occurring?

Definitely is NOT occurring (1)

Very likely is NOT occurring (2)

Probably is NOT occuring (3)

Not sure (4)

Probably is occurring (5)

Very likely is occurring (6)

Definitely is occurring (7)

Appendix B

This appendix contains supplementary materials for the study of visual and textual framing effects over time. The models estimated and presented in the figure are included in a table format below, with each column representing the underlying OLS regression estimated. Alternative model specifications, including both adjusted and non-adjusted estimates (with and without additional covariates), and the initial main effects estimates from Time 1, are displayed in the tables following.

Appendix B.1

Table 4: Treatment Effects Over Time - T2 vs T1- Adjusted

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.283**	0.039	0.080	0.337	0.099	0.277
	(0.16)		(0.19)		(0.17)	
Boston Map	0.366**	0.017	0.023	0.456	0.291**	0.050
	(0.17)		(0.20)		(0.18)	
Miami Map	0.345**	0.015	0.042	0.411	0.093	0.305
	(0.16)		(0.19)		(0.18)	
Virginia Map	0.259*	0.079	0.271*	0.077	0.454***	0.004
	(0.18)		(0.19)		(0.17)	
New Orleans Map	0.413***	0.009	0.277*	0.067	0.529***	0.001
	(0.17)		(0.18)		(0.16)	
Multiple Map	0.267*	0.076	0.310*	0.050	0.265*	0.072
	(0.19)		(0.19)		(0.18)	
Constant (Control T1)	5.451***	0.000	4.756***	0.000	5.495***	0.000
	(0.17)		(0.19)		(0.16)	
N	768		768		768	
AIC	2594.4		2778.8		2620.9	
BIC	2645.5		2829.9		2672.0	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition (T2) and the Control group (T1) baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test.

* *p<0.10,* ** *p<0.05,* *** *p<0.01*

Table 5: Treatment Effects Over Time - T2 vs T1 with Demographic Covariates

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.283**	0.039	0.080	0.337	0.099	0.277
	(0.16)		(0.19)		(0.17)	
Boston Map	0.366**	0.017	0.023	0.456	0.291**	0.050
	(0.17)		(0.20)		(0.18)	
Miami Map	0.345**	0.015	0.042	0.411	0.093	0.305
	(0.16)		(0.19)		(0.18)	
Virginia Map	0.259*	0.079	0.271*	0.077	0.454***	0.004
	(0.18)		(0.19)		(0.17)	
New Orleans Map	0.413***	0.009	0.277*	0.067	0.529***	0.001
	(0.17)		(0.18)		(0.16)	
Multiple Map	0.267*	0.076	0.310*	0.050	0.265*	0.072
	(0.19)		(0.19)		(0.18)	
Republican	-0.161	0.219	-0.067	0.379	-0.133	0.241
	(0.21)		(0.22)		(0.19)	
Democrat	0.072	0.322	0.298**	0.050	0.200*	0.084
	(0.16)		(0.18)		(0.15)	
Conservative	-0.149	0.235	-0.433**	0.016	-0.917***	0.000
	(0.21)		(0.20)		(0.18)	
Liberal	0.684***	0.000	0.691***	0.000	0.650***	0.000
	(0.15)		(0.17)		(0.13)	
Constant (Control T1)	5.451***	0.000	4.756***	0.000	5.495***	0.000
	(0.17)		(0.19)		(0.16)	
N	768		768		768	
AIC	2594.4		2778.8		2620.9	
BIC	2645.5		2829.9		2672.0	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition (T2) and the Control group (T1) baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test.
* *p<0.10,* ** *p<0.05,* *** *p<0.01*

Table 6: Treatment Effects Over Time - T2 vs T1 - Unadjusted

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.314**	0.028	0.054	0.391	0.103	0.303
	(0.16)		(0.20)		(0.20)	
Boston Map	0.316**	0.046	-0.088	0.347	0.223	0.137
	(0.19)		(0.22)		(0.20)	
Miami Map	0.357**	0.017	0.004	0.491	0.039	0.428
	(0.17)		(0.20)		(0.22)	
Virginia Map	0.258*	0.083	0.224	0.128	0.410**	0.016
	(0.19)		(0.20)		(0.19)	
New Orleans Map	0.452***	0.006	0.264*	0.087	0.548***	0.002
	(0.18)		(0.19)		(0.19)	
Multiple Map	0.276*	0.072	0.282*	0.085	0.277*	0.087
	(0.19)		(0.20)		(0.20)	
Constant (Control T1)	5.705***	0.000	5.109***	0.000	5.590***	0.000
	(0.12)		(0.13)		(0.13)	
N	768		768		768	
AIC	2679.1		2903.5		2852.5	
BIC	2711.6		2936.0		2885.0	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition (T2) and the Control group (T1) baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test.
* *p<0.10*, ** *p<0.05*, *** *p<0.01*

Appendix B.2

Table 7: Time 1 Main Treatment Effects with Adjustments

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.625***	0.000	0.263*	0.056	0.099	0.261
	(0.14)		(0.17)		(0.15)	
Boston Map	0.513***	0.001	0.359**	0.015	0.264*	0.054
	(0.16)		(0.17)		(0.16)	
Miami Map	0.584***	0.000	-0.051	0.387	-0.030	0.426
	(0.15)		(0.18)		(0.16)	
Virginia Map	0.614***	0.000	0.230*	0.087	0.214*	0.083
	(0.15)		(0.17)		(0.15)	
New Orleans Map	0.568***	0.000	0.267*	0.062	0.396***	0.005
	(0.16)		(0.17)		(0.15)	
Multiple Map	0.410***	0.005	0.054	0.382	0.197	0.103
	(0.16)		(0.18)		(0.16)	
Republican	-0.095	0.288	0.009	0.481	-0.098	0.287
	(0.17)		(0.19)		(0.18)	
Democrat	0.237**	0.036	0.509***	0.000	0.446***	0.000
	(0.13)		(0.15)		(0.13)	
Liberal	0.309***	0.010	0.452***	0.001	0.648***	0.000
	(0.13)		(0.14)		(0.13)	
Conservative	-0.119	0.242	-0.643***	0.000	-0.702***	0.000
	(0.17)		(0.19)		(0.17)	
Constant (Control)	5.552***	0.000	4.868***	0.000	5.346***	0.000
	(0.14)		(0.16)		(0.15)	
N	1050		1050		1050	
AIC	3554.2		3883.7		3606.5	
BIC	3608.7		3938.2		3661.0	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition and the Control group baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test. Indicators for partisan identification and ideology are included to account for slight imbalances across the experimental conditions.
* *p<0.10,* ** *p<0.05,* *** *p<0.01*

Table 8: Time 1 Treatment Effects - Unadjusted

	(1) Impact		(2) Concern		(3) Occurring	
	Coef.	***p-value***	***Coef.***	***p-value***	***Coef.***	***p-value***
Text Only	0.625***	0.000	0.251*	0.078	0.096	0.297
	(0.15)		(0.18)		(0.18)	
Boston Map	0.455***	0.004	0.244*	0.092	0.129	0.247
	(0.17)		(0.18)		(0.19)	
Miami Map	0.600***	0.000	-0.037	0.424	-0.015	0.469
	(0.15)		(0.20)		(0.19)	
Virginia Map	0.625***	0.000	0.244*	0.097	0.229	0.101
	(0.16)		(0.19)		(0.18)	
New Orleans Map	0.593***	0.000	0.309*	0.052	0.455***	0.005
	(0.17)		(0.19)		(0.18)	
Multiple Map	0.427***	0.005	0.092	0.319	0.238*	0.095
	(0.17)		(0.19)		(0.18)	
Constant (Control)	5.729***	0.000	5.103***	0.000	5.587***	0.000
	(0.12)		(0.13)		(0.13)	
N	1050		1050		1050	
AIC	3609.1		4063.4		3916.2	
BIC	3643.8		4098.1		3950.9	

Note: Cell entries are OLS coefficients with standard errors in parentheses below; One-tailed p-values are shown in the adjacent column. Coefficients represent the difference in means between the treatment condition and the Control group baseline. Stars indicate a statistically significant coefficient estimate using a one-tailed test.
* *p<0.10*, ** *p<0.05*, *** *p<0.01*