Four Short Experimental Interventions That Increase Hope About Humans' Ability to Solve Climate Change

by

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Abstract

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Although 70% of Americans accept the reality of climate change (Leiserowitz et al., 2021), a lack of concerted societal action has not yet moved the issue to the top tier of the political agenda. This apparent "value-action gap" has been ascribed to, among other factors, maladaptive emotions in response to climate change's threat that inhibit action–for instance, apathy that has likely been stoked by some climate denialists' claims that although climate change is real, the problem is too big to do anything about. Hope, defined by Snyder (2002) as a combination of agency and pathways thinking, has been identified as a particularly important and effective way to overcome unhelpful emotions regarding climate change—and can increase people's sense of efficacy with respect to climate change, hence prompting subsequent action. Although the theoretical value of hope regarding climate change has been identified, there is a dearth of climate-change specific interventions that have been empirically demonstrated to increase hope about the climate.

This dissertation assesses the effectiveness of four different experimental interventions designed to increase Americans' hope about our ability to successfully tackle climate change. All interventions/experiments are short, self-contained, and solution focused. Each contains factually correct information about (Experiment 1) pro-environmental actions individuals can take themselves, (Experiment 2) the effectiveness and uptake of large-scale climate change solutions, (Experiment 3) a narrative depicting the successful implementation of a climate change solution despite challenges, and (Experiment 4) an activity in which pairs of students work together to select eight out of 15 solutions that have been identified by scientists as feasible ways by which society can overcome the climate crisis. Interventions have been designed to enhance participants' sense of agency (e.g., through underdog narratives and role-play while negotiating among different climate change solutions—in Interventions 3 and 4, respectively) and pathways thinking (through ordering a list of pro-environmental behaviors and predicting and then observing the effectiveness of different societal-scale climate change solutions—in Interventions 1 and 2, respectively).

The effectiveness of the interventions was primarily assessed via quantitative pre-to-post-test changes in hope, using pre- and post-intervention survey data. In addition to quantitative analysis for all experiments, CRQA analysis of facial expressions and qualitative analysis of discussions were additionally evaluated for Intervention 4, which was the only intervention that required inter-participant collaboration. Also assessed were pre-to-post intervention changes in constructs such as global warming acceptance/concern, nationalism, moral elevation, pro-social indicators, and (for Experiment 4) partner affiliation (to better characterize the relationship between hope and these other, related, variables). Analyses found that all four interventions were successful at increasing hope about our ability to tackle climate change to a statistically significant extent. Interventions 2 and 4 (focused on societal scale solutions) were additionally shown to increase global warming acceptance. Interventions 2 and 3 increased nationalism (given their focus on Americans and their companies demonstrating agency re climate). Intervention 3 also increased moral elevation and pro-social behavioral intent. Intervention 4 also increased group connection and cohesion. In all four experiments, strong correlations between *hope about climate change* and global warming acceptance were found, indicating the interrelated nature of these two crucial constructs.

Results reveal insights into the nature of what it means to be hopeful about a societal issue such as climate change and such hope's close relationships with various related constructs, including its relationship with climate change acceptance. Ultimately, these results show that hope about our ability to successfully tackle climate change can efficiently be increased—using no deception—over short timescales. As such, the primary contribution of this dissertation is the creation of a set of factually accurate materials that can be quickly used by activists, educators, scientists, and policy makers who seek to communicate their informative results to the public in a way that inspires hope and/or action with respect to climate change.

Dedication

In memory of Shivan Velautham

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Chapter 1

Introduction and Literature Review

The accumulation of human-produced greenhouse gas emissions in the atmosphere is already manifesting in climate disruptions and extreme weather events, and impacting on infrastructure, food and water supplies (IPCC, 2021). Anthropogenic climate change has been identified as one of the most serious threats facing humanity (DiMento & Doughman, 2014) and the planet is currently nearing a tipping point (Barnosky & Hadly, 2016; Lenton, 2013) in which sudden and irreversible environmental changes will occur unless the international community (i.e., governments, organizations, industries and people) take immediate, concerted action (Sharpe & Lenton, 2021). Despite the urgent need for action, however, there has been a lack of progress, and climate change has consistently failed to move towards the top of the political agenda. While structural barriers and a lack of knowledge of the science may prevent some from acting, a large component of this lack of engagement has been ascribed to psychological barriers including limited cognition, over-reaching ideological worldviews and maladaptive emotional coping mechanisms (Gifford, 2011; Ranney et al., 2019). Communicational approaches to address such motivational barriers to action have centered on shaming or scaring people into action–a strategy which has the potential to backfire, especially if the audience feel a low locus of control with respect to the issue or are not sure how or if the problem can be solved. As such, educational and psychological interventions are needed to not only help people understand the science-based threat of climate change, but also to communicate possible solutions and motivate them to respond appropriately (Ranney & Velautham, 2021; Swim et al., 2011)

Fundamental Background

Heretofore, the bulk of science communication about climate change has been focused around persuading the public that climate change is happening (Moser, 2016). This is because, cognitively, climate change is a hard phenomenon to grasp (Grotzer & Lincoln, 2007; Marshall, 2015), given its abstractness (Weber, 2006), its lack of direct and visible culprits (Shepardson et al., 2014), its long- rather than short-term consequences (Davenport, 2017), and the spatially as well as temporally distant relationships between actions that cause emissions and their impacts (Moser & Dilling, 2007). It has also been labelled as a "wicked" (e.g., uncertain, ambiguous) problem, given its complexity and lack of clear solutions (Head, 2008; Incropera, 2015). There are accordingly many misconceptions about the causes of climate change among the U.S. public (Bostrom et al., 1994; Chen 2011; Ranney & Clark, 2016; Weber & Stern, 2011) and a marked contrast between how lay-people and experts conceive the issue exists (Bostrom et al., 1994; Read et al., 1994; Sundblad et al., 2009).

Some researchers claim that cultural ideology plays an additional, *dominant* role in climate change belief and behavior, causing individuals to selectively discount risks, expert advice, and scientific evidence that conflicts with their identifying group's position (Feinberg & Willer, 2011; Haidt, 2012; Hornsey et al., 2016; Lewandowsky & Oberauer, 2016; Kahan et al.,

2011; Kahan et al., 2012; Kraft et al., 2015; Nisbet et al., 2015). For evidence of the influence of culture, they draw on the differential perceptions of climate change among different groups, with U.S. Republicans and conservative white males particularly more likely to be skeptical of climate change compared to Democrats (e.g., Dunlap et al., 2016; Dunlap & McCright, 2008; McCright & Dunlap, 2011). The phenomenon of differentially processing information based on worldview or pre-existing beliefs is known variously as the backfire effect (Nyhan & Reifler, 2010), biased assimilation (or polarization; Lord et al., 1979), motivated reasoning (Kunda, 1990), motivated avoidance (Shepherd & Kay, 2012), confirmation bias (Nickerson 1998) or motivated skepticism (Taber & Lodge, 2006). Instances of biased reasoning have been argued to have been exacerbated by right-wing media reporting norms around climate change, which emphasize drama, pit divergent viewpoints against each other, exaggerate scientific uncertainty, and downplay scientific consensus (Boykoff & Boykoff, 2004; Carvalho, 2007; Weingart et al., 2000). Proponents of the cultural-dominance position assert that the communication of scientific evidence about climate change is ultimately counterproductive, as, due to motivated reasoning, it has the potential to drive people with opposing ideological views (e.g., liberals and conservatives) further apart (Kahan et al., 2012).

The assertion that the communication of scientific knowledge is inherently polarizing has, however, been disproved empirically with both children (Stevenson et al., 2014) and adults (Joslyn & Demnitz, 2021; Ranney & Clark, 2016; Ranney et al., 2019; Ranney & Velautham, 2021; Taube et al., 2021; Velautham et al., 2019) with the false dichotomy drawn between culture and cognition roundly criticized (Van der Linden et al., 2017). Contrarily, it has been shown that exposing people to a wide variety of short interventions that communicate scientific evidence about climate change, including its mechanism, salient statistics, and maps and graphs that quantify its impacts–and even information about the nature of science–can increase acceptance of climate change across both liberals and conservatives alike (Ranney et al., 2016; Ranney et al., 2019; Ranney & Clark, 2016; Senthilkumaran et al., 2020). The need for knowledge and evidence of climate change is pressing, given the generally widespread ignorance and misconceptions about the science of climate change among adults (Bostrom et al., 1994; Ranney & Clark, 2016), students (Shealy et al., 2019), teachers (Herman et al., 2017) and even textbooks (Roman & Busch, 2016). However, information campaigns alone tend to elicit only modest changes in attitudes and behaviors (O'Neill & Hulme, 2009; Staats et al., 1996; Steg, 2008). This has generally been ascribed to such campaigns not addressing social or cultural facets of denial. According to various models of pro-social behavior that have been applied to pro-environmental action (e.g., Schwartz's 1977 theory of norm activation or Stern's (2000) value-belief-norm theory) behavior change is driven by a number of different factors in additional to knowledge, including efficacy, contextual factors, peer pressure, information sources, values and motivation (Nisbet & Scheufele, 2009; Semenza et al. 2008; Steg & Vlek, 2009; Yeo et al., 2015).

With near total scientific consensus about human-caused climate change (Maibach et al., 2014) and evidence of its impacts starting to manifest in unusual weather patterns (Coumou & Rahmstorf, 2012), a majority of Americans (at the time of writing, 70%) have accepted that climate change is happening, is human-caused, and is a matter of concern (Leiserowitz et al., 2021). This has resulted in a "value-action gap" (Kollmuss & Agyeman, 2002), in which acceptance and concern has only partly translated to expected pro-environmental behavior. In the face of such apparent (at least partial) indifference, climate change communicators have resorted to applying social pressure to compel people to act green (e.g., social norm campaigns in the context of recycling; Schultz, 1999), home energy conservation (Nolan et al. 2008) and most notably, hotel towel re-use (Goldstein, Cialdini & Griskevicius, 2008). Another popular strategy used by climate change communicators has been to use bleak and fatalistic messaging, such as threatening images of the world on fire (or the disaster movie "The Day After Tomorrow") to attempt to motivate their audience to action (Leiserowitz, 2006; Leviston et al., 2014; Smith & Leiserowitz, 2012). However, coupled with increasingly ominous projections from scientists that may not include clear or obvious implementable solutions (Lee et al., 2007; Pruneau et al., 2003) or policy responses (Helm, 2008), such communications may backfire, creating motivated avoidance (Zhong & Liljenquist, 2006), resentment (Baumeister et al., 1995; Brennan & Binney, 2010), and even denial (Shepherd & Kay, 2012)—all of which may counterproductively serve as an even greater barrier to environmental engagement (Thøgersen & Crompton, 2009).

Currently, about 70% of Americans report feeling worried about climate change (Leiserowitz et al., 2021). Other emotions Americans have reported about climate change include concern for family or friends (Corner et al., 2015; Ojala, 2005; Threadgold, 2012), anxiety (Clayton et al., 2020; Pihkala, 2020; Weintrobe, 2012), hopelessness (Inglis, 2008; Nordensvaard 2014; Stevenson & Peterson, 2016; Strife, 2012; Taber & Taylor, 2009; Threadgold, 2012), anger (Miles-Novelo et al., 2019), stress (Doherty & Clayton, 2011), and guilt (Jacquet, 2017). Such emotions may be prompted by the anticipated loss of the natural environment (Albrecht et al., 2010; Lertzman, 2015; Soga & Gaston, 2016), in response to acute climate-related events, such as floods or extreme heatwaves (Morrissey & Reser, 2007), or as a result of more existential fears and losses (e.g., concerning the loss of a way of life; Dickinson, 2009; Randall, 2009). If such emotions are not handled effectively, they can potentially escalate into instances of "environmental-" or "ecological-grief" (Cunsolo et al., 2020; Cunsolo & Ellis, 2018; Clark, 2020; Kevorkian, 2019), environmental melancholia (Lertzman, 2015) or environmental numbness (Gifford et al., 2011)–all of which serve as significant barriers to pro-environmental engagement (Ruiter et al., 2014), pro-environmental action (Harth, 2021), and overall psychological well-being (Homburg & Stolberg, 2006; Reser & Swim, 2011; Stokols et al., 2009).

Coping With Climate Change

Ojala, drawing on the work of Lazarus and Folkman (1984) identifies two primary ways that people cope with the negative emotions raised by climate change. One is emotion-focused

coping, a maladaptive form of coping prevalent among younger students (Ojala, 2012b) and adults alike (Norgaard, 2006), in which people seek to either escape painful feelings by trying to get rid of the negative emotion via common psychological defense strategies like denial, distraction, minimizing the problem, engaging in wishful thinking, and distancing (Ojala, 2012b; Lorenzoni et al., 2007; Stoll-Kleeman et al., 2001; Burke et al., 2018; Evans, 2019; Weintrobe, 2013; Hoggett, 2019; Haltinner & Sarathchandra, 2018; Helm et al., 2018). The second, less common, primary coping way is problem-focused coping, in which people attempt to do something about the problem that is causing the uncomfortable feelings by, for instance,, researching information about actions they can take against climate change (Ojala, 2012b; Ojala, 2015). Although problem-focused coping ostensibly seems the more productive form of coping of the two, Ojala found that students in particular who engaged in it tended to report low levels of subjective well-being (Ojala, 2012b, 2013) due to the fact that the majority of actions students are aware of are individualized household-focused behaviors (e.g., switching out lightbulbs to electric ones) that 1) are often outside their scope of control (i.e., if they are dependent on their parents to buy lightbulbs; see also Evans, 2011, for a similar argument with respect to adult consumers) and 2) ultimately ineffective and inadequate in scope to deal with the essentially uncontrollable stressor of worldwide greenhouse gas emissions (Stevenson & Peterson, 2016). This is consistent with research on adolescent coping, which shows that when a problem is larger than a young person can solve alone, offering solutions individuals alone can take can impair well-being by placing too heavy a burden on young people's shoulders (Ojala, 2018).

Ojala (2012b) proposes the existence of a third possible coping mechanism–meaning focused coping, which involves acknowledging the seriousness of the issue while also reframing it in positive ways to find meaning in struggle (e.g., taking heart in the fact that people of influence are starting to take the problem of climate change more seriously). This form of coping has been found to be especially important when a stressor cannot be immediately resolved even though the problem demands active involvement (e.g., having to care for a terminally ill partner; Folkman, 2008; Folkman & Moskowitz, 2000) and is more closely related to the self-conscious activation of positive emotions (Stevenson & Peterson, 2015) rather than the reduction of negative emotions. Meaning-focused coping strategies for 11-12 year olds involve either trusting different societal actors (i.e., that government will take meaningful action or that scientists will come up with a new invention) or engaging in positive reappraisal of the issue (e.g., by recognizing increases in societal concern about climate change or searching for positive news stories about it in the media; Ojala, 2016). Young people who engage in a high degree of meaning-focused coping are reported to be less stressed, to engage in more active problem solving strategies (Ojala, 2012b; 2013), and accordingly, to demonstrate increased social and environmental engagement (Van Zomeren et al., 2010). In order to cultivate meaning-focus coping, Ojala (2012a) recommends generating alternative interpretations and challenging denial-like and catastrophic thinking. This is a technique that will not come naturally and therefore has to be trained, communicated or taught.

The Need for Hope

In order to promote meaning-focused coping, researchers have articulated the need for empowering climate change educational and communicational approaches that, as well as deepening students' knowledge about the science of climate change, convey the reality of its impacts while also fostering a sense that something can be done and that individuals and societies can improve things. Such a solution-focused approach develops students' or adults' sense of efficacy and action competence (i.e., motivation or ability to effect actual social change; Jensen and Schnack 1997), and their ability to approach future challenges with flexibility and creativity (Chawla and Cushing 2007; Dittmer et al. 2018; Jickling, 2013; Kelly, 2010; Mogensen & Schnack, 2010). Alongside knowledge, this type of action-oriented learning (Kagawa & Selby, 2010) and public engagement (Moser, 2016) should promote the development of skills, values, moral reasoning, and a sense-of-purpose necessary for becoming an active, democratic citizen in a global society (Mogensen & Schnack, 2010). In classrooms, this has been achieved in a science-education context by integrating the teaching of practices such as arguing from evidence and being familiar with the nature of science (Holbrook & Rannikmae, 2007)—and being able to identify and resist misleading media messaging about climate change (Ranney & Velautham, 2021; Velautham & Ranney, 2020). Other approaches for encouraging the development of action-competence in the classroom in the context of climate change involves cultivating skills such as anticipatory thinking (Barth et al., 2007; Gardiner & Rieckmann, 2015; Rieckmann, 2012; Wiek et al., 2011), perspective taking (Zeidler & Newton, 2017), and interpersonal competence (Brundiers & Wiek, 2017)—motivated by the close relationship between social connection and enhanced self-efficacy (Allen & Crowley, 2017; Bostrom et al., 2018; Geiger et al., 2017; Rudolph & Horibe, 2016; Winograd, 2016).

Part of this proposed climate change pedagogy involves a foregrounding of emotion, both in the classroom (Bryan, 2020; Ojala, 2013b; Russell & Oakley, 2016) and in the sphere of environmental communications (Roeser, 2012). Rather than emotions in this context being considered a challenge or distraction, Ojala (2012a) reframes them as a positive motivational, orienting force in relation to the learning and engagement that can serve as a buffer to negative emotions and help the recipient negotiate the conflicts that cause them more in a more constructive, hopeful, manner (see also Håkansson & Östman, 2019; Lundegård & Wickman, 2007; Sund & Öhman, 2014). Ojala emphasizes the important role that teachers have in shaping emotional norms in the classroom (Hufnagel, 2017; Ojala, 2015; Van Kessel, 2020) by acknowledging and reframing students' emotions (i.e., reframing worry as not just something purely negative, but a sign of concern and motivation) to cultivate students' sense of agency and influence their coping strategies. Baumgartner et al. (2008) similarly determine a relationship between the expression of specifically 'anticipatory emotions' – fear or hope about a particular future circumstance – with perceptions of agency. As such, there have been calls for a specific focus on anticipatory emotions and hope in environmental education classrooms (Hicks, 2014; Ojala, 2012a; Ojala, 2017; Stevenson & Peterson, 2015).

Of anticipatory emotions, hope has been identified by education and health psychologists as a particularly important emotion for encouraging active coping in response to difficult experiences (Barnum et al., 1998; Snyder et al., 2006), creative problem solving (Isen, 2008), and positive wellbeing (Ciarrochi et al., 2015; Yarcheski & Mahon, 2016). It is also an emotion that is significant in the shift from belief to efficacy (and hence, action), making it a pivotal emotion for activists (Feldman & Hart, 2016; Flam & King, 2005; Goodwin et al., 2001; Kleres & Wettergren, 2017). In terms of the importance of having hope about climate change, in both the US. (Stevenson et al., 2018) and Sweden (Ojala, 2012a) constructive hope (that is, the ability to envision and enact suitable alternatives to the future) has been shown to have positive associations with pro-environmental behaviors and knowledge (Geiger et al., 2021; Kerret et al., 2016; Leiserowitz & Smith, 2014; Nabi et al., 2018; Ojala, 2015; Ratinen, 2021; Ratinen & Uusiautti, 2020; Stevenson & Peterson, 2016; Van Zomeren et al., 2008) and meaning-making coping (Ojala, 2016b ; Ojala & Bengtsson, 2019).

Defining Hope

Hope has a rich philosophical history. In the context of psychology, it is typically conceptualized as an affective, cognitive and/or motivational state that reflects the manner in which individuals relate to a desired yet uncertain future (Lazarus, 1991; Peterson & Seligman, 2004). Lazarus (1991) viewed hope as both an emotion (a desire to be in a different situation in the future) and a cognitive appraisal of wishing for a desired-yet-unlikely goal to come true, framing it primarily as a coping mechanism for negative and uncertain situations (because without difficult situations, we would have no need for hope). In this sense, hope or resilience can be framed as a form of response appraisal (Blennow & Persson, 2009; Grothmann & Patt, 2005; Moser, 2017; Semenza et al., 2011), with its cognitive component involving the identification of certain goals and the means to reach them (Bovens, 1999) and its emotional component acting as a motivational force to act in the absence of certainty (McGreer, 2004). Ojala (2016), furthering Lazarus's conception of hope as a coping mechanism, proposed that hope takes different forms depending on the type of coping strategy being used by someone. She labelled the hope experienced by students using problem-focused and meaning-focused coping strategies as constructive hope, which she characterizes as an ability to face environmental uncertainty and to hold the belief that one's actions and the actions of others have the potential to make a difference. In contrast, young people who engage in emotion-focused coping by denying or distancing themselves from environmental problems are only capable of expressing hope in the sense of wishful thinking–a hope based in denial that climate change is not a serious problem, that new technologies will soon solve it, or that it will only affect people who live far away or in the distant future (Ojala, 2012a). This difference mirrors the distinction between hope and optimism (Eagleton, 2019) and also Marlon et al's (2019) differentiation of "False" versus "Constructive" hope. Ojala (2012a) found that students engaged in constructive hope are more inclined to behave pro-environmentally and more likely to perceive their teachers

communicating in a future-and-solution oriented manner, compared to their more wishfully thinking peers.

In Snyder's (2000) widely utilized cognitive theory of hope, which roots hope more firmly in its cognitive-motivational action components, hope is comprised of three key aspects: 1) goal setting (i.e., having a clear vision of future goals that are of sufficient value, long-term, and future-oriented; Snyder, 2000), 2) pathways thinking–being able to conceive of specific strategies to attain desired goals, and 3) agency thinking or "goal-directed energy" (Snyder, 2002)—feeling motivated to enact such pathways or hold a strong belief in the ability to achieve it (see also Marques & Lopez, 2017; Snyder et al., 1991; Snyder et al., 2002). Snyder et al. (2002) proposes that these core components of goal formation, pathways thinking, and agency are interrelated—with people who have high levels of hope having multiple pathways to achieve their goals and the ability to generate alternative pathways in the face of obstacles (see also Snyder et al., 2003). The clear articulation of cognitive and behavioral dimensions of hope in Snyder's model means that it is especially relevant for exploring hope that leads directly to pro-active behaviors, and it has accordingly already successfully been applied to global environmental challenges (Grund & Brock, 2019; Li & Monroe, 2019).

A criticism of Snyder's theory is that is that he defines goals relatively loosely as anything an individual desires to experience or do. This means that, for Snyder, it seems that goals such as saving a life and buying a cup of coffee are equally valid and that goals are often individual and self-directed as opposed to focused towards societally directed change. This is in contrast to other pragmatist and social theories of hope that value the pursuit of certain goals (societal progress, democracy, future good) over others. Another criticism of Snyder's theory is that it is overly individualistic, having been developed in a therapeutic context of individuals working towards their own, personal goals or coping with illness (Bernardo, 2010). This is an especially pertinent issue for the application of Snyder's theory of hope to a societal problem like climate change, in which hope is based on a common vision of social change for humanity as a whole (Bar-Tal, 2001; Braithwaite, 2004; Courville & Piper, 2004; McGeer, 2004; Ojala, 2016a)—and in which people are necessarily reliant on the actions of societal actors such as scientists, environmental organizations and politicians to tackle climate change on their behalf (McGreer, 2004). Ojala's (2012b) proposed solution is to label trust (i.e., on others to act, or with respect to the potential of technological innovations) as an important component of constructive hope (see also McGeer, 2008 and Miceli & Castelfranchi, 2010), although such views have been criticized of walking the line of techno-optimism (Flottum et al., 2016). McGreer's (2004) suggests the need for a more responsive form of hope, with an emphasis on collective goals and an increased awareness that individual action has to take place within a context of external, unpredictable forces (e.g., political will).

The possibility of societal change is typically encompassed within utopian-philosophical models of hope. For instance, the Marxist, utopian philosopher Bloch describes hope as the result of a productive tension between the vision of a better world and a recognition of the highly

flawed conditions that we currently experience (a kind of dialectic between an impulse for certainty and a future that has not yet been experienced, i.e., the is and the ought, or the present "needs be" and the future "Not-yet"; Bloch, 1986). Freire (1970) similarly perceived hope as grounded in the critical understanding of our current situation and the 'untested feasibility' of an idealized future. In both of these scholars work, hope involves a tension between realism (what's probable) and idealism (what's possible) with hope working in the direction of liberation and emancipation. Other philosophical models of hope have similarly open stances towards the future–for example, Lear's notion of "radical hope" that focuses on a generalized commitment against despair and radical transformation in responses to paradigmatic changes such as the loss of traditional ways of life (Lear, 2006; Mosley et al., 2019; Thompson, 2010). In general, a primary difference between psychological and philosophical conceptualizations of hope is its foundation in concrete visions and goals in psychology (Lazarus, 1991; Snyder et al., 2001) as opposed to being more open with respect to the future (e.g., Bloch's "Not-Yet"—a utopian-like future that is impossible to visualize).

An Overview of Hope Interventions

Some believe that hope is a pre-defined character trait, but Snyder (2002) and other proponents of positive psychology such as Keltner (2009) and Seligman (2004) claim that positive emotions such as hope are innate, having been selected for by natural selection because of the evolutionary advantage they offer (i.e., enabling humans to form more cooperative societies and problem-solve in more creative ways). Snyder accordingly describes hope as a learned pattern of thinking, claiming that those who lack hope do so because they are not taught to think in this manner (Snyder, 2002). The majority of hope interventions–that is, interventions that target hope specifically, and seek to empirically assess the change in hope resulting from the intervention (Parks & Titova, 2016)–draw on Snyder's definition of hope that emphasizes the co-interacting sub-constructs of agency and pathways thinking. Efforts to increase hope have thus centered around helping set realistic sub-goals and either identifying pathways that lead to the attainment of these goals (i.e., individual and/or collective actions) or developing agentic thinking about them (Snyder, 2002). Reflecting the common philosophical background of positive psychology and clinical psychology (Ruini, 2017), many hope interventions, especially those centered in a therapy context, share features with cognitive-behavioural interventions, including the utilization of techniques such as socratic questioning, hypothesis testing—and identifying and modifying cognitive distortions like catastrophizing, disqualifying the positive and thinking in imperatives–techniques (Parks & Biswas-Diener, 2013).

Given hope theory's origin in therapeutic settings, Snyder's definition of hope has been successfully utilized for hope-interventions in clinical contexts (Cheavens & Guter, 2018; Snyder et al., 2006; Weis et al., 2011). Strategies for accentuating hope in such circumstances are referred to under the umbrella of 'hope therapy' (Lopez et al., 2000) and include activities such as, with the help of a therapist, identifying a goal and personally committing to it (Lokhorst et al., 2013). Solution focused therapy (de Shazer, 1985), a technique common in family and

couples therapy, also increases hope through the 'crystal ball technique' (Erickson, 1954) in which clients are asked to visualize their futures without the problem, identify something in their life / family or marriage that they like, and would like to keep happening, and the miracle question, in which they are asked how they would know that a miracle solution to their problem has been found. Alternative ways to increase agency include learning positive self-talk, recalling previously successful goal pursuits, or focusing on how enjoyable the process of getting to a goal is, rather than the end-point itself. Ways to increase pathways thinking include visualizing how to circumvent obstacles, using all five senses to construct a vivid mental image (Feldman & Dreher, 2011), breaking down long term goals into shorter-term ones, practicing different routes to a goal, and picking out the best route. Narrative has also been widely used to cultivate hope, alongside conceptual questions that, for instance, ask clients to identify protagonists' goals at particular points in the story (McDermott & Hastings, 2000) and identify whether characters' statements were hopeful or not (Pedrotti et al., 2000). Pedrotti et al., (2000) in her 'Hope Talks' intervention also drew on the importance of pro-social interaction for increasing hope by pairing students with a 'hope buddy' with whom they could talk about goals for their future.

Hope and Climate Change

Research in the domain of hope and climate change have largely centered on students. The bulk of work has either involved measuring, quantifying or characterizing hope about climate change (e.g., identifying the psychological or demographic determinants of hope) or the design and evaluation of educational initiatives or interventions intended to increase hope for a specific population (e.g., students or educators).

In terms of better understanding and/or characterizing hope about climate change, Li and Monroe (2018; 2019) determined some of the psychological factors involved in fostering hope concerning climate change among high school students, which included concern about the environment, knowledge of solutions, the perception that actions taken could be meaningful (see also Hick's 2014 concept of future visioning), and the belief that society and laypeople have the ability to undertake actions to make a difference. Interventions to raise this self-efficacy aspect of hope (see Bandura, 1977) in the science classroom tend to involve students carrying out their own personally meaningful investigations (Kelsey and Armstrong, 2012; Ojala, 2017; Sobel, 2008; Winograd, 2016). Curricula that emphasize such activities are often place-based, project-based, and problem-based in nature (Derr et al., 2018–see also critical place based education, Grunewald, 2003, and critical environmental education; Au & Waxman, 2014), and involve having students work in their local communities in order to engage in civic learning and to see the tangible effects of their efforts (Monroe et al., 2019). An alternative suggestion for cultivating constructive hope is to have students spend time in nature (Kelsey and Armstrong, 2012; Sobel, 2008; Winograd, 2016). Ojala (2012a) additionally identified several sources of hope about climate change in classroom culture, including positive reappraisal from teachers and the ability for students to share their feelings about climate change without judgment (Ojala, 2015; Ojala & Bengtsson, 2019). This has been instantiated in educational programs through

structured opportunities for social interactions; Trott (2020) found that participants in a climate change program repeatedly emphasized the value of group discussions and the act of solving problems collectively, as well as individually, as an important way to cultivate agency. Li and Monroe (2018) attempted to convey the social-trust component of hope to students by incorporating activities that 'others care' and 'others are doing things' (with others being scientists and landowners) into a forestry-focused curriculum for high school students. Alternative approaches to inspiring trust in the classroom involve enabling in-person interactions between scientists and students (Hallar et al., 2011; Pruneau et al. 2003).

In terms of interventions for audiences other than students, Geiger, Swim and Fraser (2017) applied Snyder's hope theory to design a communication training program for educators working at zoos, aquariums, and national parks to increase their willingness to discuss climate change with visitors. While interventions applying Snyder's (2002) hope theory to global warming are relatively rare, they are generally designed to target two primary sources of despair: 1) feelings that there are no adequate solutions for climate change challenges (i.e., targeting goal setting and, relatedly, pathways thinking) and 2) the feeling that individuals can't make a significant difference (Stern, 2012; van Zomeren et al., 2010). Myer's et al., (2012) found that framing global warming as a health, as opposed to a national security or environmental issue increased hope, although the reasons why such this framing above others engineered higher hope remains unclear. Related to framing, Marlon et al. (2019) found that efficacy appeals regarding climate change (i.e., statements expressing the capacity of humanity or world nations to reduce global warming) increase hope, although moreso for liberals and moderates compared to conservatives, who, on exposure to response efficacy appeals, showed a slight increase in fear (Chadwick, 2015; Feldman & Hart, 2016). Such work confirms the close relationship between high valence emotions, such as hope and fear with respect to the environment—and illustrate the potential of emotional or tailored messaging about climate change to create a backfire effect among select sectors of the audience.

Anti-Hope Perspectives

While hope can offer relief from harsh reality, it has been suggested by some researchers that having hope is a 'feel good' emotion that will lead to unrealistic optimism or wishful thinking (McGreer, 2004) and hence weaken the motivation for action (Hornsey & Fielding, 2016; Kappes et al., 2013). Gifford (2011) and Lorenzoni et al. (2007) additionally frame trust in technological development and science/societal actors, identified by Ojala (2012a) as an important component in constructive hope, as a way to escape responsibility concerning environmental issues. In this vein, there are some who argue that negative emotions (e.g., fear) about climate change's risks are more useful motivational tools, given fears associated action tendency to prompt more systematic information processing regarding risk (Hart & Feldman, 2014; Mejinders et al., 2001). Other negative emotions that have been used to elicit pro-environmental behaviors include guilt, shame, anxiety, embarrassment and demoralization,

guided by negative-state relief models of pro-environmental behavior (Apsler, 1975; Carlsmith & Gross, 1969; Cialdini, et al., 1973).

Fear appeals, or messages that emphasize both the severity and salience of threats (e.g., images of the earth on fire) are accordingly common in both research and practice (Leiserowitz, 2004; Moser, 2010; Nisbet, 2009; Stern, 2012) and have been shown to have some effect in promoting behavior change (Leiserowitz, 2004; Stern, 2012; Van Zomeren et al., 2010; Witte & Allen, 2000). However, there is conflict among scholars on the effectiveness of using fear to persuade people to take pro-environmental action, given the fact that fear primes the body for immediate action (fight or flight action) and climate change is a long term, incremental problem. 'Gloom and doom' communications also have a strong chance of being counterproductive (Feinberg & Willer, 2011; Grotzer & Lincoln, 2007; O'Neill & Nicholson-Cole, 2009; Wolf & Moser, 2011). This is because there is strong evidence that if people are not aware of solution paths out of the problem, perceive low levels of agency or control over the issue (Witte & Allen, 2000) or do not feel personally at risk (Leiserowitz, 2006; Moser, 2010), then fear appeals can be ineffective and even backfire (O'Neill & Nicholson-Cole, 2009).

In contrast to fear appeals, elaboration likelihood models of persuasion suggest that positive emotions are more persuasive than negative emotions and can sustain attitude changes over longer periods of time (Petty & Cacioppo, 1986). Positive appeals also make people more likely to view the issue concerned as a moral one—and are thus more likely to engage with the issue and adopt beliefs and behaviours consistent with efforts to stem the problem (Markowitz & Shariff, 2012; Roeser, 2012). A communicational approach driven by positive, rather than negative, emotions also has the potential to draw on social-altruistic motivations for pro-environmental behavior. Such social-altruistic motivations include the desire to benefit future generations and participate in collective behavior in general (Sevilano et al., 2010), the possible moral obligation to act (Schwartz & Howard, 1981; Winograd, 2016), and the "feel good" potential of acting green (Taufik et al., 2015).

Facing the Future with Hope

In common with fear, hope derives from the perception of an uncertain future. Unlike fear, however, hope is associated with positive future expectations—and its associated motivational function is to become aware of problems and obstacles to encourage goal pursuit (Lazarus, 1991; Ojala (2017). Here, hope is not acting as a solace, or faith in the certainty of a better future outcome, like the similar construct of optimism (two related but different constructs that anti-hope scholars tend to conflate[1]). Hope's an active, motivational force starting from a point of concern (Li & Monroe, 2019) and clearly associated with action–also referred to as "good hope," "authentic hope," or "active hope" (Pihkala, 2017). Moser (2010) claims that for

[1] While hope and optimism tend to be conflated, in the psychological and philosophical literature *hope* focuses more directly on the attainment of specific goals, whereas *optimism* focuses broadly on the generalized expectation of future outcomes (see Bryant & Cvengros, 2004; Eagleton, 2010)

climate change communication to be effective, it must be empowering (Doherty & Webler, 2016; McNaught et al., 2014; Moser & Boykoff, 2013), detailing concrete suggestions of actions people can take personally and collectively (political and civic actions) and providing constructive help and conveying social norms that enhance efficacy beliefs (e.g., Feinberg & Willer, 2011; Gifford, 2011; van der Linden et al., 2015)–all content that is in line with Chadwick's (2015) guidelines for communicating authentic hope. While the need for hope is clear, however, clear and easily integrable ways to cultivate it with respect to the topic of global warming are not. The according aim of this dissertation is to produce concrete, actionable, and empirically verified interventions that increase constructive hope about our ability to solve climate change that can be easily integrated into classroom practice or climate communication efforts with the general public. Four experiments describe the development and empirical validation of four such hope interventions about climate change are described herein.

Research Problem

Given the moderately high rate of acceptance of climate change amongst the public (Leiserowitz et al., 2021), coupled with the shifting position of climate denialists from denying the existence of climate change to arguing that the problem is too big to be able to do anything about (Cann & Raymond, 2018), science communicators and educators are increasingly coming to view the lack of engagement with climate change as an emotional and/or motivational problem (Kiehl, 2016). There has been a subsequent shift to engaging with more affective and motivational dimensions of communication, with an emphasis on the roles of emotion, and efficacy and hope, in particular, in shaping perceptions of and responses to climate change (Cooper & Nisbet, 2016; Feldman & Hart, 2016; Ojala, 2012a; Roeser, 2012). According to Snyder's (2002) model of hope that is widely used in clinical practice and positive psychology, hope in this context is conceived of not so much as the generalized desire or expectation for something to happen, but more precisely, that is, as a combination of clearly defined goals, pathways thinking and agency (see Snyder, 2002).

Much of the research involving hope and climate change has been qualitative and exploratory. Example studies include either characterizing what it means, or why it is important to be hopeful about climate change, or studying the efficacy of entire curricula units (or place-based extra-curricula programs) at cultivating hope in students. There are, however, a dearth of hope-inducing interventions that can be quickly and easily integrated into study materials or disseminated by teachers and activists. The lack of quantitative assessment of hope-inducing interventions centered on climate change means that there is scant empirical evidence of causal relationships between hope and other variables, such as global warming acceptance and/or other pro-social emotions, which limits the effectiveness of intervention design. Another limitation of current scholarship on hope and climate change is that the majority of the work centers on young people or students. This means that when recommendations for solutions or actions are made, they tend to highlight a narrow spectrum of individual, easy-to-enact pro-environmental behaviors that young people can take, such as recycling, which may be ultimately ineffective in

the face of worldwide greenhouse gas emissions (the communication of which can, counterproductively, decrease hope; Ojala, 2016). Pre-existing climate change hope-interventions, as such, also do not tend to convey a sense of the potential scale or collective impact of such behaviors, and do not center societal scale solutions or new technologies that policymakers and scientists are currently negotiating in order to successfully tackle the issue.

Purpose

The purpose of this dissertation's set of experiments is to design and empirically assess the effectiveness of a series of interventions aimed at increasing hope about society's ability to successfully solve climate change among the American public. The effectiveness of the interventions will be assessed using a mixed methods approach, using quantitative methods used for Expertiments 1, 2 and 3 and both quantitative and qualitative methods for Experiment 4. Common variables measured for all four studies include hope about climate change and acceptance of climate change. Research was conducted online, using either US-based Amazon Mechanical Turk users (Experiments 1, 2 and 3) or UC-Berkeley undergraduate and graduate students (Experiment 4).

The overarching three research questions guiding this research are:

(1) Can hope about our ability to tackle climate change be increased through solution-focused interventions designed around Snyder's sub-constructs of hope: pathways thinking, agency and collective agency?,

(2) How does the construct of hope about our ability to solve climate change relate to the constructs of climate change acceptance, nationalism and other pro-social emotions?, and

(3) Does conveying factually correct information through formats such as ordering, statistics, shaped narratives, and a joint activity increase hope about our ability to solve climate change.

Theoretical Framework

In this dissertation, the construct of hope about climate change derives from Snyder's (2002) cognitive model of hope, in which hope is defined as a positive motivational state consisting of two interactively derived core components—(a) pathways thinking and (b) agency—the first being the capability of identifying multiple pathways to desired goals and the second being the capability to motivate oneself to adopt such pathways in order to achieve desired goals. In practice, this means that to be truly hopeful, one's positive expectations (as opposed to certainties) about the future should be driven by clear, actionable goals and by active strategies to achieve them (Chadwick, 2015). Such a framing of hope is aligns to the cognitive appraisal theory of emotion (see Lazarus, 1982) in which rational thoughts and the cognitive appraisal of threat play an essential role in emotion-formation (as opposed to emotions arising from physiological sensations or bodily arousal alone).

Snyder's theory (2002) has been successfully utilized in hope-interventions in settings as diverse as clinical contexts (Cheavens et al., 2006; Snyder et al., 2006; Weis & Speridakos, 2011) and in educational contexts (Davidson et al., 2012; Marques et al., 2011). However, it has been criticized as framing the pursuit of goals as an overly individualistic endeavor (Bernado, 2010). Indeed, McGreer (2004) argues that Snyder's overwhelming focus on individualized goals and pathways makes it inappropriate to apply to a societal issue such as global warming, which involves the coordination and collaboration of and reliance on multiple stakeholders for a successful resolution, rather than the enactment of an individualized pathway to a well-defined goal. Given the lack of characterization of pathways thinking and agency with respect to climate change and the lack of theoretical justification of the interrelation of pathways thinking and agency for societal (as opposed to personal) issues, I plan to assess the interventions' effects on the construct of overall hope about climate change as opposed to their effects on the sub-constructs of pathways thinking and/or agency in my analysis.

Significance

If the interventions are successful at increasing hope about our ability to solve climate change, they can either be disseminated directly to the public or used to inform or enhance the design of activists', educators', and even scientists' communications about climate change to the public. This work will additionally be of value to those wishing to invoke hope in their communications about climate change to the American public, such as scientists, politicians, and others. In terms of a research contribution, the work of this dissertation also helps further characterize hope about climate change and support the appropriateness of applying Snyder's (2002) hope theory, which is therapeutic in origin, to a large-scale societal issue. As such, these experiments inform the field regarding techniques for cultivating hope about societal issues that can be transferred to other domains.

Study Assumptions

A primary assumption is that the American participants recruited from Amazon Mechanical Turk are engaging with the interventions and pre- and post-tests in an honest, straightforward and concentrated way, without the help of outside resources–although the assumptions were probed and verified via the use of attention checks and data cleaning procedures. All information conveyed in the interventions was factually correct and up-to-date at the time they were shared with participants. A more general assumption underlying all four studies is that hope is a measurable construct and can be accurately assessed using an adapted form of Li and Monroe's (2018) Climate Change Hope Scale.

Thesis Scope

Each experiment presented in this thesis asseses short-term increases in hope (i.e., immediate pre-test, immediate post-test, and in the case of Study 4, within-intervention hope) rather than long-term effects–a decision made because not enough is known about hope about

climate change to warrant a long-term effect measure with the particular scale being used. Experiments 1, 2 and 3 were conducted online, and so only information about changes in surveyed variables was collected, as opposed to information about how participants made sense of, or interacted with, the text-based interventions. For Experiment 4, while intersubjective group interactions were investigated, I was limited to studying the dynamics of groups of two in an online (i.e., dyads over Zoom) setting, due to a combination of methodological constraints and the covid-19 pandemic. This means that results relating to Experiment 4 may be more useful for teachers framing partner-based learning activities rather than larger-group settings.

Summary

Overall, there are multiple barriers that prevent people from taking action to solve climate change, including a lack of understanding or an appreciation of the science underlying it. Climate communication efforts have sought to increase climate change acceptance through disseminating scientific information about climate change's causes. However, while climate change is now moderately widely accepted among the American public, this has not led to massively increased uptake in pro-environmental behavior or action. This has widely been ascribed to negative emotions about climate change, exacerbated by poor media reporting, as well as scientific projections and extreme weather events that overwhelm people, and stymie their ability to act. Hope (based on Snyder's 2002 definition of hope as a solution-oriented, motivational force) is a positive emotion that has been determined to be one of the most effective at overcoming apathy and motivating people to act (Stevenson & Peterson, 2015). The aim of this thesis is thus to develop and empirically assess a series of interventions to cultivate much-needed hope about our ability to solve climate change amongst the American public.

Chapter 2

Experiment 1: An Intervention Targeting Individual Goals and Pathways Thinking

Although achieving a sustainable future will ultimately involve the adoption of multiple pathways–from the technological to the political–any solution will also necessarily involve changes in individual behavior (Midden et al., 2007). With roughly 45% of the U.S's 2019 greenhouse gas emissions deriving from travel and household energy use (EPA, 2021), the widespread adoption of more pro-environmental behaviors has the potential to greatly contribute to the reduction of greenhouse gas emissions (Clayton et al., 2015; Dietz et al., 2009; Gardner & Stern, 2008; Girod et al., 2014), with the added advantage that changes at the level of individual behavior can take place more quickly than policies or technology that might take years to develop and implement. Williamson et al. (2018) estimate that behavioral solutions such as reducing food waste and ridesharing have the potential to eliminate up to 36.8% of global emissions from 2020-2050.

Individual pro-environmental behaviors (PEBs)–behaviors that are a deliberate expression of a wish to minimize a negative impact on the environment (Kollmus & Agyeman, 2002) tend to be classified by experts as either efficiency-improving or energy-reducing. Efficiency improving behaviors are characterized as high cost, low frequency behaviors that most often center around the upgrading of technology, such as purchasing a more fuel efficient car or installing an energy efficient washing machine. Energy reducing behaviors, in contrast, are low-cost high frequency behaviors that involve changing habits to reduce the use of pre-existing equipment, such as turning lights off when not in use or walking rather than driving to work (Barr et al., 2005; Black et al., 1985; Gardner and Stern, 2008; Inskeep and Attari, 2014; Karlin et al., 2014). The majority of PEBs identified by experts and publicized in textbooks and government resources center on relatively low impact household behaviors, due either to the fact that they tend to take the least amount of effort to adopt (see Dieckmann & Preisendorfer's (2003) "low cost hypothesis") or due to the fact that from a research standpoint, such behaviors are easiest to measure (Kempton et al., 1985).

Communication about pro-environmental behaviors has previously centered around the conveyance of information about types of PEBs to adopt or justifying the need to act pro-environmentally (Kollmus & Agyeman, 2002). This was based on the premise that individuals failed to engage in pro-environmental behavior due to a lack of knowledge–either not being aware of the harmful consequences of their actions or not knowing which actions to take (Attari et al., 2010; Bamberg & Moser, 2007; Bostrom et al., 2019; Reynolds et al., 2010; Swim et al., 2009; Whitmarsh, 2009). However, evidence has shown that information alone so far (e.g., lists of easy ways individuals can help) has generally not promoted substantial changes in pro-environmental behavior as much as desired (Abrahamse et al., 2005; Geller, 2002; McKenzie-Mohr, 2000; Skinner, 1987). The modest effectiveness of such campaigns has been explained by them not usually addressing individuals' motivation to act and rarely accounting for, or even acknowledging, the costs (in terms of difficulty or convenience) associated with carrying out such actions (Stern & Wolske, 2017).

A lack of knowledge regarding PEBs that can be adopted to tackle climate change can contribute to a relative lack of hope, leaving individuals with no actionable behavioral goals. This can generate a sense of helplessness and detachment regarding climate change, manifesting in apathy or outright denial of the issue (Norgaard, 2011) and affecting related constructs such as participants' sense of nationalism (see Ranney's RTMD theory; Ranney et al., 2012). However, a dearth of informational or educational campaigns that address more structural concerns (e.g., how realistically PEBs might fit into someone's lifestyle) may affect hope according to Snyder's definition, by impacting mechanistic thinking–the ability to conceive of a pathway, involving judging the costs and the tradeoffs that may have to be made in the fact of such costs, that one might take to realistically achieve the PEB in question.

Interventions that seek to foster hope through helping participants identify behavioral goals and engage in pathways thinking often utilize a process called "stepping," which involves asking participants to develop lists of potential goals and to rank-order the generated items in terms of personal priority (Pedrotti et al., 2008; Snyder, 2005). Such activities are said to work by helping people to 1) identify or more clearly conceptualize attainable goals, 2) anticipate specific strategies they might put into practice to reach such goals (pathways thinking) and, in doing so, 3) initiate motivation for engagement in these strategies (agency thinking). The act of prioritizing goals also involves an implicit assessment of the obstacles preventing one attaining a goal–a necessary first step for the generation of alternative pathways to circumvent such obstacles and, therefore, higher hope. As such, this study seeks to investigate the following hypotheses:

> H1-1: A "stepping" activity involving ordering a set of PEBs from most-to-least likely to engage in will increase a) hope about our ability to solve climate change, b) related constructs such as global warming acceptance or nationalism.
>
> H1-2: Related constructs (e.g., participants' initial global warming acceptance and/or participants' conservatism) are predictive of changes in hope.

An additional hypothesis of interest is that participants' PEB rankings will provide additional information about (a) how participants negotiate and make tradeoffs between different environmental behaviors, as well as (b) participants' perceptions of high and low-cost behaviors.

Methods

Materials

Based on an extensive review of the energy conservation and environmental psychology literature, I chose nine possible pro-environmental behaviors to present to participants in this experiment (Attari, 2014; Attari et al., 2010; Barr et al., 2005; Black et al., 1985; Dietz et al., 2009; Gardner and Stern, 2008; Gatersleben et al., 2002; Harland et al., 1999; Karlin et al., 2014; Karp, 1996; Larson et al., 2015; Poortinga et al., 2004; Toner et al., 2012; Truelove and Parks, 2012; Van der Werff et al., 2014; Vandenbergh et al., 2010; Whitmarsh and O'Neill, 2010). The possible behaviors were chosen to appeal to as broad a demographic and socio-economic range as possible and on the basis that they could be carried out by people of any age and would not

require home-ownership in order to be enacted. Nine behaviors were chosen in order to not overwhelm participants in their consideration of tradeoffs between the different options. To present participants with behaviors that were easy and realistic to implement, the focus was on recurring curtailment behaviors (i.e., to drive less) that may be incorporated as a change in habit, rather than one-off, more expensive efficiency behaviors (Gardner & Stern, 1996). The nine pro-environmental behaviors were also chosen to reflect as varied a range of actions as possible—ranging from widely publicized household energy behaviors, such as changing out incandescent light bulbs to fluorescent ones, to less commonly recognized behaviors that are harder to quantify the impact of, such as talking to friends and family about climate change (see Table 2-1 for a full list of all nine behaviors). Behaviors were largely classified as approach goals, focusing on an active behavioral shift that participants could take (i.e., to wash clothes in cold water), rather than as avoidance goals, in which participants would have to stop doing something (i.e., to stop washing clothes in hot water), given evidence that approach-framing is a more productive approach to goal setting (Snyder et al., 2000).

Table 2-1

The Complete List of Nine Pro-environmental Behaviors Presented to Participants.

Pro-Environmental Behavior
Drive less
Fly less
Wash clothes in cold water
Change out household lightbulbs
Talk with friends and family about climate change
Contact an elected official about climate change
Plant a tree
Recycle / re-use resources
Eat a more plant-based diet

Participants

Amazon Mechanical Turk (MTurk) US-based participants were recruited in mid-2021 and paid $5.00 upon survey completion, with 152 survey responses being collected. After incomplete responses were deleted and other exclusion criteria (detailed below) applied, 108 responses were analyzed. Of the responses analyzed, 56% were from men and 44% women. The average age of participants was 35 years old, and 56% of the sample identified as Democrats, with 16% as Independents and 24% as Republican. The average social conservatism rating, on a

9-point scale, was 4.04 and 4.32 for economic conservatism (between significantly liberal and moderately liberal)—indicating a slightly liberal orientation among remaining participants.

Procedure and design

After providing informed content, participants completed a pre-test that assessed the constructs of hope about climate change, global warming acceptance, and nationalism. Hope about climate change was assessed using an adapted version of Li & Monroe's (2018) 12-item Climate change Hope Scale, with Chronbach's alpha to range from 0.88-0.89 across the pre- and post-test. Eight items were used to assess global warming acceptance with Chronbach's alpha ranging from 0.90-0.91 across the pre- and post-test respectively—and four items were used to assess participants' nationalism, with Chronbach's alpha ranging from 0.65-0.78 across the pre- and post-test. All of the Chronbach alpha's presented were calculated from the present study. The items used to assess global warming acceptance and nationalism were drawn from prior studies (e.g., Ranney et al., 2019; Ranney & Clark, 2016). For a full list of pre-and post-test items, see Appendix A. Participants were then presented with Table 1's list of the nine actions identified by experts as actions that can be taken by individuals to limit global climate change and asked to rank them from (1) the action participants would be most likely to engage in to (9) the action participants would be least likely to engage in. After this, participants were asked to provide justifications of their top and bottom choice. They then completed a post-test that was identical in form to the pre-test and asked to provide some demographic information before being dismissed and thanked for their participation.

Exclusion criteria

Participants received a score based on a combination of any incorrect responses to four catch-items (one point for each incorrect catch item), an assessment of their written justifications for their top and bottom choice (i.e., if the justification was not related to the choice specified or copied and pasted text from Wikipedia, participants were given a score of one; if the writing was nonsensical or had no relation to the task, participants were given a score of two) and were given one point if their time to complete the experiment was excessively shorter or longer than the average survey completion time of 20 minutes. They were excluded if their score exceeded 75% of the total possible score of seven points—or if their IP address indicated they were outside of the US. In total, 44 participants were excluded from the study.

Results

As predicted, the act of ordering pro-environmental behaviors according to the actions participants would most to least likely engage in caused hope to significantly increase, overall, from pre-intervention ($M = 6.12$, $SD = 1.27$) to post intervention ($M= 6.25$, $SD =1.31$, $t(225)= 7.0589$, $p<0.01$, $d=0.10$;see Table 2-2). Global warming acceptance and nationalism, however, stayed fairly consistent (see Table 2-2), although the global warming finding may have effected a slight ceiling effect.

Table 2-2

Pre-to-post Changes in Study Variables (n=108)

Study Variable	Pre-test / 9		Post-test / 9		Average pre-to-post-test change	*t*-value	df	*p*
	M	*SD*	*M*	*SD*				
Hope	6.12	1.27	6.25	1.31	+0.13	-2.901	107	0.004516**
Global Warming Acceptance	6.94	1.62	6.97	1.61	+0.03	-0.69786	107	0.4868
Nationalism	5.30	1.52	5.26	1.64	-0.04	0.57556	107	0.5661

†p<0.1, *p<0.05, and **p<0.01

Means, standard deviations, and correlations of the major variables (hope, global warming acceptance, and nationalism, along with conservatism—a demographic variable that has been found to strongly correlate with global warming acceptance in past studies, see Ranney et al., 2019) across all conditions are presented in Table 2-3.

Table 2-3

Means and Correlations of Study Variables, Including Conservatism (n=108)

Variable	*M*	*SD*	2.	3.	4.	5.	6.	7.
1. Hope T1	6.12	1.27	0.55*	-0.076	0.94**	0.57**	-0.093	-0.273**
2. GW T1	6.94	1.62		-0.40**	0.58**	0.96**	-0.36**	-0.558**
3. Nat T1	5.30	1.52			-0.083	-0.38**	0.89**	0.405**
4. Hope T2	6.25	1.31				0.61**	-0.093	-0.255**
5. GW T2	6.97	1.66					-0.36**	-0.609**
6. Nat T2	5.26	1.64						0.357**
7. Conservatism	4.18	2.66						

†p<0.1, *p<0.05, and **p<0.01

Twenty-four out of 28 correlations among the study variables were statistically significant, with the only non-statistically significant correlations being between pre- and post-test hope and pre- and post-test nationalism (see Table 2-3). As predicted, these results suggest that participants who were the most hopeful about global warming tended to have a higher acceptance of it and were less conservative. They also evidence negative correlational relationship between pre- and post-test global warming acceptance and nationalism (and global

warming acceptance and conservatism)– replicating the RTMD relationships that Ranney et al. have demonstrated as both a correlation and a causation (Ranney et al., 2019; Ranney et al., 2012)

Ranking Analysis

To analyze participants' ranked choices, the average rank of each pro-environmental behavior was determined by multiplying the weight of each ranked position (with 1 having the highest weight and 9 having the lowest weight) with the number of participants who ranked the behavior in that position (see Table 2-4). For each behavior the sum of weight*count products was taken to produce a total "score" for each pro-environmental behavior. The higher this "total response score," the higher ranked, on average (and hence, the more likely participants were likely to carry out), the behavior.

Table 2-4

Ranking Frequencies of Each PEB and Overall Rank of Item, After Weighting Into a "Total Response Score" (n=108)

	Pro-environmental Behavior								
Rank	Drive less	Fly less	Less meat	Cold wash for clothes	Recycle more	Plant a tree	Change light bulbs	Talk to friends / family	Contact an elected official
1	12	13	12	10	20	16	15	8	2
2	14	14	8	18	21	12	13	4	4
3	10	9	7	17	17	10	24	9	5
4	7	13	12	11	18	22	11	11	3
5	10	14	12	13	12	13	13	14	7
6	17	12	11	12	12	10	9	17	8
7	12	14	12	6	6	15	13	17	13
8	11	15	15	8	1	8	7	18	25
9	15	4	19	13	1	2	3	10	41
Total Response Score	523	564	482	579	704	610	630	468	300
Overall rank	6	5	7	4	1	3	2	8	9

Recycling or (less so) changing out household light bulbs were identified as the two most pro-environmental behaviors participants were most likely to engage in, while the options of

contacting an elected official about climate change and (less so) talking with friends and family about climate change were the actions most likely to be ranked as ninth out of nine (that is, the behavior participants would be least likely to engage in; see Table 2-4). As one example, people were 13 times more likely (among individuals' rankings) to not want to talk to a friend or elected official about climate change than to cut back on flying.

Ranking Justifications

The written justifications for the most popular pro-environmental behaviors (recycling and changing out household light bulbs) and the least popular behaviors (contacting an elected official and talking with friends and family about climate change) were qualitatively coded. A five-category coding scheme was developed by extracting major patterns from each set of explanations and coding all justifications within the scheme (see Table 2-5).

Table 2-5

Codes for the Most and Least Popular PEBs

Most popular PEB justifications	Least popular PEB justifications
Easy to do, affordable, accessible	People are not interested / don't care
Do already	Social anxiety, awkwardness
Effective	Have never done before
Results in money savings	Don't know relevant facts to quote
Aesthetic (prefer the look of an LED lightbulb)	Anti-politics (politicians don't listen)

Participants indicated that they were most likely to recycle and change out light bulbs due to the fact that both were low-cost (i.e., easy and affordable) behaviors for which participants would not have to overcome significant structural barriers to engage in (being in the habit of performing these behaviors already). The fact that both resulted in saving money was also cited, although claims that both behaviors were effective in comparison to some of the other behaviors listed indicate an erroneous assessment of the true relative impact of recycling and/or changing out lightbulbs.

Although the more socially oriented behaviors (talking to officials—or friends and family—about climate change) are similarly affordable in terms of economic cost, participants cited social costs such as (1) having to overcome social anxiety or awkwardness, (2) anticipated dis-interest in their audience, and (3) a general unfamiliarity with this type of PEB and how to engage with it (e.g., the relevant facts to quote when attempting to persuade or even simply communicate with, a friend or official; see Table 2-5).

Multiple regression analyses were performed to assess whether any of the pre-test variables and/or demographic traits of participants significantly predicted participants' changes in hope after engaging with the intervention. In particular, regression analyses were run to examine the relationships predicting post-test hope with: pre-test hope, pre-test global warming acceptance, and conservatism (constructs that were both theoretically justified and that showed significant correlations to each other in the pre- and post-tests). Table 2-6 shows the regression weights for the four models compared. Model 1 yielded an $R^2 = 0.8831$ ($F(3,104)=261.8$, $p<0.01$), explaining 88% of the variance. In this default model, it was found that pre-test hope significantly predicted post-test hope ($\beta= 21.936$, $p<0.01$), as did pre-GW acceptance ($\beta=2.624$, $p<0.01$).

Table 2-6

Regression Analyses Predicting Post-Test Hope With Relevant Study Variables (n=108)

Variable	Model 1			Model 2			Model 3			Model 4		
	Coef	SE Coef	*t*	Coef	SE Coef	*t*	Coef	SE Coef	*t*	Coef	SE Coef	*t*
Intercept	-0.13	0.31	-0.42	0.33	0.75	0.44	-0.31	1.18	-0.26	-0.17	2.78	-0.062
Pre. Hope	0.91	0.042	21.94*	0.83	0.13	6.26*	0.90	0.16	5.43*	0.89	0.47	1.88
Pre. GW	0.099	0.038	2.62*	0.031	0.11	0.29	0.12	0.16	0.72	0.044	0.35	0.13
Conservatism	0.028	0.021	1.35	0.027	0.021	1.29	0.086	0.086	0.99	0.015	0.36	0.043
Pre.H*Pre.GW				0.012	0.018	0.68	0.0037	0.022	0.17	0.013	0.058	0.23
Pre.GW*Conserv							-0.0089	0.013	-0.71	0.016	0.049	0.32
Pre.H*Conserv										0.0081	0.064	0.13
Pre.H*Pre.GW*Pre. Conserv										-0.0033	0.0082	-0.41
R^2	0.883			0.883			0.8842			0.8852		
F for change in R^2	261.8			195.4			155.7			110.2		

*p<0.05

It was hypothesized that there may be interactions between the various constructs and that accounting for these (in models 2, 3 and 4) may yield a model that would perform better than model 1. These more complex models yielded $R^2 = 0.8836$ ($F(4, 103)=195.4$, $p<0.01$; Model 2), $R^2 = 0.8842$ ($F(5, 102)=155.7$, $p<0.01$; Model 3) and $R^2 = 0.8852$ ($F(7, 100)=110.2$, $p<0.01$; Model 4), with pre-test hope providing significant contributions to Models 2 and 3 (see Table 2-6). The predictive utility of Models 2, 3, and 4 were each compared with Model 1 using a series of ANOVAs. It was found that neither models 2, 3, or 4 significantly outperformed Model 1 (with an F ratio of $F(1,104)=0.4647$, $p=0.4969$, for model 2 vs. model 1; $F(2,104)=0.4814$, $p=0.6193$ for model 3 vs. model 1; and $F(4,104)=0.4722$, $p=0.756$ for model 4 vs. model 1, respectively; see Table 2-6).

Discussion

Overall, this short intervention based around the process of "stepping" (i.e., ranking) pro-environmental behaviors and justifying the behaviors participants would be most and least likely to adopt was shown to significantly increase hope about our ability to solve climate change (see Table 2-2). Although engaging with the intervention left participants' global warming acceptance and nationalism largely unchanged (see Table 2-2), pre- and post-test data showed statistically significant correlations between hope about our ability to solve climate change and acceptance of climate change (see Table 2-3). Both pre-test hope and global warming acceptance were also significant predictors of post-test hope scores (see Table 2-6), indicating that this intervention was more effective at raising hope for participants who had higher global warming acceptance and higher initial levels of hope regarding climate change.

Analyzing the order of participants' choices, the most popular behaviors (i.e., the behaviors with the highest average rank) was found to be recycling (and changing light bulbs; see Table 2-4). These were justified as generally being easier to do, and/or get into the habit of doing, with some misconceptions being displayed by participants about the true relative impact of such behaviors (see Table 2-5). The least popular actions (i.e., those that were on average ranked lowest by participants) were social in nature, involving talking to friends or family about climate change or (especially) contacting an elected official (see Table 2-4). Justifications for the low ranking of such options ranged from general cynicism about politics, the misconception that the majority of people aren't interested or don't care about climate change, social awkwardness, and/or a lack of knowledge of the relevant facts/evidence to quote in support of a conversation about climate change (see Table 2-5). This result supports cross-cultural research that people find it difficult to share their emotions—or even simply to talk about climate change (Norgaard, 2011)—and suggests the need for more scaffolding of conversations about climate change (e.g., in the form of either behavioral interventions or as classroom exercises). The high ranking of a behavior such as recycling reflects one of the more prominently studied PEBs in psychological research (i.e., product purchase and disposal) and reflects the need for more research on how to re-frame public-sphere actions, such as conversations with friends and activism as common pro-environmental behaviors. Behaviors that are shared in nature (i.e., "we" goals, rather than "me" goals; Snyder et al., 1997) tend to be characteristic of higher hope, and practicing these may engender a sense of community and mutual responsibility that may be especially effective at promoting hope amongst the young (Dahlberg, 2001).

Conclusion

A short intervention asked participants to (a) rank nine pro-environmental behaviors on the basis of what they would most—and would least—likely engage in and then to (b) justify their rankings. This intervention was shown to increase participants' hope about people's ability to successfully solve climate change. Participants stated that they were most likely to engage in easy-to-implement behaviors such as recycling, and least likely to enact social behaviors such as talking to elected officials and/or friends/family about climate change. These result indicates the necessity of identifying and removing structural and motivational barriers to the more socially oriented pro-environmental behaviors. Results also demonstrate a relationship between hope

about our ability to solve climate change and climate change acceptance, reflected both in correlational relationships between pre- and post-test variables—and also in terms of global warming acceptance's predictive power in determining post-test hope after engagement with the intervention.

Chapter 3

Experiment 2: An NDI-Intervention Targeting Collective (i.e., Societal) Pathways

Snyder's (2002) model of hope, based on the trio of interacting constructs of individual goal formation, pathways thinking and agency, has been criticized by some as framing hope as an overly individualistic pursuit of personal goals (Aspinwall & Leaf, 2002; Bernado, 2010). McGreer (2004), for instance, argues that Snyder's overwhelming focus on individual goals and pathways makes his model of hope hard to apply to a societal issue like global warming, which necessarily involves the coordination and collaboration of multiple stakeholders for a successful resolution. Snyder, however, claimed that a characteristic of high hope is an implicit attendance to collective thinking (i.e., communal or shared goals and commensurate pathways/agency thoughts), enhancing both individual as well as shared future goals (Snyder & Feldman, 2000).

While individual behavior change plays an important role in solving climate change, such change is only impactful if carried out on a collective scale and in combination with large-scale, societal-level shifts (Avelino & Wittmayer, 2016; Fischer-Kowalski & Rotmans, 2009). Despite the importance of collective goals and pathways (Farla et al., 2012) and the pivotal role of socio-technological innovation in solving the climate crisis, educators and researchers tend to focus largely on researching individual energy conservation behaviors (Jorgenson et al., 2019) or, relatedly, often on propagating the idea that society will be able to reach a sustainable future through individuals simply consuming less (Tainter, 2011). Such an approach creates a disjunction between the field of sustainability, which is seeking to conceptualize and influence change at a systems-level, and the field of environmental education which is more so focused on change at the level of individual persons (Courtenay-Hall & Rogers, 2002) and less-influential private sphere actions over more public, collective ones (Chawla & Cushing, 2007; Courtenay-Hall & Rogers, 2002; Jensen, 2002).

Critical scholars view this focus on individual as opposed to collective behaviors as a politically-motivated neoliberal choice, which conceals the structural character of the environmental crisis, shifts responsibility to households and individuals and hence makes it more difficult to realize structural change (Clover 2002, Courtenay-Hall and Rogers 2002, Jensen 2002, Jensen and Schnack 2006). Barr (2014) accordingly suggests that the main focus on individual behaviors in pro-environmental behavior communication has the effect of stifling debate about the role of social norms and economic practices in environmental behavior and contributes to a narrow vision of what it means to be pro-environmental. A focus on individual behavior change with no conveyance of the collective impact of such actions also creates a sense of unclearness and skepticism about how beneficial or effectual such actions are (Gardner & Stern, 2008; Lorenzoni et al., 2007), ultimately inhibiting hope (Faiers et al., 2007; Kenis & Mathijs, 2012).

In order to help people develop a sense of scale and of the collective impact of their actions (i.e., to reframe climate change as a collective problem to be tackled at a collective level), people need to engage in mechanistic thinking (i.e., to develop an awareness and understanding of the relationships between actions taken on an individual scale and global reductions in greenhouse gas emissions—a kind of systems-level thinking that is challenging to engage in (Marshall, 2015; see also Bostrom et al., 1994). If the collective nature of individual pro-environmental behaviors can be highlighted, this may help the "drop in the ocean" (i.e., individual helplessness) feeling and accordingly activate belief that collective action will lead to

success—and that one's participation will contribute to that (Lubell, 2002; Rousser-Renouf et al., 2014), increasing hope, efficacy and possibly global warming acceptance (Lertzmann, 2015). One way I hypothesize that such mechanistic thinking, systems-level thinking, and quantitative reasoning can be activated (other than simply reading mechanistic descriptions of pro-environmental behaviors) is through the Numerically Driven Inferencing paradigm (NDI; e.g., Ranney Munnich & Lamprey, 2016).

Numerically driven inferencing is characterized by estimating salient quantities (and sometimes generating preferences) relating to policy issues (e.g., abortion) before receiving the actual or true values as feedback, in order to catalyze surprise-mediated changes in belief systems (Ranney et al., 2001; Ranney & Velautham, 2021). During the act of estimating a numerical quantity, participants evoke networks of facts, set relationships, and causal (e.g., mechanistic) beliefs from among other sources, personal experiences, and media sources, which in turn increases the likelihood of conceptual change (diSessa & Sherin, 1998; Thacker & Sinatra, 2022). This interaction of mechanistic and numerical reasoning has some of its roots in Tversky and Kahneman's (e.g., 1979) seminal studies of risk management and has more recently been explored by Krynski and Tenenbaum (2007) and Pearl (2000), who have both drawn a connection between people's causal scenario models and normative Bayesian reasoning. It has additionally been shown by Ranney et al. (2016) that surprising numerical feedback can cause changes in one's mechanistic understanding, affecting one's policy preferences, sense of nationalism when the quantities are US-centered, and, for the purposes of this study, hopefulness (Munnich et al., 2003). This study thus seeks to investigate 2 primary hypotheses:

> H2-1: Exposure to an NDI-intervention centered around US-specific climate change solutions increases participants 1) hope about our ability to solve climate change, 2) climate change acceptance and/or 3) nationalism.
>
> H2-2: Surprise (e.g., at the discrepancy between one's estimate and the true numerical feedback) is a significant driver in any change of climate change hope.

Methods

Materials

Through a search of the relevant scientific literature and consultation with climate scientists, three societal-level-scale solutions were identified that had been heralded by scientists and policy-makers as the most feasible ways to address the climate change—and have the most significant impact on our current greenhouse gas emission levels. Solutions were required to have an empirical justification in a prominent journal that had been widely accepted by the wider scientific community (i.e., not attracted controversy or been 'debunked'). The three identified solutions were 1) sustainable electrification, 2) energy efficiency, and 3) societal reduction in meat consumption.

Once confirmed, solutions were entered into Google and links from the first five pages of results were reviewed for surprising quantitative statistics. Statistics were chosen on the basis of either relating to impacts of behaviors or demonstrating the extent to which they have already

been adopted and/or effective. Since participants were anticipated to be US-based, and nationalism was a construct of interest, statistics that demonstrated the effectiveness of the three solutions in a US context were given preference. Overall, ten surprising statistics were chosen for each solution and then whittled down to five, through iterative rounds of feedback with both scientists and trial participants. The final five statistics associated with each solution are identified in Table 3-1.

Table 3-1

Surprising statistics Associated with Each of the Three Identified Solutions.

Solution		Statistic
Electrification	1	Greenhouse gas emissions associated with the U.S. power sector have [increased/decreased] by 28% since 2005, due to changes in the kinds and amounts of fuels used to generate electricity. (Source: The U.S. Energy Information Administration)
	2	A new law requires California, the world's fifth-largest economy, to have 100% carbon-free (i.e., no fossil-fuel derived) electricity by 2045.
	3	In 2018, the United States currently had 249,983 solar workers (defined as those who spend 50% or more of their time on solar-related work) compared to the 198,583 people who worked in the coal-, oil-, and gas-extraction industries combined. (Source: The National Solar Jobs Census)
	4	70% of the state of Washington's current electricity is generated from existing hydroelectric sources. (Source: U.S. Energy Information Administration)
	5	Between 2009 and 2014, the cost of solar electricity (measured in dollars per kilowatt-hour) in the U.S. [increased/decreased] by 78%. (Source: California Public Interest Research Group)
Energy Efficiency	1	From 1960 to today, the disposal of everyday (that is, non-industrial) U.S. waste directly to landfills has changed from 94% of the total waste generated to 52% of the total waste generated. (Source: EPA)
	2	In 2017, the average American person recycled (including composting) 1.58 pounds of household material per day. (Source: EPA)
	3	The U.S. recycling industry generates 8.5 times as many jobs as the U.S. landfill industry, equating for the weight of material recycled versus landfilled. (Source: recycleacrossamerica.org)
	4	Recycling a single aluminum can save the equivalent of enough energy to power a TV for 3 hours.
	5	In terms of energy savings, recycling a single can of aluminum can keep 19 cans from having to be mined and manufactured from raw materials. (Source: Stanford Recycling Center)

Table 3-1 continued

Meat Reduction	1	According to a recent study in the journal "Science Reports", if everyone in the U.S. reduced their consumption of beef, pork and poultry 25% by

	substituting plant proteins-we'd reduce yearly greenhouse gas emissions by about 180,000,000,000 (180 billion) pounds. (Source: Science Reports)
2	Americans' current per capita beef consumption has [increased/decreased] by 33% since the 1970s (Source: New York Times)
3	A study published in the "Journal of Hunger and Environmental Nutrition" estimated that vegetarians saved $750 per year, compared to meat eaters. (Source: Journal of Hunger and Environmental Nutrition)
4	From a representative sample of Americans, 60% report they have either stopped or reduced their meat consumption over the last ten years. (Source: Public Health Nutrition)
5	A study published in "Environmental Research Letters" found that eating a plant-based diet had an average of 8 times a more positive environmental impact than upgrading light bulbs (in which "positive impact" is measured in terms of CO2-equivalent emissions). (Source: Environmental Research Letters)

Participants

Amazon Mechanical Turk (MTurk) participants were recruited early in 2021 and paid $5.00 upon survey completion. Three hundred survey responses were collected. After incomplete responses were deleted and other exclusion criteria (detailed below) applied, 226 responses were analyzed. Of the responses analyzed, 62% were men and 38% women. The average age of participants was 37.2 years old, and 57% of the sample identified as Democrats, versus 22% as Independents and 16% as Republicans. The average social conservatism rating was 3.92 and 4.27 for economic conservatism (out of nine), indicating a mildly liberal orientation among remaining participants.

Procedure, Design and Analytic Strategy

After providing informed content, participants completed a pre-test that assessed their hopefulness about climate change, climate change acceptance, and nationalism. Hopefulness was measured using an adapted version of Li & Monroe's (2018) 12-item Climate Change Hope Scale, with Chronbach's alpha ranging from 0.88-0.90 across the pre- and post-test, eight items measuring global warming acceptance, with Chronbach's alpha ranging from 0.90-0.91 across the pre- and post-test and four items regarding their nationalism, with Chronbach's alpha ranging from 0.69-0.76 across the pre- and post-test. For a full list of pre- and post-test items used, see Appendix A. Participants were then randomly assigned to one of three conditions in which they were shown a brief text that gave an overview of one of three solutions for climate change, electrification (n=67), energy efficiency (n=82), or meat reduction (n=77)—and asked to answer two comprehension questions relating to the text (for texts/comprehension questions for each condition, see Appendix B). Participants were then shown five statistics on their assigned topic (for a full list of the statistics shown see Table 3-1). For each statistic, a variation on NDI's EPIC procedure (Munnich et al., 2004; Rinne et al., 2006) was used, in which participants were shown the statistic with the quantity blanked out and then asked to estimate the quantity. For each

statistic, participants were then given feedback on their estimate (i.e., what the true number was, along with the magnitude of the error of their estimates), and then asked to rate how surprised they were by this feedback on a scale of 1-9. After going through this process for five statistics, participants completed a post-test that was identical in form to the pre-test. They were then asked to provide some demographic information before being dismissed and thanked for their participation.

Exclusion Criteria

Participants were scored, regarding possible data-exclusion, depending on their accuracy in answering four catch-items in the pre/post-tests, their answers to the comprehension questions, and the relative duration of their pre-and post-tests (compared to the average survey completion time of 18 minutes). They were excluded if they fell below 75% of the total possible exclusion score, or if their IP address indicated they were taking the survey outside of the US. In total, 74 participants were excluded, yielding the 226 remaining.

Results

Overall, the process of reading an overview of a solution and estimating and receiving feedback on quantities relating to it was shown to cause a robust gain in both climate-change hope and global warming acceptance. Aggregating pre-to-post changes across the three experimental conditions indicated a statistically significant increase in hope from M = 6.31 (SD = 1.22) to M= 6.54 (SD =1.26; t(225)=-7.0589: p<0.01, d=0.19), and a statistically significant increases in global warming acceptance from M=7.10 (SD = 1.53) to M=7.18 (SD=1.57); t(225)=-2.2219: p<0.05, d=0.05) and nationalism—from M = 5.50 (SD = 1.59) to M=5.61 (SD = 1.65; t(225)=-2.5749: p<0.05, d=0.07; see Table 3-2)

Table 3-2

Pre-to-post Changes in Study Variables (n=226)

	Pre-test / 9		Post-test / 9		Average pre-to-post-test change	*t*-value	df	*p*
	M	*SD*	*M*	*SD*				
Hope	6.31	1.22	6.54	1.26	+0.23	-7.0589	225	2.061e-11**
GW Acceptance	7.10	1.53	7.18	1.57	+0.08	-2.2219	225	0.02728*
Nationalism	5.50	1.59	5.61	1.65	+0.10	-2.5749	225	0.01067*

†p<0.1, *p<0.05, and **p<0.01

Means, standard deviations and correlations of the major variables (hope, global warming acceptance and nationalism, along with conservatism—a variable that has been found to strongly correlate negatively with global warming acceptance in past studies, see Ranney et al., 2019) across all conditions are presented below. See Table 3-3.

Table 3-3

Correlations of Study Variables, with Conservatism (n=226)

	M	SD	2.	3.	4.	5.	6.	7.
1. Hope T1	6.31	1.22	0.493**	0.0720	0.924**	0.482**	0.0723	-0.23**
2. GW T1	7.10	1.53		-0.330**	0.523**	0.95**	-0.34**	-0.66**
3. Nat T1	5.50	1.59			0.034	-0.278**	0.932**	0.36**
4. Hope T2	6.54	1.26				0.51**	0.0365	-0.25**
5. GW T2	7.18	1.57					-0.292**	-0.64**
6. Nat T2	5.61	1.65						0.38**
7. Conservatism	4.09	2.32						

†p<0.1, *p<0.05, and **p<0.01

Twenty-four out of 28 correlations were statistically significant, with the only non-significant correlations being those between *pre*-test hope and both pre-and-post-test nationalism, as well as *post*-test hope and both pre- and post-test nationalism (see Table 3-3). In general, these results suggest that people who are hopeful about global warming tend to have a higher acceptance of it. These data also add additional support for the strongly negative correlation between global warming acceptance and nationalism–a relationship that Ranney et al. have consistently demonstrated in both correlational and causal studies (Ranney et al., 2019; Ranney, 2012).

Change in Variables per Condition

Participants in all 3 conditions experienced statistically significant increases in pre-to-post-test hope: M=6.24 (SD=1.17) to M=6.49 (SD=1.14) for the Electrification Condition (t(66)=-4.5579, p<0.01, d=0.22) M=6.38 (SD=1.29) to M=6.62 (SD=1.34) for the energy Efficiency Condition (t(81)=-4.083, p<0.01, d=0.18) and M=6.30 (SD=1.20) to M=6.49 (SD=1.29) for the Meat Reduction Condition (t(76)=-3.6352, p<0.01, d=0.15). Global warming acceptance also increased marginally for the Meat Reduction Condition: M=7.06 (SD=1.53) to M=7.19 (SD=1.62: t(76)=-1.9645, p<0.05, d=0.08). Participants in the Electrification Condition experienced a significant increase in their nationalism (M=5.21 (SD=1.66) to M=5.44 (SD=1.72), t(-2.8369)=0.20338, p<0.01, d=0.14; see Table 3-4)

Table 3-4

Pre-to-post Changes in Study Variables per Condition (n=226)

Condition	Variable	Pre-test / 9		Post-test / 9		Average pre-to-post-test change	*t*-value	df	*p*
		M	*SD*	*M*	*SD*				

Electrification (n=67)	Hope	6.24	1.17	6.49	1.14	+0.25	-4.5579	66	2.294e-05**
	GW	7.20	1.45	7.27	1.44	+0.07	-1.0596	66	0.2932
	Nat	5.21	1.66	5.44	1.72	+0.23	-2.8369	66	0.006045**
Energy efficiency (n=82)	Hope	6.38	1.29	6.62	1.34	+0.24	-4.083	81	0.0001037**
	GW	7.06	1.60	7.10	1.64	+0.04	-0.74935	81	0.4558
	Nat	5.53	1.60	5.64	1.66	+0.11	-1.7291	81	0.0876†
Meat Reduction (n=77)	Hope	6.30	1.20	6.49	1.29	+0.19	-3.6352	76	0.0005028**
	GW	7.06	1.53	7.19	1.62	+0.13	-1.9645	76	0.05313†
	Nat	5.73	1.51	5.71	1.58	-0.02	0.20338	76	0.8394

†p<0.1, *p<0.05, and **p<0.01

To compare the changes in variables across the different conditions, three one-way ANOVAs were performed to compare the effect of the three conditions on change in hope, change in global warming acceptance, and change in nationalism. It was found that there was no statistically significant difference for change in hope ($F(2,223)=[0.337]$, $p=0.714$), global warming acceptance ($F(2,223)=[0.53]$, $p=0.589$), or nationalism ($F(2,223)=[2.932]$, $p=0.055$) across the conditions.

To study participants estimates, the maximum and minimum estimate for each blanked quantity was calculated, along with median estimate, participants' average percentage error (e.g., the discrepancy between the median estimate and the true feedback), the true quantity, and participants' average self-rated surprise at the discrepancy between their estimate and the true numerical feedback. Consistent with past NDI studies, participants' average percentage error for estimates, above 45% for all conditions, was found to be highest for the meat reduction condition, the condition yielding the highest surprise (see Tables 3-5a to 3-5c).

Table 3-5a

Estimates for the Electrification Statistics (Condition 1, n=67)

Statistic	Estimate range	Median estimate	Actual answer	% Error	Average surprise / 9
Greenhouse gas emissions associated with the U.S. power sector have changed by ____% since 2005, due to changes in the kinds and amounts of fuels used to generate electricity [source: the U.S. Energy Information Administration]	-70% - +80%	-10%	-28%	64	4.94

Table 3-5a continued

A new law requires California, the world's fifth-largest economy, to have _____% carbon free (i.e., no fossil fuel derived) electricity by 2045.	0-100	80	100	20	4.72
In 2018, the United States had _____ solar workers (defined as those who spent 50% or more of their time on solar-related work) compared to the 198,583 people who worked in the coal-, oil- and gas extraction industries combined (Source: The National Solar Jobs Census)	15-550,000	91,842	249,983	63	6.64
___% of the state of Washington's current electricity is generated from existing hydroelectric sources (Source: U.S. Energy Information Administration).	8-89	40%	70%	43	6.03
Between 2009 and 2014, the cost of solar electricity (measured in dollars per kilo-watt-hour) in the U.S. changed by _____% (Source: California Public Interest Research Group)	-100 - +70%	-20%	-78%	74	6.96
		Means:		53	5.86

Table 3-5b

Estimates for the Energy Efficiency Statistics (Condition 2, n=82)

Statistic	Estimate Range	Median estimate	Actual answer	Percentage Error	Average surprise
From 1960 to today, the disposal of everyday (that is, non-industrial) U.S. waste directly to landfills has changed from 94% of the total waste generated to ___% of the total waste generated (source: EPA)	2-98%	69%	52%	33	6.05
In 2017, the average American person recycled (including composting) ___ pounds of household material per day (source: EPA)	0.5 - 400	5	1.58	46	4.71

Table 3-5b continued

The U.S. recycling industry generates ___ times as many jobs as the U.S. landfill industry, equating for weight of material recycled versus landfilled (source: recycleacrossamerica.org)	2 – 100,000	4.5	8.5	47	5.40
Recycling a single aluminum can can save the equivalent of enough energy to power a TV for ___ hours.	1 - 452	4	3	33	4.40
In terms of energy savings, recycling a single aluminum can can keep ___ cans from having to be mined and manufactured from raw materials (source: Stanford recycling center)	0.5 – 2,000,000	5	19	74	6.57
		Means:		47	5.43

Table 3-5c

Estimates for the Meat Reduction Statistics (Condition 3, n=77)

Statistic	Estimate Range	Median estimate	Actual answer	Average % error	Average surprise
According to a recent study in the journal 'Science Reports', if everyone in the US reduced their consumption of beef, pork, and poultry 25% by substituting plant proteins- we'd reduce greenhouse gas emissions by about ___ pounds.	1 – 1E+08	500	180,000,000,000 (i.e., 180 billion) lbs	99	7.80
Americans' current per capita beef consumption has changed by ____% since the 1970s (Source: New York Times).	-75% - +1200%	+1%	-33%	97	4.99
A study published in the "Journal of Hunger and Environmental Nutrition" estimated that vegetarians saved $___ per year, compared to meat eaters.	6- 2,500,000	500	750	33	5.58

Table 3-5c continued

From a representative sample of Americans, ____% report that they have either stopped or reduced their meat consumption over the last three years (Source: Public Health Nutrition).	2-86%	15%	60%	75	7.47
A study published in "Environmental Research Letters" found that eating a plant-based diet has an average of ___ times a more positive environmental impact than upgrading light bulbs (in which "positive impact" is measured in terms of CO2-equivalent emissions).	1.25-300	10	8	25	5.23
		Means:		65.8	6.21

An ANOVA was performed to compare whether participants' average surprise at the feedback they received to their estimates differed significantly across condition. A one-way ANOVA revealed that there was a statistically significant difference in average surprise at feedback between at least two conditions ($F(2,223)=[5.29]$, $p<0.01$. Tukey's HSD test for multiple comparisons found that the average surprise was significantly different between condition 2 and condition 3 ($p<0.01$, 95% C.I. = [0.21, 1.36]—that is, that the meat-reduction statistics were more surprising than the energy efficiency statistics. There were no statistically significant difference in average surprise between condition 1 and condition 2 ($p=0.20$) or between condition 1 and condition 3 ($p=0.344$)

Regression Analyses

Regression analyses were carried out to assess to what extent *post*-test hope was predicted by two models: (model 1) pre-test GW acceptance, pre-test hope, conservatism, the condition a participant was assigned to, or (model 2) all these together with average surprise at the numerical feedback participants received (see Table 3-6).

Table 3-6

Regression Analysis with Study Variables (n=226)

Variable	Model 1			Model 2		
	Coef	SE Coef	*t*	Coef	SE Coef	*t*
Intercept	0.19	0.27	0.71	0.25	0.29	0.85
Pre. H	0.91	0.030	29.93*	0.91	0.031	29.50*
Pre. GW	0.085	0.031	2.71*	0.084	0.031	2.67*
Condition						
Condition 2	-0.0028	0.079	-0.036	-0.0084	0.080	0.92
Condition 3	-0.0048	0.080	-0.60	-0.045	0.080	0.58
Conserv	0.010	0.019	0.54	0.011	0.019	0.57
Surprise				-0.011	0.021	0.61
R^2	0.8604			0.8605		
F for change in R^2	271.1			225.2		

Note: Condition was represented as two dummy variables with Condition 1 serving as the reference group.

Model 1 evidenced an $R^2 = 0.8604$ ($F(5, 220)=271.1$, $p<0.01$), explaining roughly 86% of the variance. In this model, it was found that pre-Hope significantly predicted post-hope ($\beta= 29.93$, $p<0.01$), as did pre-GW-acceptance ($\beta=2.71$, $p<0.01$). Model 2 with the additional surprise term evidenced an almost identical $R^2 = 0.8605$ ($F(6, 129)=225.2$, $p<0.01$), also roughly explaining 86% of the variance. In this model, it was again found that pre-Hope significantly predicted post-Hope ($\beta= 29.50$, $p<0.01$), as did pre-GW acceptance ($\beta=2.67$, $p<0.01$; see Table 3-6). Model comparison using an ANOVA indicated that the additional term of surprise did not significantly improve the predictive utility of Model 1 ($F(1,220)=0.2649$, $p=0.6073$).

Discussion

Pooling data from all conditions, exposure to the intervention–that is, reading an overview of a societal solution to climate change and estimating and receiving feedback on estimates of five quantities relating to it–caused a statistically significant increase in participants' hope about humans' ability to solve climate change ($t(225)=-7.0589$, $p<0.01$) as well as statistically significant increases in global warming acceptance ($t(225)=-2.2219$, $p<0.05$) and nationalism ($t(225)=-2.5749$, $p<0.01$), due perhaps to the US-centric agency-affirming nature of the statistics (see Tables 3-1 and 3-2). These results confirm that hope about climate change and (once again) global warming acceptance can be changed using relevant information—and that statistics conveying the quantitative impact of solutions is an effective method to do so. Although exposure to each of the conditions caused statistically significant increases in hope ($t(66)=-4.5579$, $p<0.01$, for the electrification condition, $t(81)=-4.08$, $p<0.01$, for the energy efficiency condition and $t(76)=-3.6352$, $p<0.01$ for the meat reduction condition), only the (most surprising) meat reduction intervention yielded a marginally statistically significant increase in global warming acceptance ($t(76)=-1.9645$, $p<0.05$; see Table 3-4). An ANOVA confirmed that changes in hope, global warming and nationalism across the conditions were not statistically significant (i.e., all conditions were comparable in their effect on all of these variables), indicating that one solution was not demonstrably more effective than others.

A review of estimates showed that participants gave, on average, the most inaccurate answers for the meat reduction statistics and, accordingly, had the highest average surprise at the discrepancies between their estimates and the true values (see Tables 3-5a to 3-5c). An ANOVA found that participants' average surprise in the meat reduction condition was significantly higher than surprise in the energy efficiency condition. This may be due to the fact that reduction in meat consumption is a comparatively less publicized strategized compared to energy efficiency. The most surprising two statistics from this condition (and from all 5 statistics of the meat reduction conditions' statistics) illustrated (a) the large impact of a comparatively small reduction in meat and (b) the comparatively large number of people across the US who have either stopped or reduced their meat consumption in the past three years. Participants' level of surprise at these two statistics indicates an underappreciation of the effectiveness of relatively small lifestyle changes in terms of greenhouse gas emissions and an underestimation of Americans' pro-environmental actions and attitudes.

In terms of correlations between major variables, statistically significant positive correlations were observed between hope and global warming acceptance ($r(225)=0.493$, $p<0.01$ for pre-test hope vs. pre-test global warming acceptance), and also significant negative correlations between conservatism and, respectively, hope and global warming acceptance ($r(225)=-0.23$, $p<0.01$ for hope vs. conservatism—and $r(225)=-0.66$, $p<0.01$ for global warming vs. conservatism; see Table 3-3). Regression models relatedly indicated that roughly 86% of the variance in post-test hope could be explained by the major constructs of pre-test hope, pre-test global warming acceptance, condition, and conservatism: the addition of participants' surprise at their feedback did not significantly improve the predictive utility of this model (see Table 3-6). These results strengthen the case for a notable relationship between the variables of hope about climate change and climate change acceptance—and indicate that while an intervention of this sort will likely not immediately and fully "convert" deniers of climate change, that it will increase hope (especially for those with an underlying acceptance and concern about the future of the planet).

Conclusion

An intervention was developed to increase hope about climate change by asking participants to estimate relevant quantities relating to the impact and/or uptake of societal-level solutions. As well as indicating that hope about climate change and (again) climate change acceptance can be changed with relevant factual information, results show that communicating about societal-level pathways for solving climate change is an effective way to increase hope, in contrast to the field's usual focus on relatively low-impact behaviors individuals might take in the face of this global problem. Pragmatically, the results also point to the importance of leaders, communicators, and activists utilizing numbers when communicating about societal topics when trying to enhance emotion-relevant responses. The results also point to an extension of the scope of NDI. While NDI research has focused mostly in the more cognitive realm (e.g., conceptual change, mental models, decision making), results here suggest further extend NDI to the realm of "hot cognition" (Thagard, 2006)–the intersection of cognition and emotion.

Chapter 4

Experiment 3: An Intervention Targeting Agency

Stories, defined by Dahlstrom (2014) as narratives that describe a problem, present its consequences, and illustrate potential solutions, have the potential to elicit emotional responses. To this end, some stories have been used as aids to promote hopeful thoughts and behaviors in the context of positive psychology interventions (Snyder et al., 2003; McDermott & Snyder, 1999) and cognitive behavioral therapy (Otto, 2000). In the "Making Hope Happen" program (Lopez et al., 2000), for example, underdog narratives were used to model future-oriented pathways thinking (see also Diedrich et al., 2011) and examples of overcoming adversity–providing a model on which children could begin to build a sense of their own agency (Prestin, 2013). Selbin (2013) proposed that narratives work by invoking mimesis in their audience–a form of imitation prompting people to adopt characters' pro-social actions in their own lives. It has additionally been suggested that stories involving individual heroes and underdogs in particular, in which people overcome challenges with persistence and effort, work by producing a sense of moral elevation in their reader–an emotion associated with mixed affect (i.e., happiness and sadness) and a belief in the goodness of humanity (Aquino et al., 2011; Haidt, 2003; Schnall et al., 2010).

Currently, narratives about global warming that the public will be familiar with are problem- rather than solution-focused. This is in line with current news cycle norms (Freaut & Segnit, 2006; Howard-Williams, 2009; O'Neil et al., 2015), which emphasizes conflict and sensation (Horsbol, 2013)—and offers catastrophic framing (Bettini, 2013) and apocalyptic visions of the future (McNally, 2018) to motivate viewers to action. Such an overwhelming focus on the negative, however, can cause compassion fatigue (Kinnick, Krugman, & Cameron, 1996), learned helplessness (Maier & Seligman, 1976; a paralyzing condition that causes a lack of motivation to act due to feelings that any effort is not correlated with a successful outcome) and affective disengagement with the topic (Smith & Leiserowitz, 2014; Spence & Pigeon, 2010; Whitmarsh, 2009). The increasing appetite for hopeful stories in the public is reflected in the emerging field of constructive journalism (McIntyre & Gyldensted, 2017) and exemplified in the increasingly popular New York Times blog series "Fixes," which feature solution-oriented stories. Another constructive take on climate change is the "Covering Climate Now" initiative, in which 400 newsrooms across the world (including "The Guardian") have pledged to drive hope and report on solutions to the climate crisis. However, even in rare instances when media report climate change *solutions*, they tend to frame these as top-down governmental directives, implying that any power to change the situation lies in the hands of politicians and technology—and inhibiting the potential for agency (and hence, hope—and possibly, relatedly, global warming acceptance) among citizens (McNally, 2018).

Studying the effectiveness of narrative as a communicational tool, Narrative Policy Framework (NPF) uses narratives as tools to maximize attention to, or the uptake of, scientific evidence in policymaking (Jones & Mcbeth, 2010; Shanahan et al., 2018). Recent research has begun to use NPF to examine the utility of climate narratives in communicating the science of climate change and to shape public opinion on the issue (Flottum 2017; Flottum and Gjerstad 2017; Flottum and Gjerstad 2017; Jones & Peterson, 2017; Krovel 2011; Smith et al. 2014; Wozniak et al. 2014), with "hero stories" being shown to be particularly successful at

communicating green policy initiatives (Janda & Topouzi, 2015) and shaping perceptions of climate risk and policy preferences (Jones, 2014). Such climate narratives, and narratives in general that have been created within the NPF framework, are designed to persuade–to convince a person and/or change their mind (Peterson & Jones, 2016). In general, the effectiveness of different forms and contents of US-centric narratives to mobilize readers–enhancing motivation to act, the emotion of hope, and possibly nationalism in the context of global warming—have been underexplored. This study seeks to explore the following hypotheses:

> H3-1: Short climate change narratives set in the US can increase a) hope about our ability to solve climate change, b) global warming acceptance, and/or c) nationalism.
>
> H3-2: Changes in hope caused by the narratives are driven by changes in moral elevation or pro-social behavioral intention.
>
> H3-3: Hero and/or underdog narratives (e.g., narratives centered on an individual and/or emphasizing struggles that the protagonist has overcome) are especially effective at increasing hope about our ability to solve climate change.

Methods

Materials

A short narrative was crafted to illustrate a successful example of an impactful societal-level solution to climate change. The decision was taken to set the story in the U.S. (given that it would be read by an American audience), emphasize American values (i.e., resilience and commercial success), focus on the actions of a single protagonist, and have a clear plot–establishing a problem and illustrating how the actions of the protagonist reduced the problem.

A true story relating to the wind industry in Texas was found (Galbraith & Price, 2011) and summarized, with an emphasize on the features noted above. Wind energy was chosen as a focal solution to base a narrative around due to its high profile and capacity (as wind is America's largest renewable source of electricity generation) and due to the diversity of other industries and populations that are affected by it. In its initial drafts, the narrative focused on the actions of Jay Carter Sr., the founder of Carter Wind Energy, as he developed turbines in response to an energy crisis. After iterative rounds of feedback with a panel of readers, this central narrative was refined down to 272 words and represents Condition 3 of this four-condition experiment.

Given uncertainty expressed by readers about the potential of individuals to successfully achieve societal-level change, a second version (Condition 1; 261 words) of the narrative was developed, substituting Jay Carter Sr.'s name out with that of the company, Carter Wind Energy. To additionally test whether underdog narratives that emphasized the protagonists struggle may be more effective at increasing hope, two more conditions (4 and 3, respectively) were added that included an additional sentence that explained in detail some of the difficulties Jay Carter Sr. (or the company) encountered when developing wind turbines (blades falling off, etc.). Four narratives were thus developed in total, utilizing a 2x2 factorial design (individual-or-company x

struggle-or-no-struggle), and varying in length from 261-322 words (for the narratives in full, see Table 4-1).

Table 4-1

*The Four Narratives with Their Associated Word Count**

Condition	Text	Number of words
1 – Company no Struggle	According to the U.S. Department of Energy, wind energy is fast becoming the alternative energy source of choice in the US. This is particularly the case in Texas, which generates the most wind power of any U.S. State. In 1973, when an oil crisis sent electricity prices soaring, **Carter Wind Energy** had the notion that wind might be an "oil well that never runs dry". **The company** anticipated it would take up to a year to develop turbines that would be smaller, lighter and more efficient than their competitors - in fact it took them three years of tinkering before they settled on a design that worked. Production at their 25,000 square-foot warehouse peaked in 1983 – however the business struggled and in 1988, production was put on hold. In the early 90s however, motivated by a desire to prevent Texas, the energy state, becoming a net importer of energy, Governor Ann Richard's administration started to push for renewable energy production. This, federal wind incentives and entrepreneurial spirit prompted **Carter Wind Energy** to reorganize and to start up the development of new efficient turbines again. Texas now leads the nation in wind energy production, with up to 26% of its electricity being generated by wind. Carter Wind Energy has installed around 800 turbines around the world and is now on the verge of licensing its technology for a 160-turbine field spread over eight thousand acres. "We just believed in the idea of wind," says the **CEO of Carter Wind Energy**. The **sustainable** business, he adds, owes its success to resilience and perseverance.	261
2 – Company Struggle	According to the U.S. Department of Energy, wind energy is fast becoming the alternative energy source of choice in the US. This is particularly the case in Texas, which generates the most wind power of any U.S. State. Like the early oil pioneers, the story of those behind the wind power revolution is one of tenacity and resilience. In 1973, when an oil crisis sent electricity prices soaring, **Carter Wind Energy** had the notion that wind might be an "oil well that never runs dry". **The company** anticipated it would take up to a year to develop turbines that would be smaller, lighter and more efficient than their competitors - in fact it took them three years of tinkering before they settled on a design that worked. Among their struggles were turbines toppling over and exploding into flames and wind blades falling off. Production at their	311 words

	25,000 square-foot warehouse peaked in 1983 – however due to competition with rock bottom fuel prices and few incentives for renewable energy, the business struggled and in 1988, production was put on hold. In the early 90s however, motivated by a desire to prevent Texas, the energy state, becoming a net importer of energy, Governor Ann Richard's administration started to push for renewable energy production. This, federal wind incentives and entrepreneurial spirit prompted **Carter Wind Energy** to reorganize and to start up the development of new efficient turbines again. Texas now leads the nation in wind energy production, with up to 26% of its electricity being generated by wind. Carter Wind Energy has installed around 800 turbines around the world and is now on the verge of licensing its technology for a 160-turbine field spread over eight thousand acres. "We just believed in the idea of wind," says the **CEO of Carter Wind Energy**. The **sustainable** business, he adds, owes its success to resilience and perseverance.	
3 – Individual No Struggle	According to the U.S. Department of Energy, wind energy is fast becoming the alternative energy source of choice in the US. This is particularly the case in Texas, which generates the most wind power of any U.S. State. In 1973, when an oil crisis sent electricity prices soaring, **Jay Carter Sr.** had the notion that wind might be an "oil well that never runs dry". **He and his son, engineer Jay Carter Jr.** anticipated it would take up to a year to develop turbines that would be smaller, lighter and more efficient than their competitors - in fact it took them three years of tinkering before they settled on a design that worked. Production at their 25,000 square-foot warehouse peaked in 1983 – however, the business struggled and in 1988, production was put on hold. In the early 90s however, motivated by a desire to prevent Texas, the energy state, becoming a net importer of energy, Governor Ann Richard's administration started to push for renewable energy production. This, federal wind incentives and entrepreneurial spirit prompted **father and son** to reorganize and to start up the development of new efficient turbines again. Texas now leads the nation in wind energy production, with up to 26% of its electricity being generated by wind. Carter Wind Energy, **now led by Jay Carter Jr.'s son, Matt**, has installed around 800 turbines around the world and is now on the verge of licensing its technology for a 160-turbine field spread over eight thousand acres. "We just believed in the idea of wind," says **Matt Carter**. The **3-generation family** business, he adds, owes its success to resilience and perseverance.	272 words

4 – Individual Struggle	According to the U.S. Department of Energy, wind energy is fast becoming the alternative energy source of choice in the US. This is particularly the case in Texas, which generates the most wind power of any U.S. State. Like the early oil pioneers, the story of those behind the wind power revolution is one of tenacity and resilience. In 1973, when an oil crisis sent electricity prices soaring, **Jay Carter Sr.** had the notion that wind might be an "oil well that never runs dry". **He and his son, engineer Jay Carter Jr.** anticipated it would take up to a year to develop turbines that would be smaller, lighter and more efficient than their competitors - in fact it took them three years of tinkering before they settled on a design that worked. <u>Among their struggles were turbines toppling over and exploding into flames and wind blades falling off</u>. Production at their 25,000 square-foot warehouse peaked in 1983–however due to competition with rock bottom fuel prices and few incentives for renewable energy, the business struggled and in 1988, production was put on hold. In the early 90s however, motivated by a desire to prevent Texas, the energy state, becoming a net importer of energy, Governor Ann Richard's administration started to push for renewable energy production. This, federal wind incentives and entrepreneurial spirit prompted **father and son** to reorganize and to start up the development of new efficient turbines again. Texas now leads the nation in wind energy production, with up to 26% of its electricity being generated by wind. Carter Wind Energy, **now led by Jay Carter Jr.'s son, Matt**, has installed around 800 turbines around the world and is now on the verge of licensing its technology for a 160-turbine field spread over eight thousand acres. "We just believed in the idea of wind," says **Matt Carter**. The **3-generation family** business, he adds, owes its success to resilience and perseverance.	322 words

*Company vs. individual variation in wording is highlighted in bold and the sentence depicting the struggles involved in developing the turbines is underlined in Conditions 2 and 4 (with bolding/underlining not seen by participants)

Participants

Amazon Mechanical Turk (MTurk) participants were recruited during late spring of 2021 and paid $5.00 upon survey completion—with 341 survey responses collected. After incomplete responses were deleted and other exclusion criteria (detailed below) applied, 257 responses were analyzed. Of the responses analyzed, 61% were men and 38% women. The average age of participants was 33 years old., with 60% of the sample identified as Democrats, 17% as Independents and 21% as Republican. The average social conservatism rating was 4.28 and 4.70 for economic conservatism indicating a slight liberal orientation among remaining participants.

Procedure, Design and Analytic Strategy

After providing informed content, participants completed a pre-test that assessed their hope about climate change, global warming acceptance, moral elevation, prosocial behavioral intention, and nationalism. An adapted version of Li & Monroe's (2018) 12-item Climate change hope scale was used to measure hope (with Chronbach's alpha ranging from 0.8-0.84 across the pre- and post-test), eight items measured global warming acceptance (with Chronbach's alpha ranging from 0.9-0.91 across the pre- and post-test), and four items measured participants' nationalism (with Chronbach's alpha ranging from 0.66-0.69 across the pre- and post-test). Constructs not measured in the prior experiments included adapted version of Schnall et al's (2010) 7-item scale to measure moral elevation (with Chronbach's alpha ranging from 0.88-0.89 across the pre- and post-test) and an adapted version of Baumsteiger & Siegel's (2019) four-item scale to measure pro-social behavioral intention (with Chronbach's alpha ranging from 0.84-0.86 across the pre- and post-test). For a full set of pre- and post-test items used in this experiment, see Appendix A. Participants were then randomly assigned to one of four conditions in which they were asked to read a short (252-322 word, depending on condition) narrative about the founding of a Texas wind energy company. Depending on the condition participants were assigned to, the protagonist of the narrative was either (a) the individual who founded the company (Jay Carter Sr.) or, more generically, the company itself, and either (b) contained explicit examples of the struggles that were overcome to establish the business or not. The combination of these two dimensions yielded a 2x2 (individual-or-company x struggle-details-or-no-struggle-details) factorial design. After reading the narrative, participants were asked to answer two comprehension questions and three longer, more reflective questions about: why the company was founded (i.e., pertaining to the central character's goals), obstacles the company (or founder, depending on condition) overcame in order to reach their goals, and how such obstacles were overcome (for a full list of the questions asked, see Appendix C). After answering these long-form textual questions, participants were asked to complete a post-test that was identical in form to the pre-test, then were asked to provide some demographic information, and finally were dismissed and thanked for their participation.

Exclusion Criteria

Participants were given an exclusion score based on the answers to four catch items in the pre- and post-test (see Appendix A), the accuracy of their responses to the interventions' comprehension questions, the quality of their written reflective responses (i.e., whether their written response was relevant to the narrative), and the relative duration of the time they took to complete the survey (compared to the average time of 19 minutes). Participants were excluded if they exceeded 75% of the exclusion score. Participants were also excluded if their IP address indicated that they were outside of the US. Eighty-four participants in total were excluded. The final sample was thus 257 participants.

Results

Paired t-tests were used to assess pre-to-post changes in each of the major variables. Over all conditions, the process of reading the short narrative and answering a series of reflective questions about it caused statistically significant increases in moral elevation ($M = 3.14$ ($SD = 0.94$) to $M= 3.37$ ($SD = 0.95$; $t(225)=-7.0589$: $p<0.01$, $d=0.24$)), prosocial behavioral intension,

(M = 5.63 (SD = 1.06) to M= 5.73 (SD =1.08; t(225)=-7.0589: p<0.01, d=0.09)), hope about climate change (M = 6.31 (SD = 1.08) to M= 6.54 (SD = 1.17; t(225)=-7.0589: p<0.01, d=0.15)), and nationalism (M = 5.52 (SD = 1.56) to M= 5.62 (SD = 1.59; t(225)=-7.0589: p<0.01, d=0.06)). See Table 4-2.

Table 4-2

Pre-to-post Changes in Study Variables (n=257)

Study Variables	Pre-test		Post-test		Average pre-test to post-test change	*t*-value	df	*p*
	M	*SD*	*M*	*SD*				
Moral elevation / 5	3.14	0.94	3.37	0.95	+0.23	-6.1296	256	3.312e-09**
Prosocial behavioral intention / 7	5.63	1.06	5.73	1.08	+0.10	-2.9253	256	0.00375**
CC Hope / 9	5.98	1.08	6.15	1.17	+0.17	-5.1269	256	5.815e-07**
GW acceptance / 9	6.63	1.73	6.65	1.79	+0.02	-0.45133	256	0.6521
Nationalism / 9	5.52	1.56	5.62	1.59	+0.10	-2.3688	256	0.01859**

†p<0.1, *p<0.05, and **p<0.01

Means, standard deviations, and correlations of the major variables (moral elevation, prosocial behavioral intention, hope, global warming acceptance, and nationalism—along with conservatism, a demographic variable that has been found to strongly correlate with global warming acceptance in past studies) across all conditions are presented below. See Table 4-3.

Table 4-3

Table Illustrating the Correlational Relationships Between Major Variables (n=257)

Variable	M	SD	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Me T1 / 5	3.14	0.94	0.064	0.096	-0.42**	0.337**	0.81**	0.012	0.027	-0.42**	0.33**	0.42**
2. Pro-s T1 / 7	5.63	1.06		0.30**	0.27**	0.18**	0.13	0.88**	0.33**	0.27**	0.15**	-0.0077
3. Hope T1 / 9	5.98	1.08			0.49**	0.025	0.22**	0.34**	0.89**	0.50**	0.014	-0.17**
4. GW T1 / 9	6.63	1.73				-0.36**	-0.25**	0.31**	0.54**	0.95**	-0.33**	-0.57**
5. Nat T1 / 9	5.52	1.56					0.36**	0.14	0.026	-0.35**	0.90**	0.48**
6. Me T2 / 5	3.37	0.95						0.14**	0.20**	-0.24**	0.36**	0.29**
7. Pro-s T2 / 7	5.73	1.08							0.39**	0.34**	0.13	-0.072
8. Hope T2 / 9	6.15	1.17								0.57**	0.046	-0.21**
9. GW T2 / 9	6.65	1.79									-0.32**	-0.57**
10. Nat T2 / 9	5.62	1.59										0.46**
11. Conserv / 9	4.49	2.62										

†p<0.1, *p<0.05, and **p<0.01

Out of 55 correlations between the major variables, 42 were statistically significant (see Table 4-3). The only correlations that were not statistically significant were those between (a) prosocial intention (at both times) and conservatism, (b) prosocial intention and moral elevation and (c) prosocial intention and nationalism (at time T1), and those between hope and nationalism at all times. In general, the results replicate a high positive correlation between global warming acceptance and climate-change hope, indicating that participants who were the most hopeful about global warming tended to have a higher acceptance of it (r's =.49 and .57). It should also be noted that at least two correlations "flipped significance" from pre- to post-test, including that between pro-social intention and moral evaluation (pre-test r=0.064, post-test r=0.14*) and hope and moral elevation (pre-test r=0.096, post-test r=0.20*); but such changes in correlation were small in magnitude. These data also demonstrate temporally stable negative correlations between global warming acceptance and nationalism, an inverse relationship that has been demonstrated in both the correlational and causal realm (Ranney et al., 2019; Ranney, 2012).

Changes in Variable per Condition

Pre-to-post changes in the major variables within each condition were assessed using paired t-tests. See Tables 4-4a to 4-4d.

Table 4-4a

Pre-to-post Changes in Study Variables in Condition 1 (Company + No Struggle; n= 59)

Variable	Pre-test average		Post-test average		Average pre-test to post-test change	*t*-value	df	*p*
	M	*SD*	*M*	*SD*				
Moral elevation / 5	3.14	0.92	3.40	0.97	+0.26	-4.0851	58	0.0001369**
Prosocial behavioral intention / 7	5.56	0.95	5.69	0.94	+0.13	-1.7875	58	0.07908
CC Hope / 9	5.92	1.01	6.04	1.07	+0.12	-1.9107	58	0.06099
GW acceptance / 9	6.63	1.86	6.45	1.95	-0.18	2.2637	58	0.02735**
Nationalism / 9	5.62	1.44	5.83	1.43	+0.21	-1.9321	58	0.05823

†p<0.1, *p<0.05, and **p<0.01

Table 4-4b

Pre-to-post Changes in Study Variables in Condition 2 (Company + Struggle; n=64)

Variable	Pre-test average		Post-test average		Average pre-test to post-test change	*t*-value	df	*p*
	M	*SD*	*M*	*SD*				
Moral elevation / 5	3.22	1.05	3.29	1.03	+0.07	-1.1204	63	0.2668
Prosocial behavioral intention / 7	5.62	1.25	5.63	1.27	+0.01	-0.069638	63	0.9447
CC Hope / 9	6.07	1.08	6.10	1.17	+0.03	-0.6754	63	0.5019
GW acceptance / 9	6.64	1.61	6.72	1.62	+0.08	-1.2912	63	0.2014
Nationalism / 9	5.40	1.77	5.47	1.72	+0.07	-0.81266	63	0.4195

Table 4-4c

Pre-to-post Changes in Study Variables in Condition 3 (Individual + No Struggle; n=60)

Variable	Pre-test average		Post-test average		Average pre-test to post-test change	*t*-value	df	*p*
	M	*SD*	*M*	*SD*				
Moral elevation / 5	3.33	0.92	3.54	0.96	+0.21	-3.3598	59	0.001372**
Prosocial behavioral intention / 7	5.86	0.93	5.93	1.00	+0.07	-1.3666	59	0.1769
CC Hope / 9	5.99	1.19	6.21	1.18	+0.22	-3.0793	59	0.003147**
GW acceptance / 9	6.51	1.84	6.62	1.87	+0.11	-1.9012	59	0.06216
Nationalism / 9	5.73	1.45	5.75	1.63	+0.02	-0.3183	59	0.7514

†p<0.1, *p<0.05, and **p<0.01

Table 4-4d

Pre-to-post Changes in Study Variables in Condition 4 (Individual + Struggle; n=74)

Variable	Pre-test average		Post-test average		Average pre-test to post-test change	*t*-value	df	*p*
	M	*SD*	*M*	*SD*				
Moral elevation / 5	2.93	0.84	3.27	0.85	+0.34	-3.8651	73	0.0002385**
Prosocial behavioral intention / 7	5.52	1.06	5.69	1.07	+0.17	-2.284	73	0.025528**
CC Hope / 9	5.96	1.08	6.24	1.23	+0.28	-4.0242	73	0.0001381**
GW acceptance / 9	6.73	1.65	6.76	1.76	+0.03	-0.43942	73	0.6617
Nationalism / 9	5.36	1.57	5.47	1.56	+0.11	-1.4269	73	0.1579

†p<0.1, *p<0.05, and **p<0.01

Participants in three out of the four conditions experienced statistically significant increases in moral elevation after reading the narrative and answering the reflective questions: M=2.93 (SD=0.84) to M=3.27 (SD=0.85) for the individual+struggle condition (t(73)=-3.8651, p<0.01, d=0.40), M=3.33 (SD=0.92) to M=3.54 (SD=0.96) for the individual+no struggle condition (t(59)=-3.36, p<0.01, d=0.22); M=3.14 (SD=0.92) to M=3.40 (SD=0.97) for the company+no struggle condition (t(58)=-4.08, p<0.01, d=0.23). See Tables 4-4a, 4-4c and 4-4d. Although pro-social behavior either stayed constant or increased in all conditions, this increase was only statistically significant in the individual+struggle condition: M=5.52 (SD= 1.06) to M=5.69 (SD=1.07; t(73)=-2.284: p<0.05, d=0.16; see Table 4-4d). Hope increased to a statistically significant extent for the conditions that were framed around the individual–M=5.96, (SD=1.08) to M=6.24 (SD=1.23) for the individual+struggle condition (t(73)=-4.02, p<0.01, d=0.24) and M=5.99 (SD =1.19) to M=6.21 (SD=1.00) for the individual+no struggle condition, (t(59)=-3.0793, p<0.01, d=0.19); the increases in hope were not significant for conditions that centered the more impersonal company (see Tables 4-4a-4-4d). Indeed, participants in the company+no-struggle condition experienced an unexpected statistically significant decrease in global warming acceptance on reading and reflecting on their narrative (M=6.63 (SD=1.86) to M=6.45 (SD=1.95); t(58)=2.26, p<0.05, d=0.094; see Table 4-4a).

A series of one-way ANOVAs were used to compare the effect of condition on changes in dependent variables. It was found that there was no statistically significant difference in changes in moral elevation (F(3,253)=2.492, p=0.0607), pro-social intention, F(3,253)=1.251, p=0.292, or nationalism, F(3,253)=0.797, p=0.496, across the four conditions. There was, however, shown to be a statistically significant difference in both change in global warming

acceptance (F(2,253)=3.508, p<0.02) and change in hope (F(2,253)=2.881, p>0.05) between at least two conditions.

Tukey's HSD test for multiple comparisons found that the mean change in global warming acceptance was significantly different between (a) group 2's gain (company+struggle) and group 1's loss (company+no struggle; p= 0.042, 95% C.I. = [0.0063, 0.51]) and (b) group 3's gain (individual+no struggle) and group 1's loss (company+no struggle; p=0.018, 95% C.I. = [0.036, 0.54]). Tukey's HSD test also found that the mean change in hope was significantly different between group 4's gain (individual+struggle) and group 2's inertness (company+ struggle; p=0.034, 95% C.I. = [0.013, 0.47]).

Unpaired t-tests were used to compare changes in major variables according to whether the participant was assigned to a narrative with individual- or company-framing (Table 4-5a) or according to whether the narrative included details of the struggle faced by the protagonist(s) or no-struggle (Table 4-5b).

Table 4-5a

Pre-to-post Changes in Study Variables for Individual (Conditions 3&4, n=134) vs. Company (Conditions 1&2, n=123) Narratives

Construct	Individual conditions (N=134) pre-to-post change		Company conditions (N=123) pre-to-post change		*t*-value	df	*p*
	M	*SD*	*M*	*SD*			
Moral elevation / 5	0.281	0.647	0.163	0.509	1.6285	249.36	0.1047
Prosocial behavioral intention / 7	0.129	0.560	0.061	0.490	1.0341	254.43	0.3021
CC Hope / 9	0.253	0.578	0.076	0.448	2.7633	248.21	0.00615**
GW acceptance / 9	0.067	0.524	-0.041	0.563	1.6019	248.84	0.1104
Nationalism / 9	0.071	0.632	0.140	0.777	-0.78094	235.46	0.4356

†p<0.1, *p<0.05, and **p<0.01

Table 4-5b

Pre-to-post Changes in Study Variables for Struggle (Conditions 2&4, n=138) vs. No-struggle (Conditions 1&3, n=119) Narratives

Construct	Struggle conditions (N= 138) pre-to-post change		No struggle conditions (N= 119) pre-to-post change		*t*-value	df	*p*
	M	*SD*	*M*	*SD*			
Moral elevation / 5	0.214	0.662	0.236	0.488	-0.31203	249.28	0.7553
Prosocial behavioral intention / 7	0.094	0.569	0.099	0.477	-0.069471	254.81	0.9447
CC Hope / 9	0.165	0.530	0.172	0.525	-0.10562	250.23	0.916
GW acceptance / 9	0.053	0.537	-0.029	0.552	1.2046	247.36	0.2295
Nationalism / 9	0.091	0.669	0.120	0.746	-0.32775	239.17	0.7434

†p<0.1, *p<0.05, and **p<0.01

It was found that hope increased significantly more if participants were assigned to an individual framing compared to a more impersonal company framing of the narrative (t(248.21) =2.7633: p<0.01, d=0.34; see Table 4-5a). No other changes in variables for the individual versus company narratives were significantly different. There were no significant differences in pre-to-post variable changes between the struggle and no-struggle conditions (see Table 4-5b).

Linear modelling was used to assess the contribution of each of the pre-test variables measured (pre-test hope, pre-test global warming acceptance, pre-test moral elevation, pre-test pro-social tendencies, condition and conservatism) to post-test hope. The predictive utility of three models were assessed: Model 1, with pre-test hope, pre-test global warming and condition as predictors for post-test hope, Model 2, which added the additional predictors of pre-test moral elevation and pre-test pro-social tendencies to the three predictors of Model 1, and Model 3 which added the additional predictor of conservatism to Model 2.

Table 4-6

Assessing Linear Models of Post-Test Hope (n=257)

Variable	Model 1			Model 2			Model 3		
	Coef	SE Coef	T	Coef	SE Coef	t	Coef	SE Coef	t
Intercept	0.17	0.19	0.90	-0.014	0.25	-0.055	-0.023	0.27	-0.085
Pre. H	0.89	0.033	24.67**	0.88	0.037	24.08**	0.88	0.037	23.98**
Pre. GW	0.090	0.021	4.266**	0.087	0.025	3.44**	0.089	0.029	3.09**

Table 4-6 continued

Condition									
Condition 2 (company struggle)	-0.071	0.091	0.4351	-0.073	0.091	-0.80	-0.072	0.091	-0.79
Condition 3 (individual no struggle)	0.12	0.092	0.1921	0.11	0.093	1.15	0.11	0.093	1.15
Condition 4 (individual struggle)	0.15	0.088	0.0833	0.16	0.088	1.78	0.16	0.088	1.78
Pre-Moral elevation				0.0073	0.041	0.18	0.0066	0.042	0.16
Pre-Pro-social behavior				0.044	0.032	1.39	0.044	0.032	1.36
Conservatism							0.0014	0.016	0.091
R^2	0.82			0.82			0.82		
F for change in R^2	224.4			160.6			140		

†p<0.1, *p<0.05, and **p<0.01

Note: Condition is here represented as three dummy variables with condition 1 (the company no struggle condition) serving as the reference group.

Model 1 had an $R^2 = 0.82$ ($F(5,251)=224.4$, $p<0.01$), explaining roughly 82% of the variance of post-test hope scores. Model 2, which included the additional predictors of pre-test moral elevation and pre-test pro-social tendency had an $R^2 =0.82$ ($F(7,249)=160.6$, $p<0.01$). Model 3, which added the predictor of conservatism to those of Model 2 had an $R^2=0.82$ ($F(8, 248)=140$, $p<0.01$; see Table 4-6). In all three models, only the pre-test hope and pre-test global warming acceptance terms carried significant weight (with $\beta= 29.67$, $p<0.01$; $\beta= 24.08$, $p<0.01$ and $\beta= 23.98$, $p<0.01$ for *pre-test* hope in Models 1, 2, and 3 respectively, and $\beta= 4.266$, $p<0.01$; $\beta= 3.44$, $p<0.01$; and $\beta= 3.09$, $p<0.01$ for *pre-test* global warming acceptance). Comparisons of the nested models using ANOVAs indicated that neither the additional terms of pre-test moral-elevation+pro-social-tendencies (for Model 2) nor pre-test moral-elevation, pro-social-tendencies, and conservatism (for Model 3) significantly improved the predictive utility of Model 1 ($F(2, 251)=1.0284$, $p=0.3591$ for Model 2 vs Model 1—and $F(3,251)=0.6856$, $p=0.5616$ for Model 3 vs. Model 1).

Discussion

Overall, across all conditions, the common intervention (that is, exposure to a narrative and reflecting on the challenges facing the protagonist(s), and how those challenges were overcome) successfully (but unequally) increased participants' moral elevation, prosocial behavioral intention, hope and nationalism (see Table 4-2). Looking at the individual conditions, although participants in three out of the four conditions showed pre-to-post increases in their moral elevation, only participants assigned to conditions with a narrative focused on the experience of an individual (as opposed to a company) experienced significant increases in hope (although the company+no-struggle condition's effect was close to statistical significance; see

Tables 4-4a to 4-4d). This pattern was supported by unpaired t-tests comparing change in hope for participants in "individual" conditions 3+4 (individual+no-struggle and individual+ struggle) with the change in hope for participants in "company" Condition 1+2 (company+struggle and company+no struggle), which showed that the change in hope was significantly higher for participants assigned to the individual Conditions 3+4 (see Table 4-5a). There were, however, no significant changes in either hope or any other of the major variables when comparing the struggle conditions (i.e., Conditions 2+4) with the no-struggle conditions (i.e., Conditions 1+3; see Table 4-5b). The only condition that yielded a *decrease* in global warming acceptance was the company no struggle condition (p=0.027), and it was observed that participants' change in global warming acceptance in this condition was significantly different from the non-significant *increases* of that of the company+struggle condition and individual+no-struggle condition (and even the remaining conditions also yielded a non-significant *increase*).

The fact that the increase in hope was significantly higher for the narratives centered around an individual (especially compared to a company that struggled) indicates that participants find it easier to build a sense of their own agency through the experiences of a specific person, rather than a corporate entity (unless the company did not struggle). This may be because a specific person may face more challenges (or be "up against" more) compared to a company, and thus have more to overcome—or due to the fact that narratives centered around individuals may heighten identification and empathy in a reader. Oddly, participants were unmoved by a company struggling, compared to either an individual struggling or a company not struggling (Table 4-4b vs. Tables 4-4a vs. 4-4d). Broadly, these results indicate a strong social component underlying hope about climate change. While the lack of differences in aggregated change in hope between the struggle and no struggle conditions is surprising (although this may interact with the individual/company dimension), this may be due to the fact that the reflection questions prompted participants to identify challenges that the protagonist(s) overcome whether the struggles were detailed in the narrative or not–hence, all participants had to identify with the protagonists' struggle (detailed or imagined) to a certain extent. The explanation for the possibly-spurious decrease in global warming acceptance for participants in the company+no-struggle condition, however, is harder to explain, and indeed, a seemingly anomalous result among these dissertation studies (as well as with respect to the other three conditions). It should be noted that the company+no-struggle condition also saw the biggest increase in nationalism amongst all of the conditions (albeit marginal: p=.058; whereas the overall dimension yielded a p=.019 gain), which is shown in many prior studies—as well as in Table 4-3—to be negatively correlated with global warming acceptance. To further explore why this condition caused global warming acceptance to (possibly spuriously) decrease, however, qualitative probing (i.e., recording a focus-group conversation about the narrative or asking participants to relate back what they remember from the narrative, to get a better sense of what parts they paid the most attention to) in a future study may be recommended.

Although statistically significant positive correlations between hope and global warming (r's of 0.49 and 0.57), between hope and moral elevation (at post-test only, r=0.20) and between hope and pro-social-behavioral intention (r=0.3-0.39) were shown (see Table 4-3), pre- and/or post-test hope was found not to correlate with pre- and/or post-test nationalism (r's of 0.025 and

0.046) Linear modelling of post-test hope indicated that post-test hope was best predicted by pre-test hope, pre-test global warming acceptance, and condition, capturing 82% of the variance, with pre-test hope and pre-test global warming acceptance holding significant weights in this model (see Table 6). These results point to a strong relationship between global warming acceptance and hope, specifically that those with higher global warming acceptance are likely to experience higher increases in hope after exposure to the intervention[2].

Conclusion

An intervention was developed to increase hope about climate change by asking participants to read and reflect on a narrative illustrating the experience of either an individual or a company as he/they overcame challenges to tackle climate change. As well as indicating that climate-related narratives can be successfully used to increase hope about our ability to solve climate change, results also show that despite the large-scale nature of the threat of climate change, personal stories following the actions of individuals—as opposed to companies—are more likely to create hope about climate change in readers. These results also extend the narrative policy framework, showing the potential of narratives to be used for climate-relevant emotional mobilization in addition to policy communication.

[2] Overall, these results suggest that such interventions designed to increase hope about climate change may be slightly more effective when targeted at people who already accept global warming, given the slightly higher pre-to-post increase in hope of +0.17 for participants with an initial global warming acceptance of above 5 compared to a +0.14 increase for participants with an initial global warming acceptance of below 5.

Chapter 5

Experiment 4, Part I: How Cognitive Heuristics and Biases Shape Attitudes Towards Climate Change Solutions

There are many misconceptions about climate change among experts and the general public alike. These include (a) the erroneous belief that stabilizing the current rate of emissions will immediately stop global warming's effects (Sterman & Booth-Sweeney, 2002), (b) confusions between ozone holes and the greenhouse effect, or (c) more simply confusions between weather and climate (Bostrom et al., 1994). There are also more fundamental levels of ignorance or inconsistent misunderstandings about climate change's causes and the underlying scientific mechanism among the American public (Ranney & Clark, 2016). Such misconceptions are harmful, given that the effectiveness with which society responds to climate change (e.g., distinguishing between effective and ineffective strategies to tackle the climate crisis) depends on how well it is understood by its citizens.

Ignorance about climate change is generally ascribed to the hypothesis that climate change is, cognitively, a hard phenomenon to grasp (Grotzer et al., 2012). While our brains are evolutionarily geared to be alert and respond to immediate dangers in our local environment (e.g., large and noisy animals), climate change is a mostly invisible, long-term and uncertain phenomenon, with non-linear, large spatial/temporal gaps between causes (greenhouse gas emissions) and effects (rising temperatures)—and with distributed and largely unintentional causality. These inherent characteristics of climate change, coupled with misperceptions and biases that hinder the recognition of incremental environmental degradation, prevent it from being recognized as an urgent and actionable problem (Johnson & Levin, 2009), increasing the likelihood that humanity will only be motivated to act after experiencing extreme and visceral weather disasters (i.e., at a point when it may be too late; Diamond, 2005). Moore et al. (2019) illustrates this problem metaphorically by drawing parallels between people's perceptions of climate change over time and a proverbial frog placed in water. If the frog is placed in boiling water, it will jump out immediately, but if it is placed in a pot of tepid water which is heated up incrementally, the frog will stay in the pot until it dies, as it will not become aware of the increase in temperature until too late. Gifford (2011) accordingly refers to the psychological barriers that impede or inhibit awareness of climate change and the adoption of pro-environmental behavioral choices as "dragons of inaction" and argues that these are more significant barriers to action than structural impediments (e.g., not having enough money to buy solar panels), given that they lead people to downplay the likelihood and danger of climate change and their role in it—while increasing perceived incentives to maintain the greenhouse gas emitting status quo.

Bounded Rationality

When confronted with complex situations, people tend to make simplifying assumptions (otherwise known as cognitive heuristics or "reductive biases" (Busenitz & Barney, 1997; Feltovich et al., 1993; Schwenk, 1986; Simon, 1957; Tversky & Kahneman, 1974), which are formally defined as cases in which human cognition produces "representations that are

systematically distorted compared to some aspect of objective reality" (Haselton et al., 2015). Such biases have been shown to influence the perception of risks and judgment and decision-making outcomes (Simon et al., 2000), resulting in a generalized tendency for people to preserve the status quo—and avoid change unless highly necessary. While broadly framed as a negative feature of reasoning in the literature, some cognitive scientists such as Gigerenzer (2008) argue that heuristics are adaptive, having evolved to equip us with faster and more efficient decision-making abilities that help us make sense of the complex information that we are constantly bombarded with. Others believe that the truth is somewhere in between—that heuristics are usually, but not always, adaptive.

Many various examples of cognitive biases have been identified. Five of the most prominent include:

Temporal discounting. This describes the tendency of people to place lower value on an equivalent outcome if it lies further in the future (Frederick et al., 2002; see also Mendelson & Shultz, 1976), even accounting for inflation. Temporal discounting manifest in people generally over-weighting short-term considerations (Loewenstein & Thaler, 1989), prioritizing the short-term consequences of behavior or more immediate rewards (Hoffman & Bazerman, 2007). More broadly, temporal discounting also encompasses being unable to reasonably assess (i.e., use an extremely high discounting rate for) risks that are in the future (Beattie, 2010), especially a future that is perceived as uncertain and distant (Wade-Benzoni, 1999). Since the majority of people have a limited ability to imagine a future beyond 10-20 years (Tonn et al., 2006), this results in a generalized tendency to discount longer-term (i.e., >15 years) risk, especially risk that falls outside of relatively shorter social time constructs of (e.g., four-year) election cycles. In terms of climate change, temporal discounting results in people—especially economists—assessing environmental or financial consequences as less important the more delayed they are into the future (Hardisty & Weber, 2009).

The availability heuristic. Proposed by Kahneman and Tversky (1973, 1985), the availability heuristic describes a tendency to make predictions based on information that's most accessible or easily retrievable from memory—rather than from more systematic assessments of risk (Combs & Slovic, 1979; Slovic et al., 2000). This manifests in a tendency for people to over-estimate the probability of dying in a plane crash and under-estimate the (in reality greater likelihood) of dying in a car crash, owing to the fact that the former tend to be more saliently reported in the media. In terms of climate change, the availability heuristic influences people's tendency to attribute recent, local, weather events to the likelihood of global warming occuring (Taylor et al., 2014).

The optimism bias: A phenomenon reported among animals such as rats, birds, and humans (Harding et al., 2004; Matheson et al., 2008), the optimism bias refers to the finding that when making inferences about the future, people tend to overestimate the likelihood of positively valenced events and underestimate the likelihood of negatively valenced events (Weinstein, 1980). For instance, people tend to overestimate their likelihood of living a long and fulfilling life, and underestimate their chances of getting divorced, being involved in a car accident or burgled. Sharot et al., (2011) found that even when people were presented with the average

probability of such events happening to someone like them, they were only slightly (albeit significantly) more likely to change their likelihood estimates, and this was only in cases where the average probabilities were more positively valenced than they had originally anticipated. Although the optimism bias has been framed as evolutionarily adaptive (McKay & Dennett, 2009), it is generally viewed as a negative in the context of climate change—inhibiting the perception of risk and lessening the urgency and motivation for mitigative action. For instance, eye tracking studies indicate that those with higher levels of dispositional optimism presented with arguments for and against the idea of climate change happening now spend significantly less time reading the "for" arguments, are more likely to frame the two opposing positions as a debate and feel less personally threatened by climate change, compared to those identified as non-optimists (Beattie et al., 2017).

Prospect theory. Otherwise referred to as loss aversion theory, prospect theory (Kahneman & Tversky, 1979) describes how individuals assess losses and gains in an asymmetrical manner. The theory manifests in a greater likelihood of risk aversion when faced with a risky choice that leads to losses, and a lesser likelihood of risk-seeking behavior when faced with a risky choice that leads to potential gains, given the higher emotional impact associated with losses as compared to the equivalent amount of gain. It also manifests in the certainty effect, in which the weighting of certain (as opposed to probabilistic) outcomes is disproportionately high. Applied to climate change, prospect theory can explain why some are reluctant to engage in climate-related action (Eisenack & Stecker, 2012; Osberghaus, 2017). For instance, if mitigation effects are perceived as uncertain (i.e., consisting of a certain high economic cost now and relatively uncertain gains, in terms of future CO_2 reduction), people will be less likely to advocate for mitigative action, and more likely to gamble on doing nothing to avoid *today's* potential losses. If the impact of climate change is deemed improbable, then prospect theory would indicate that response measures with lower associated risks would thus be preferred. Such a sense of loss-aversion arguably underpins the more socially-oriented system justification theory (Jost et al., 2003), in which individuals are motivated to view the world as predictable—and hence defend and justify the existence and perpetuation of existing social, hierarchical, economic, and political societal structures. Fear of the risk of societal upheaval or change may be a contributing factor to the negative bi-causal relationship between global warming acceptance and U.S. citizens' sense of general, military, and economically-bolstered U.S. nationalism, empirically demonstrated in Ranney et al.'s Reinforced Theistic Manifest Destiny (RTMD) theory (see Ranney et al., 2019).

Representative heuristic: The representative heuristic involves estimating the likelihood of an event by comparing it to a pre-existing prototype that takes the form of the most relevant, salient, memorable, or typical example of that particular event, object, or group (Kahneman & Tversky, 1973). It generally manifests in people associating things that are alike, invoking the principle that members of the same category roughly all adhere to a certain prototype while ignoring how common such categories are in the general population. For instance, Kahneman and Tversky (1973) gave participants a description of a person named Tom, who was orderly, detail-oriented and competent. When asked to determine Tom's college major, representativeness led people to believe he was an engineering major, despite the relatively small proportion of engineering students at the school where the study was conducted. Although the representative heuristic has

more commonly been invoked to explain prejudice, stereotyping, and discrimination when people make judgments about other people (Hinton, 2017), it has been shown to play a role in informing out-group biases and the general overestimation of levels of climate change rejection among the public (Leviston et al., 2013), contributing to (false) perceptions of widespread societal polarization on the topic.

Biases such as these above have long been identified as significant barriers to understanding climate change and being able to grasp its seriousness (Zhao & Luo, 2021). However, although such heuristics have been strongly associated with people's perceptions of the phenomenon of climate change, it is unclear if—or in what way—they shape people's thinking about acceptable *solutions* for the issue, or even the roles such biases play in people's negotiations of tradeoffs between (e.g., adaption and mitigation-focused) solutions (Moser, 2012). In this experiment, I thus sought to investigate the hypothesis that biases shape participants' choice and perception of climate change solutions.

Methods

Hotinski's (2007) Stabilization Wedge game was chosen as a suitable activity to facilitate participants' discussions of a variety of climate change solutions. Participants were presented with a table of fifteen solutions identified by The Intergovernmental Panel on Climate Change (the IPCC) as the most feasible ways to overcome climate change by 2060. Each solution was available at the time the activity was developed and had the potential to be scaled up over the next 50 years to reduce global carbon dioxide emissions by 1 billion tons per year. Solutions were grouped into four main categories–efficiency and conservation, nuclear energy, fossil-fuel-based strategies, and renewables and biostorage. Participants were presented each of these solution in a table, which also displayed (a) the specific sector that each solution was relevant to (e.g., electricity production, heating and direct fuel use, transportation and biostorage), (b) a brief description of each solution and how it might be scaled up, (c) an indication of the solution's cost relative to others, and (d) some of the challenges associated with each solution. Participants were asked to work together to choose a total of eight out of the 15 strategies. Although they were able to pick a solution more than once, they were constrained in only being able to have a maximum of six electricity-sector solutions, five transportation-sector solutions and five-heat or direct fuel sector solutions overall–a constraint designed to inhibit participants from picking the same solution too many (e.g., eight) times. After participant dyads had successfully chosen their set of eight solutions, as a second part of this study, they were shown a list of stakeholders (e.g., taxpayers, manufacturers, industrialized and developing country governments) and asked to work together again to predict how each stakeholder would rate their chosen set of solutions on a scale of 1-5.

Aside from providing participants with a list of feasible climate change solutions to choose from, ranging from the more familiar (solar electricity) to the less familiar (carbon capture and sequestration/storage [CCS] electricity), the activity had the advantage of placing participants in a position of agency with respect to the climate crisis. It also had the advantage of conveying the complexity of socio-scientific decision making–for instance, that there is rarely one easy or "right" solution to climate change that would please everyone–as well as providing

participants an opportunity to exercise their scientific argumentation skills by having to verbally communicate and defend their choice of solution to their partner. Although interactions between participants and the researcher were kept to a minimum during the activity, the researcher was on hand during the activity to elicit justifications of solutions if not provided, ask guiding questions or clarify task-oriented questions. To standardize the researcher's interactions with participant pairs, a protocol was developed and iteratively refined during a pilot phase involving four trial interviews (for the full interview protocol, see Appendix D).

In total, 48 UC Berkeley students (four graduate students and 44 undergraduates) were recruited via UC Berkeley's Experimental Social Science Laboratory (xlab) and randomly paired. Before the activity, each pair was asked to fill out a pre-test, which measured their hopefulness that climate change could be solved, climate change acceptance, perceptions of entiativity (or coherence with their partner) and perceptions of partner rapport (for more detail about study measures, see Appendix A). On pre-test completion, 18 out of the 24 pairs were asked to engage in an additional short, pro-social task depending on the condition they were assigned to (for more details about the pre- or post-test or the pre-activity pro-social task, see Appendix A and Appendix D, respectively, and Chapter 6). All participants were then asked to collaboratively work together to engage in the Stabilization Wedge Activity (for a set of materials shared with participants during the experiment, see Appendix E). After they had completed the activity, each participant was asked to fill out a post-test survey, which was identical in form to the pre-test, and debriefed. The average length of each session was 42 minutes, and interviews were conducted in batches of three from 3/15/21 to 4/21/21. While this activity was originally intended to be carried out in person, due to restrictions on in-person gatherings associated with the COVID-19 pandemic, sessions had to be conducted over Zoom. However, aside from isolated instances of connection break-ups, there was no salient indication that the move to an online format significantly affected the quality of participants' task-oriented discussion. This may have been due to the students' familiarity with Zoom-based classes at this point in the pandemic (i.e., a year after the area's first shutdown).

In terms of demographics, participants had an average age of 21.1 years (SD=2.51). 71% identified as female, and the majority (63%) identifying as Democratic, with only 6% identifying as Republican. The average social conservatism of participants was 2.85 / 9 (i.e., significantly liberal) and average economic conservatism was 3.5 / 9 (i.e., between significantly liberal and moderately liberal), indicating a significant (and expected) liberal bias amongst participants. Participants also came to the activity with high levels of climate-change acceptance, with an average of 7.88 acceptance on a 9-point scale. Majors of students taking part in the study included philosophy, history, computer science, cognitive science, English, and microbial biology. Please note that the next chapter expands on this experiment's Methods.

Analysis Scheme

Following data collection, each activity session was transcribed verbatim. Transcripts were then analyzed according to thematic analysis, following the procedure outlined by Braun and Clarke (2013). This included a first step of open coding, involving the identification of meaningful units that encapsulated justifications for the inclusion or exclusion of a solution.

Each interview transcript was separately analyzed in this way by two coders and discussed in order to ensure consistency and agreement regarding the themes that most accurately captured participants' reasoning. This resulted in several hundred initial codes being generated. After this, codes were reviewed, refined and categorized into seven distinct emergent thematic categories. The fully developed coding scheme is presented in Appendix F. All coding was carried out by hand and no specialized software was used during this portion of the analysis.

In order to determine whether biases shaped participants' choice of climate change solutions, codes pertaining to participants' perceptions of climate change solutions were identified. Evidence was found for five biases: 1) the availability bias, pertaining particularly to nuclear energy; 2) loss aversion, which both influenced conceptions of feasibility and manifested in preferences for back-end and non-technical solutions; 3) projection bias, which created both a focus on upfront rather than long-term cost and a preference for short-term solutions; 4) representativeness bias, where perceived characteristics of taxpayers shaped the kind of solutions participants thought would be most widely accepted; and 5) a pessimism (rather than an optimism)[3] bias, which seemingly relaxed participants' tolerance of risk. Themes relevant to each of these biases will be presented alongside illustrative quotes and additional analyses assessing the prevalence of certain codes across the data corpus.

Results

Availability Bias

The availability bias was most frequently evoked when participants were discussing the solution of nuclear energy. This is reflected by the common associations of nuclear with the words "scary," "risk," and "fear" (see Table 5-1), reflecting the majority of pairs' seemingly disproportionate discussion of nuclear energy's safety risks compared to the safety considerations of other solutions.

Table 5-1

Number of Instances the Words 'Scary', 'Risk' or 'Fear' Were Used with Respect to Three Prominent Solutions (n=48)

Descriptive Code	Solution		
	CCS hydrogen	Soil storage (potentially being reversible)	Nuclear
"scary"	2	2	4
"risk"	4	0	8
"fear"	0	0	1

While nuclear was referred to as "scary" and "risky" in general terms, few participants specified what risks exactly they were scared of. This was reflected by the high proportion of A4

[3] No marked evidence of optimism about climate change was found in participants' discussions, which is why pessimism was the measure.

codes associated with discussions about nuclear energy (see Table 5-2 and Appendix F) which referred to more general or existential fears as opposed to the more specific E3 code, which was used when participants referenced specific concerns about the fallout from nuclear waste (e.g., loss of biodiversity or radiation).

Table 5-2

Top 6 Most Commonly Occurring Codes Associated with Discussions About Nuclear Energy (n=48)

Code	A4	F3	E3	D2	C2	A3
Code description	Fear	Nuclear waste production	Specific effects of nuclear waste	Infrastructural challenges, general safety	Cost	Public opposition
Frequency	10	7	6	4	4	4

Participants also frequently mentioned famous nuclear disasters from the past, such as from this pair, regarding Chernobyl:

> A: We didn't talk about nuclear and nuclear's fine, efficient, etc. the problem is that people are now against it due to some disasters and so if we can do wind and hydrogen and stuff, that might be better… what's the worst that could happen with a hydrogen plant going wrong, do you know?
>
> B: It could just like blow up?
>
> A: Okay, well, so that's not quite Chernobyl.
>
> B: Yeah, it's not going to like – you can't walk in this area anymore."

The mention of this specific and memorable disaster and associated, vivid image of destruction (e.g., a no walk zone) here takes the place of a more methodical assessment of the likelihood of the risk of a nuclear disaster. Relatedly, while Chernobyl and Fukashima were invoked by several pairs, there was no mention of examples of productive and safe nuclear energy production (e.g., in France, where nuclear supplies 70% of the country's energy). As such, the instant dismissal of nuclear as a solution to climate change by many participants seems to have been driven by an availability bias (in particular, prominent and widely reported news events) and not through a more rational or methodical assessment of nuclear energy's risks.

Loss Aversion

During the Stabilization Wedge game activity, there was evidence that loss aversion was guiding participants away from the more technical solutions (e.g., CCS hydrogen). This was illustrated by the use of the D6 code (see Appendix F) indicating transition feasibility or attainability, being closely associated with solutions that were "basic," "more doable," or

"something that's more in the works according to news already." Indeed, one participant argued that if a solution to climate change were truly viable, it would have already been enacted:

> "I'm not too familiar with how the technology is, but I feel like it's kind of difficult, like if it were very feasible right now, I feel like it would already be done."

By seeming to confer a greater likelihood of effectiveness to solutions that participants were already familiar with, without a consideration of impact in terms of greenhouse gas reduction, participants appeared to be demonstrating the certainty effect bias, weighing perceived outcomes that were more certain as disproportionately high. Loss aversion also appeared to manifest in a preference for less-labor-intensive "natural" solutions:

> "I'm like a strong believe in letting the earth repair itself, so it means like allowing for forests to be preserved, so that it can kind of store carbon on its own, naturally, I feel like that's better than doing it with like human intervention."

Preferences for natural and "non-mechanical" or "non-technical solutions" were justified by references to the "inherent goodness" (i.e., lack of side effects) of sustainable solutions and a seemingly reciprocal relationship between technical (wind) and non-technical (re-forestation) solutions:

> "soil storage and then the challenge isn't really a challenge, it's only it'll be reversed if the land is deep ploughed later, but that shouldn't be a problem if it's sustainable "

> "like if you increase reliance on wind electricity, wouldn't it also increase deforestation or something? "

Overall, a dis-preference for technical and more labor-intensive solutions and a preference for lower-impact solutions, such as leaving nature to take care of itself, signaled that participants ascribed value to solutions with certain (i.e., already demonstrated) outcomes, demonstrating risk aversion in their selections. This manifestation of prospect theory in solution preference suggests that participants view climate change as a phenomenon that is largely situated in the future, given their apparent weighting of potential losses in the present (e.g., in terms of cost) more highly than potential future CO_2 reduction gains.

Projection Bias/Temporal Discounting

The majority of participants displayed some form of temporal discounting in their justifications for choices of solutions. For instance, temporal discounting drove participants to favour solutions that would be effective in the short-term and that could be implemented quickly, despite being required by the activity to lower emissions by the target year of 2060 (i.e., 40 years away):

> "if they're asking us to mitigate by 2060 and it's 2021, I don't see all of these coming up in like 15 or 10 years, like this is like – I won't say it's wasted time or money, because in the long run it will definitely help, but seeing how global warming is right now we need something that is really, really efficient, like we could do it right now. And I think we could do much more things by implementing some of the other ones right now, which are

more cost efficient and much more ad hoc than the much bigger impact ones, like the blue ones."

"How do you feel about 5? Because, again, we said it's not ideal, but it can be done right away vs. for like nuclear electricity, we have to set up all these plants and then start."

While many participants' acknowledged the need for a mix of long and short-term solutions, the emphasis for the majority was on solutions that could be enacted immediately, perhaps reflecting the urgency with which participants felt climate change should be addressed:

"the issue with biofuels is just like it's costly to produce for now"

" it's hard for people to make their homes like more efficient, it's a high capital cost."

This was reflected in participants' tendency to focus on the upfront cost of solutions (as opposed to longer term cost efficiency, taking into account returns from investments over time). This manifested in the C2 code being used four times more in discussions than either the C4 and C7 codes combined that dealt with cost-efficiency or long-term costs (see Table 5-3).

Table 5-3

Comparing Counts of the C2 and C4 & C7 Codes in Participant Discussions (n=48)

Code	C2	C4 & C7
Code description	'cost'	'cost effectiveness' & 'switching costs'
count	105	26

The focus on short-term (e.g., upfront as opposed to long-term) cost was also reflected in participants' viewing current technical limitations of technology (e.g., solar or hydrogen fuel technology) as fixed, without acknowledging the possibility of future change or improvement.

"Apparently production of solar panels isn't great, there are some problems on that front. Like it's fairly wasteful in certain ways."

"I personally don't believe in hydrogen fuels. I think that currently we're not at the stage where hydrogen infrastructure is safe enough or even substantial enough for us to go into."

The examples above are illustrative of temporal discounting in that these participants are over-estimating the influence of short-term considerations (current technical limitations, upfront cost) as constant into the future, viewing these impediments as static and not subject to change. Lastly, while some solutions such as natural gas use are seen by experts as transitional measures, the term "intermediate" or "transition" was only used in six out of the 24 transcripts—with the majority of participants only viewing natural gas as a natural resource that would inevitably deplete:

> "because natural gas is a natural resource which is going to deplete soon, so. I don't see this one helping."

The lack of consideration of natural gas as a transitional measure, and instead, focusing on its upfront cost and likelihood of depletion, is a manifestation of temporal bias and more broadly indicates that participants had trouble thinking about change—or incorporating the consideration of future change into their decision-making process.

Representativeness Bias

In the second part of the activity, each dyad was given a list of stakeholders (taxpayer, energy company, manufacturer, etc.) and asked to anticipate how each stakeholder would rate their dyad's set of strategies on a scale of 1-5. This elicited discussion among the partners that revealed underlying assumptions and stereotypes about each stakeholder. For instance, Table 5-4 shows that the majority of participants assumed that taxpayers were largely concerned about money and lowering the cost of addressing climate change.

Table 5-4

Participants' Assumptions About Taxpayers/Consumers (out of n=24 dyads)

Taxpayer / consumer assumptions	N
Favor low-cost solutions	23
Resistant to behavior change	7
Equally divided between climate change believers and skeptics	6
Prefer easily understandable solutions	1
Always unsatisfied or unhappy	1
Dislike nuclear	1
Prefer new technology	1
Prefer hidden solutions	1

Further analysis showed that the assumptions about taxpayers' values that were revealed in the second half of the activity reflected participants' perceptions of how likely solutions in part 1 were to be successfully implemented. This appears to be an example of the representativeness heuristic in that participants appeared to have the underlying assumption that citizens would adhere to the stereotype of a taxpayer and be mostly concerned with the cost of solutions, without attempting to assess how common and overriding this concern would be among citizens. For instance, when choosing between solution 1 (efficiency-transport, increasing car efficiency) and solution 2 (conservation-transport, increasing public transport options), the majority of participants opposed increasing public transport options based on their predictions of citizen-pushback. Consider the following quotes:

> "the thing is what comes to my head is we're kind of like punishing people, like everyday people by saying oh, you can't drive as much and so you know, people don't like that, especially in America."

> "a lot of people take issue with the freedom. Like I want a car, I want to be able to drive to places that the bus doesn't go, or I just want to be alone and private and that I think is one of the major ones as well, freedom and economic."

Participants' negotiations between these two solutions were underlined by the assumption that public would be resistant to behavior-change-oriented solutions, seeing them as an affront to their freedoms–a stereotype ascribed to taxpayers in the second half of the activity. This assumption does not acknowledge the possibility that people may not use public transport due to structural considerations (e.g., if it is not easily available in the area in which they live) or acknowledge the general cost of car ownership. In general, participants also seemed to expect public resistance to their solutions and anticipate high levels of skepticism and disbelief, driving a preference for "back-end" solutions that the public would not notice:

> "from what I hear now, wind turbines are dangerous and they change your genetic code, is that right? Something about, there's a conspiracy theory – like that seems like the simplest most straightforward thing imaginable, nonetheless if you have people protesting against that now, then it seems possible that they'd protest against all sorts of stuff. People protest about anything."

> "I feel like large scale policy things since this task is assuming that we can do all this, I would say policy like government policy making would be way more efficient than relying on citizens because of disbelief and you know, stuff like that"

The assumption of a lack of acceptance among the public (another stereotype associated with the category of taxpayer in general, see line 3 from Table 5-4) is not reflective of reality, because a majority of Americans accept that climate change is happening and would like action to be taken to solve it (Leiserowitz et al., 2022). In discussions about public reactions to their solutions, no pairs attempted to estimate the proportion of public opposition or the amount of political power held by those opposing climate change solutions. The assumption of invariable opposition to solutions from the public led to participants quickly discounting higher-risk (albeit more effective) solutions such as nuclear and led to a preferential consideration of low-cost solutions, despite the fact that for the activity they were not constrained by budget.

> "I feel like first things first we should look at the costs, because that's generally what people care about the most. … Don't touch their wallet.
>
> "Yeah, and I think that cost is important, because obviously if it's higher in cost, then fewer people will want to implement it. Yeah, and so for example solar electricity is really great, but it's also incredibly costly."

Such a strong focus on budget for the majority of pairs seems to be informed by the view, revealed in this second part of this study, that taxpayers are most concerned with the cost of solutions. However, it also means that participants assumed that taxpayers (as opposed to private companies or social ventures) would be exclusively funding climate change solutions. This is consistent with the first part of the activity, where participants invoked the reactions of taxpayers and consumers much more than other stakeholders (e.g., energy companies, environmental

groups) who might have more power and influence in the future enactment of environmental solutions.

Pessimism Bias

In the domain of climate change cognition, there is a widely reported optimism bias, manifesting in the belief that people will be untouched by climate change (Gifford et al., 2009) or holding seemingly unjustified levels of faith in technology, scientists or even God (Marlon et al., 2019) to solve the issue before or when it gets bad enough. During the activity, however, participants showed a high awareness of the likely inevitability and impending nature of climate change and a common response was pessimism—or using black humor to make light of the situation. For instance, when discussing whether to choose the solution of forest storage in light of the fact that forests might be destroyed by humans in the long-term future, one participant broke off his chain of thought in response to more existentialist concerns:

> "Cause even if it sounds like a good thing in the long term, it's like will it matter? Will we still be here? To put it really bleakly, so."

A seeming bias towards a pessimistic outlook appeared to guide participants towards strategies that prioritized immediately short-term over long-term effectiveness and to minimize risks of solutions being potentially reversibile in the future (e.g., the solution of soil storage, if soil is later de-ploughed). A pessimism bias also manifested in participants discounting the potential of individuals and companies to change environmentally costly behaviors:

> "Just cause we know that companies are gonna keep on growing and banking on building, so if you can't stop why not just try and minimize the damage they do?"

Overall, a pessimism bias led participants to discount longer-term risks (underpinned by the belief that humanity will not be around to face the consequences of such risks) and to pick adaptive, as opposed to mitigative, solutions—due to their lack of faith in the ability of individuals and businesses to engage in behavior change. Although such an apparent bias towards pessimism is perhaps more justified than an optimism bias given current scientific projections about the increasingly apocalyptic risks associated with climate change, it seems to be equally stymieing in terms of the consideration of longer-term risks and motivation for behavior change.

Discussion

Participants were shown to rely on biases and heuristics to assess the relative merits of the climate change solutions presented to them in the Stabilization Wedge game. For instance, the availability heuristic seemingly led some participants to discount the solution of nuclear energy without specific or systematic assessment of the risks involved with nuclear options. Loss aversion seemingly led participants to favor non-technical solutions (perceived as more "basic" or "doable") that are already widespread. Both temporal discounting and a bias towards pessimism seemingly led participants to privilege solutions that would be effective in the short-term, and for their discussions to focus on short-term cost- and effectiveness-considerations rather than long-term consequences or longer-term costs. Representative bias similarly

seemingly led participants to assume the public would generally be hostile to climate change solutions, thereby leading them to favor back-end and low upfront cost solutions.

Overall, this study demonstrates that the biases and heuristics, which hinder people's ability to truly grasp the threat of climate change and respond to its emerging reality, additionally reflect how people think about and assess the risks associated with climate change solutions. This "intuitive" thinking when considering climate change solutions may be especially pronounced due to communication efforts that have been overly focused on spreading awareness of the causes of climate change as opposed to information about how it can be solved. Although participants' solution choices appear to reflect heuristics, such biases are systematic and have the potential to be highlighted or addressed through targeted communicational or educational efforts designed in recognition of them.

For instance, one possible way to address both the availability bias and temporal discounting effects indicated by participants' data is to build solidarity among people of different professional groups, traditional societies and long-standing institutions (Marris, 2003). This may have the effect of overcoming short time-scale thinking, as Marris (2003) argued that such solidarity, rooted in non-instrumental attachments to place, might open people up to an appreciation of different timescales—compared to those associated with interactions between individuals. Another way that short-term thinking might potentially be overcome is through emphasizing memories of the past in order to stimulate thoughts about the future (Szpunar et al., 2012), given the psychological processes that underpin thinking about the past and future (Trope & Liberman, 2000). Temporal discounting might alternatively be overcome by (a) directing participants to visualize their future personal lives (Nicholson-Cole, 2005) or (b) the use of technology, such as Net Logo simulations, to help adults and students alike better reason about complex causalities and dynamic system-behavior (e.g., Tisue & Wilensky, 2004)

Limitations

The limitations of Part I (i.e., this chapter of) this study primarily stem from the structure of the Hotinski's (2007) Stabilization Wedge activity itself. For instance, in the activity all solutions were implied as equally effective within the 2060 timeframe (e.g., saving 1 billion CO_2 tons/yr), and the materials provided few quantitative indicators of each solution's efficacy, which, in a sense, prompted participants to unduly rely on biases and heuristics rather than making decisions based on objective evidence. Given that the activity was developed with funding from BP and Ford Motor company as well as Princeton University, there may have also been an excessive weight or glossing over the limitations of the more technically oriented solutions. In terms of the activity structure, participants also came to the task with a variety of prior knowledges and interests in climate change–because some had taken classes on particular solutions, and some declared themselves as "not science people", which meant that they expressed ignorance and were more likely to immediately exclude the more scientifically technical solutions (e.g., CCS electricity). Similarly, the structure and set-up of the activity wasn't necessarily geared to activate long-term thinking–for instance, students were provided with a relative cost associated with each solution (e.g., one, two, or three dollar signs, see Appendix E) and not given an indication in the activity materials of the possibility or likelihood

of any return on investment. Lastly, the activity was developed in 2007, and while all of the information provided was accurate, some information provided to participants was not necessarily up-to-date. For example, although solar was listed as three-dollar signs (i.e., one of the most expensive solutions), technical advances have substantially brought the price down so that it would now be one of the cheaper options.

Conclusion

Cognitive biases and heuristics have been widely accepted to shape people's general assessments of risk, particularly with respect to judging risks associated with climate change. However, there is a lack of research on whether, and in what way, such biases shape perceptions of the feasibility or effectiveness of climate change solutions. In this study, 24 pairs of UC Berkeley students' discussions when choosing eight out of fifteen feasible solutions to climate change were assessed. Discussions indicated evidence of biases that especially privileged short-term, natural, and back-end solutions, and led participants to discount either more technical solutions or ones that relied on societal behavior change. While the scalability of the activity outside of classroom and small-group settings is limited, these findings extend work on perceptions of climate change solutions, and thereby inform ways in which climate change solutions can be taught or more generally framed to the public. These might include a focus on (a) quantities such as long-term cost effectiveness over upfront cost, (b) successful examples of solutions perceived to be high-risk, (c) current levels of climate change support among the American public, or (d) examples in history of societies' willingness to change or adapt in the face of societal pressures.

Chapter 6

Experiment 4, Part II: An Intervention Targeting Group Efficacy

Climate change cannot be solved by a single individual. To effectively tackle the issue, collaboration, collective action, and expressions of "collective hope" are required (Van Zomeren et al., 2008)–defined by Snyder and Feldman (2000) as the goal-directed thinking of a large group of people, in which there is a shared belief in the group's efficacy–that is, their collective power to produce the desired result. Such a sense of group efficacy, taken to be synonymous with the construct of collective agency, has been characterized as an emergent, group-level property that depends on group-specific interpersonal dynamics (Bandura, 2000). Group efficacy has been shown to be a predictor of collective action (Hornsey et al., 2006; Klandermans, 2004) and, as such, positively correlated with hope (Basabe et al., 2017).

In the social psychological literature, the efficacy of a group is shown to be mediated by participants' sense of group cohesiveness and in-group identification (Hackel et al., 2014). Accordingly, one way in which group efficacy has been increased in groups that are new to each other is through emotional arousal and social interaction concerning emotional topics (Yzerbyt et al., 2016). As people talk about emotional topics to each other, emotional contagion and social appraisal effects occur, resulting in the greater likelihood of behavioral synchrony, shared perspectives and an increased sense of in-group identification (Manstead & Fischer, 2001). Similarly, it has been proposed that increasing the social identity salience of the group (i.e., making salient what group members have in common) can create stronger in-group identification between group members and more subsequent intense group-based emotions (Yzerbyt et al., 2016). Several authors have also referred to empirical evidence of the association between lower-level behavioral synchrony via perceptual, motor, and behavioral processes in joint action, and increased interpersonal feelings of solidarity and cooperativeness (e.g., Pacherie 2014; Tollefsen & Dale 2012). This relationship has been explained by the fact that coordination of actions towards a shared task goal involves many real-time coordination mechanisms (e.g., shared gaze, constant monitoring of a partners' actions) and increased sensitivity attunement to the others' emotional state (Michael, 2011). Accordingly, coordinated action has been shown to increase affiliation (Hove & Risen, 2009), rapport, and cooperative ability (Valdesolo et al., 2010) between group members–thereby increasing the agency and efficacy of the group.

While relationships have been empirically demonstrated between the constructs of hope, in-group identification, and collective efficacy (Fritsche & Masson, 2021; Salomon et al., 2017; Xiang et al., 2019), these are generally in "high-hope" contexts in which it is generally assumed that change is possible, and the main question is whether "we" can be motivated to change the situation through collective action (Cohen-Chen & Van Zomeren, 2018). However, it is not clear what constitutes a "high-hope" context with respect to climate change, given that it is a global-scale and relatively abstract issue, in which a reliance on multiple stakeholders (scientists, politicians) and structural-level solutions in addition to collective action—are necessary in order for a solution to be reached. It is therefore not yet clear whether presenting participants with different, feasible, societal solutions for climate change in the context of an activity requiring partner-collaboration offers enough of a context to increase climate change hope and global

warming acceptance. It is additionally not yet clear whether boosting in-group identification or collective efficacy (through means detailed in the paragraph above) will significantly enhance any changes in hope that stem from the activity. Overall, this study seeks to investigate three main hypotheses:

> H4-1: Participating in a group activity about climate change solutions can significantly increase 1) hope about our ability to solve climate change and/or 2) climate change acceptance.
>
> H4-2: Group efficacy can be increased in dyads through short manipulations centered on 1) emotional sharing, 2) establishing in-group salience, and 3) joint action.
>
> H4-3: Manipulating group efficacy before an activity about climate change solutions can significantly enhance changes in hope about our ability to solve climate change.

Methods

Participants

As more briefly mentioned in Chapter 5, a total of 48 participants were recruited from UC Berkeley's Experimental Social Science Laboratory. The students in the sample (44 undergraduates and 4 graduate students) had an average age of 21.1 years (SD=2.51), 71% identified as female, and the majority (63%) identifying as Democratic—with only 6% identifying as Republican. The average social conservatism of participants was 2.85 / 9 (i.e., moderately liberal) and average economic conservatism was 3.5 / 9 (i.e., between mildly liberal and moderately liberal), indicating an expected significant liberal bias amongst participants. Majors of students taking part in the study included philosophy, history, computer science, cognitive science, English, and microbial biology. Pre-test measures confirmed that none of the paired participants were acquainted with each other prior to the study.

Design

Participants were randomly paired and each pair assigned to one of four conditions. All participants were initially asked to fill out a pre-test that assessed individuals' hope about global warming, global warming acceptance, perceived entitativity or cohesion of their group, feelings of closeness (i.e., rapport or connection) to their group, with the latter construct (e.g., cohesion) being taken as a proxy for group efficacy. (See Appendix A for a complete set of pre/post-test questions.) Participants assigned to Conditions 1–3 then engaged a group dynamic manipulation that involved only one of either: 1) identifying three things each of them had in common; 2) sharing something they were looking forward to in the upcoming week, or 3) reading a line from the poem "The Little Red Cap" by Carol Ann Duffy—"words, words were truly on the tongue" as simultaneously as possible over Zoom. Participants assigned to Condition 4 did not engage in any group dynamic manipulation. For the full protocol used to conduct the experiment, including details of the group dynamic manipulation, see Appendix D.

As more briefly mentioned in Chapter 5, all participants were then asked to work together to complete the "Stabilization Wedges Game" activity (Hotinski, 2007)–in which they were

asked to compare 15 different, feasible, greenhouse-gas-emission cutting—solutions and to work together to choose eight plus keeping track of their choices on a worksheet. Each solution was associated with one or two out of four specific sectors (i.e., electricity production, heating and direct fuel use, transportation, and biostorage). Participants were able to pick a solution more than once, but they were constrained in only being able to use a total maximum of six electricity-sector solutions, five transportation-sector solutions, and five heat or direct fuel sector solutions in their overall choice. Finally, participants were asked to work together to predict how six different societal stakeholders (e.g., taxpayers, industrialized country governments, manufacturers) would rate their solutions. For the full set of Stabilization Wedge activity resources shared with participants, see Appendix E.

After completing the activity, participants were asked to fill out a post-test composed of the same questions as the pre-test, along with a demographic survey (see Appendix A). This represented the end of the experiment, after which participants were thanked and dismissed. An overview of experimental conditions is presented in Figure 6-1.

Figure 6-1

An Overview of Experimental Conditions

Condition 1	Condition 2	Condition 3	Condition 4
Pre-test	Pre-test	Pre-test	Pre-test
Highlight similarities	Emotional Sharing	Joint-action task	No intervention
Stabilization wedge activity	Stabilization wedge activity	Stabilization wedge activity	Stabilization wedge activity
Post-test	Post-test	Post-test	Post-test

Due to the COVID-19 pandemic, the activity took place over Zoom, with participants keeping track of their choices via Google Doc. The average length of each session was 42 minutes, and the activity was conducted in batches that counter-balanced conditions during the spring of 2021.

Quantitative Measures: Pre-and Post-test

A largely identical pre-test and post-test was conducted at both the beginning and end of the study. It included measures of: (1) hope about climate change using a 12-item scale that was adapted from Li and Monroe's (2018) Climate Change Hope Scale (α pre-test=0.78, α post-test = 0.84), (2) global warming acceptance using eight-item scale previously used in Ranney et al., 2019 (α pre-test=0.86, α post-test=0.83), (3) Laken's (2010) three-item scale measuring perceived group cohesion or entiativity (α pre-test=0.76, α post-test=0.86), and (4) Puccinelli and Tickle-Degnen's (2004) four-item scale assessing rapport or group connection (α pre-test=0.9, α post-test=0.88). All of the Chronbach alpha's presented are calculated from the present study. To ensure that participants did not know each other prior to the activity, they were asked if they had

met their partner before, and, for additional context, if they were actively involved in environmental activism at UC-Berkeley (1=extremely disagree to 9=extremely agree). For a full list of items used in the pre- and post-tests, see Appendix A.

Qualitative Measures

Given associations of self-report data with inaccuracy (Prince et al., 2008)—and in particular, social desirability response biases (Van de Mortel, 2008)—quantitative measures of participants' immediate perceptions of group connection and cohesion were supplemented with a qualitative analysis of these measures. As a visual indicator of group efficacy within each dyad, measures of behavioral synchronization within each dyad were assessed. This follows from research that higher levels of synchrony are observed in socially cooperative, positively valenced, situations (Delaherche et al., 2012). Synchrony has been found to have positive associations with the intensity of rapport in social situations (Vink et al., 2017), levels of sympathy between participants (Hove & Risen, 2009), co-operative ability (Valdesolo et al., 2010), increased attention towards a partner (Macrae et al., 2008), and pro-social behavior in general (Mogan et al., 2017)—making it a strong behavioral indicator for group connection and cohesion.

Synchronization behavior was studied using Cross-Recurrence Quantification Analysis (C-RQA)–a recurrence-based method used for assessing changes over time in complex dynamic systems (Dale et al., 2011; Riley et al., 1999; Wallot & Leonardi, 2018). Recurrence Quantification Analysis (RQA) is commonly used to assess continuous physiological or movement data in the context of joint-action phenomena in settings such as doctor–patient conversations (Angus et al., 2012) or interactions between children and caregivers (Lira-Palmer et al., 2018). It can also be used to assess the degree of synchronization or co-occurrence of categorically coded behaviors. In the current study, CRQA will be used to assess the degree of coupling of a categorically coded behavior between the two interacting individuals in each dyad to determine if such behavioral coupling is stronger in conditions in which a social-activity manipulation was undertaken before the start of the activity.

The specific behavior that was coded to assess degree of synchronization was an instance of smiling. Instances of smiling, and in particular synchronizations of naturally unfolding smiling, were chosen because smiles have been associated with interpersonal affiliative functions, especially the seeking of enhanced social integration (Brown et al., 2003; Golland et al., 2019; Keltner & Bonanno, 1997; Papa & Bonanno, 2008; Van Vugt et al., 2014)—and play an important role in the formation of cooperative relationships (Mehu & Dunbar, 2008). Mimicry of positive facial expressions (as opposed to spoken or gestural indicators) has also been shown to be an empirically robust phenomenon (Blocker & McIntosh, 2016; Hess & Bourgeois, 2010; Van Der Schalk et al., 2011).

For each of the 18 dyads from Conditions 1, 2 and 3, a five-minute excerpt of each video recording was taken. Each excerpt was taken from the beginning of the activity, after the rules of the activity had been explained to the participants by the researcher, and also after the participants had had time to review the solutions and ask any clarifying questions if any arose. At

each 0.10 second interval, a researcher used the annotation software "ELAN v3.6" to assess whether each individual in the dyad was smiling or not. For each video, an initial round of static frame-by-frame micro-analytic analysis was untaken by the researcher in this manner, and then each video was watched in full as a source of additional verification for smiling instances. In total, each five-minute video-excerpt corresponded to 602 dichotomously coded events (s=smiling, ns=not smiling, 301 events for each individual). Data for each dyad was then analyzed by means of CRQA and measures of recurrence of smiling in each pair was estimated. The same analysis was applied to six randomized dyads, formed by combining data from non-originally paired individuals, and compared to the degree of smiling synchronization from dyads in conditions 1, 2 and 3. If the original and randomized data series were shown to have similar values of recurrence, it could then be concluded that the system (in this case, conditions 1, 2 and 3) had negligible smiling synchronization or coupling (i.e., a null hypothesis could not be ruled out).

Results

Pre-to-post changes in all study variables were assessed for all participants (see Table 6-1). Hope about climate change, global warming acceptance, group cohesion, and group connection were all found to increase to a statistically significant extent (pooling all conditions, as appropriate).

Table 6-1

Changes in Pre-to-post Measures Across all Conditions (n=48)

	Mean Pre.		Mean Post.		Average pre-to-post-test change	*t*	df	*p*
	M	SD	M	SD				
Hope / 9	6.59	0.78	6.92	0.83	+0.33	-3.6332	47	0.000691**
GW acceptance / 9	7.88	0.97	8.09	0.81	+0.21	-2.4317	47	0.01889**
Group cohesion / 9	5.60	1.04	7.03	0.92	+1.44	-9.2508	47	3.717e-12**
Group connection / 5	2.61	0.77	3.89	0.63	+1.27	-12.528	47	<2.2e-16**

$p<0.05$, $p<0.02$**, p<0.01****

To disentangle whether these changes were caused by the stabilization wedge activity alone or whether they were due to the social manipulations preceding the activity, pre-to-post changes in study variables were assessed for Conditions 1, 2, and 3 (e.g., the with-social-manipulation conditions; see Table 6-2) and Condition 4 (e.g., the control condition; see Table 6-3) separately.

Table 6-2

Changes in Pre-to-post Measures Across the With-Social-Manipulation Conditions (Conditions 1, 2, and 3, n=36)

	Mean Pre.		Mean Post.		Average pre-to-post-test change	*t*	df	*p*
	M	SD	M	SD				
Hope / 9	6.55	0.85	6.86	0.84	+0.31	-2.9274	35	0.005973***
GW acceptance / 9	7.75	1.04	8.01	0.87	+0.26	-2.2988	35	0.02761**
Group cohesion / 9	5.53	1.09	6.93	0.87	+1.40	-7.4643	35	9.712e-09***
Group connection / 5	2.58	0.69	3.84	0.54	+1.26	-12.346	35	2.607e-14***

p<0.05, p<0.02**, p*<0.01***

Table 6-3

Changes in Pre-to-post Measures Across the Control Condition (Condition 4, n=12)

	Mean Pre.		Mean Post.		Average pre-to-post-test change	*t*	df	*p*
	M	SD	M	SD				
Hope / 9	6.72	0.55	7.10	0.80	+0.38	-2.1497	11	0.05468*
GW acceptance / 9	8.27	0.57	8.34	0.58	+0.07	-0.85976	11	0.4083†
Group cohesion / 9	5.81	0.92	7.36	1.01	+1.55	-5.639	11	0.0001513***
Group connection / 5	2.69	1.01	4.02	0.89	+1.33	-4.7751	11	0.0005759***

p<0.1†, p<0.05, p<0.02**, p*<0.01***

In Conditions 1, 2, and 3 (the with-social-manipulation *experimental* conditions), climate change hope and global warming acceptance significantly increased (M=6.55 [SD=0.85] to M=6.86 [SD=0.84, t(35)=-2.9274, p<0.01] for climate change hope—and M=7.75 [SD=1.04] to M=8.01 [SD=0.87, t(35)=-2.2988, p<0.01] for global warming acceptance, see Table 6-2). For the without-social-manipulation *control* condition (likely due to its much lower statistical power) there was a marginally significant increase in hope, but no statistically significant change in global warming acceptance (Condition 4; M=6.72 [SD=0.55] to M=7.10 [SD=0.80, t(11)=-2.1497, p=0.055] for climate change hope and M=8.27 [SD=0.57] to M=8.34 [SD=0.58, t(11)=-0.85976, p=0.4083] for global warming acceptance; see Table 6-3).

To assess whether group efficacy was successfully increased with the short manipulations centered on 1) emotional sharing; 2) establishing in-group salience; and 3) joint action, pre-to-post changes in group cohesion and connection in Conditions 1, 2, and 3 and the Control Condition (Condition 4) were additionally assessed (see Tables 6-2 and 6-3). Group cohesion and group connection were shown to increase significantly in all comparisons—that is, in both the Control Condition (i.e., no social-manipulation, Condition 4 [M=5.81, SD=0.92 to M=7.36, SD=1.01, t(11)=-5.639, p<0.01 for group cohesion and M=2.69, SD=1.01 to M=4.02, SD=0.89, t(11)=-4.7751, p<0.01 for group connection] and in Conditions 1-3 (i.e., the with-social-manipulation Conditions [M=5.53, SD=1.09 to M=6.93, SD=0.87, t(35)=-7.4643, p<0.01 for group cohesion and M=2.58, SD=0.69 to M=3.84, SD=0.54, t(35)=-12.346, p<0.01 for group connection]. This indicates that the wedges activity increased group cohesion and connection to a statistically significant extent by itself. The social manipulation interventions did not markedly add to the wedge activity's effect.

Table 6-4

Comparing Pre-to-post Changes in Group Cohesion and Connection Between With-social-manipulation Conditions (Conditions 1, 2 and 3; n=36) and (versus) the Control Condition (Condition 4; n=12)

	Pre-to-post change for conditions 1, 2 and 3 (with social manipulation) (n=36)		Pre-to-post change for condition 4 (control condition, without social manipulation) (n=12)		*t*	df	*p*
	M	*SD*	*M*	*SD*			
Cohesion / 9	+1.40	1.12	+1.55	0.96	-0.4681	21.981	0.6443
Connection / 5	+1.26	0.61	+1.33	0.97	-0.25702	14.041	0.8009

In addition, unpaired t-tests were used to compare pre-to-post changes in both group cohesion and group connection across Conditions 1,2 and 3—and Condition 4. See Table 6-4. The mean pre-to-post increase in group connection among Conditions 1, 2 and 3 (M=1.26, SD = 0.61) was not significantly higher than the increase in group connection in the Control condition (M=+1.33, SD = 0.97, *t*(14.041)=-0.25702, p=0.8009). Similarly, pre-to-post increases in self-reported group cohesion in Conditions 1, 2 and 3 (M=+1.40, SD=1.12) was also not significantly higher than the increase in cohesion in the Control (i.e., with no social manipulation before the wedge activity) condition (M=+1.55, SD=0.96, t(21.981)=-0.4681, p=0.6443). To explore the relative efficacy of the particular social manipulations used, two one-way ANOVAs were carried out to assess any significant difference in the changes of both variables among the four conditions (see Tables 6-5 and 6-6).

Table 6-5

One-way ANOVA Test of Between-condition Effects on Group Cohesion (n=48)

	Df	Sum Sq	Mean sq	F value	Pr (>F)
Condition	3	0.67	0.2241	0.183	0.907
Residuals	44	53.74	1.2215		

Table 6-6

One-way ANOVA Test of Between-condition Effects on Group Connection (n=48)

	Df	Sum Sq	Mean sq	F value	Pr (>F)
Condition	3	0.327	0.1089	0.208	0.891
Residuals	44	23.078	0.5245		

ANOVAs revealed there were no statistically significant differences in either change in group cohesion or change in group connection across the four conditions ((F(3,44)=0.183, p=0.907) for change in cohesion and F(3,44)=0.208, p=0.891) for change in connection; see Tables 6-5 and 6-6 respectively. These results indicate that the group social manipulations were not effective at increasing (participants' perceptions of) the cohesion or connection of the pair beyond that from playing the Wedge game itself. However, although there were no significant differences in relative cohesion or connection change in Conditions 1, 2, and 3 relative to the Control (see Table 6-4), after pooling pre-activity and post-activity data from all conditions together, there were substantial pre-to-post activity increases in cohesion and connection (see Table 6-1) regardless of condition (i.e., regardless of whether a social-manipulation activity was added to the Wedge game activity).

Quantitative Analysis of Qualitative Measures

Assessments of group connection and cohesion were additionally assessed using qualitative measures. For each dyad in Conditions 1, 2 and 3 (18 dyads in total), a time series plot was created showing the rate of occurrence of each participant smiling over the five-minute excerpt. Cross Recurrence Quantification Analysis (CRQA) was then used to assess the degree of co-occurrence of smiling in the dyad over time, with the hypothesis that partners who felt more closely connected to their partner would exhibit higher behavioral synchrony. Following recommendations from Dale et al. (2011) for the implementation of CRQA with categorical data, recurrence measures were estimated with one embedded dimension, and with delays of 0.2s lag. Measures of recurrence were calculated for smiling behavior in each of the 18 dyads in Conditions 1-3 (see Table 6-7). To assess our hypothesis, this analysis was repeated for six randomized dyads.

Table 6-7

Recurrence Values for all Pairs in Conditions 1, 2 and 3, and 6 Randomized Dyads (n=48)

	Condition 1: highlighting similarities	Condition 2: emotional sharing	Condition 3: joint action task	Random
Pair 1	0.67135	0.65480	0.75965	0.66278
Pair 2	0.72766	0.79843	0.81280	0.83874
Pair 3	0.73205	0.78075	0.70850	0.79304
Pair 4	0.81106	0.81968	0.80615	0.78757
Pair 5	0.83441	0.84312	0.65187	0.71704
Pair 6	0.80451	0.76140	0.7217	0.68947
average	0.763507	0.776363	0.743445	0.748107

Based on recurrence values, although smiling behavior had a slightly higher level of recurrence between pairs in Conditions 1 (manipulation = highlighting similarities) and 2 (manipulation = emotional sharing) relative to random dyads, the recurrence values across Conditions 1, 2 and 3 and the randomized pairs are in a similar range, indicating that the social-interaction manipulation was not a strong predictor of subsequent smiling behavior. This was confirmed by the use of a Wilcoxon signed-rank test, a non-parametric test, to compare the original and random samples. A non-parametric test was used due to the relatively small sample size and non-normal distribution of the data. The Wilcoxon signed-rank test showed that the recurrence of smiling behavior in conditions 1, 2 and 3 (M=0.761, SD=0.061) was not significantly different compared to the recurrence of smiling in the six randomized pairs (M=0.748, SD=0.069, z=0.321, p=0.6261). Comparisons of recurrence values from each individual condition to the recurrence from the random pairs additionally showed that in no condition was recurrence of smiling behaviors significantly higher than in the randomized dyads (with z=0.22, p=0.5887 for Condition 1 and the randomized pairs, z=0.22, p=0.5887 for the Condition 2 and the randomized pairs and z=0.12, p=0.904 for Condition 3 and the randomized pairs). To assess the dynamics of smiling behavior, and in particular, to assess how the degree of coupling of smiling behavior changed over time, graphical representations of a matrix of smiling behavior for each dyad were created. See Figure 6-2. From these plots, the mean diagonal line length was assessed; see Table 6-5.

Figure 6-2

Recurrence Plots for Smiling Behavior for Condition 1, 2, 3 Dyads, and for Randomized Dyads (n=48)

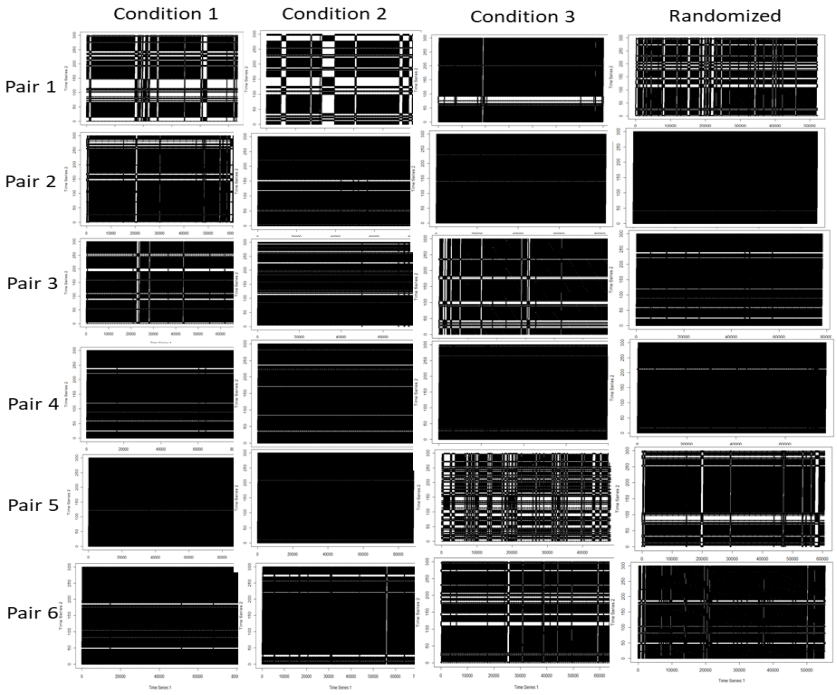


Table 6-8

Mean Diagonal Line Lengths Drawn From the Recurrence Plots (n=48)

	Condition 1	Condition 2	Condition 3	Randomized
Pair 1	7.97	9.61	15.04	49.13
Pair 2	9.76	24.19	22.30	17.93
Pair 3	15.10	13.53	11.31	6.51
Pair 4	26.37	31.52	22.01	42.71
Pair 5	74.57	74.81	3.99	15.02
Pair 6	24.08	16.81	9.57	18.82
Average	26.31	28.41	14.04	25.02

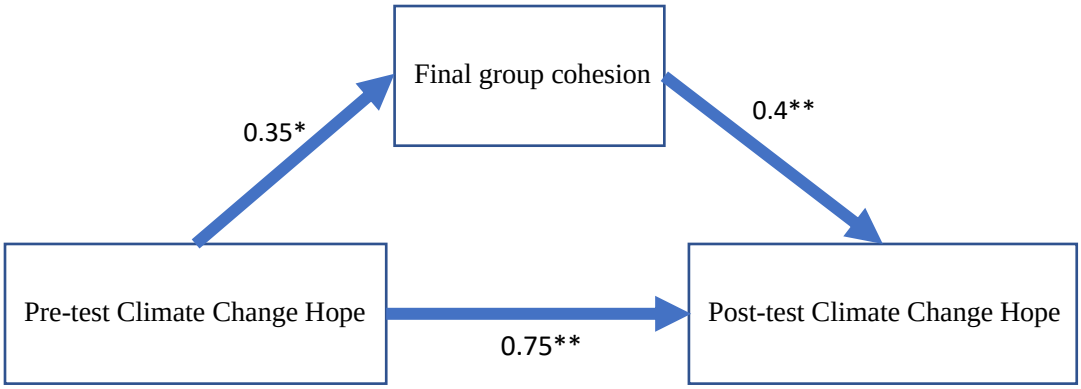
Pairs in Condition 3 have, numerically, a low average diagonal length compared to dyads for other conditions, meaning that pairs in Condition 3 displayed numerically the least coupled or more random behavior. The similar magnitude of average diagonal line length across conditions 1, 2, and the randomized dyads indicates that the pro-social interventions of highlighting similarity and sharing emotions were not effective at enhancing the coupling of smiling behaviors. The fact that the average mean diagonal line length of Condition 3 is numerically lower than that of the randomized dyads indicates that the pro-social intervention of a joint action task was perhaps especially ineffective (and perhaps even counterproductive) at promoting the synchronization of smiling behavior. Overall, the relative lack of smiling recurrence in Conditions 1, 2 and 3 is confirmed by a Wilcoxon signed-rank test, which showed that the mean diagonal line length from the recurrence plots for Conditions 1, 2, and 3 (M=22.92, SD=20.21) was not significantly different compared to the mean diagonal line length from the recurrence plots for the randomized pairs (M=25.02, SD=16.89, z=0.35, p=0.7211). Thus, the

more qualitative analyses were consistent with the quantitative results: the social manipulations before the activity did not significantly boost participants' cohesion or connection (as qualitatively assessed through the coupling of smiles) within their dyad.

To assess the relationship between group efficacy and climate change hope, mediation analysis using the Barron Kelly method was carried out to determine whether group cohesion or connection were mediating the pre-to-post change in climate hopefulness in participants. In step 1 of the method, the regression of post-test hope and pre-test hope, ignoring the mediator, was significant ($b=0.74$, $R^2=.0.49$, $F(1,46)=44.3$, $p<0.01$). Step 2 showed that for the regression of pre-test hope on both potential mediators, post-test group cohesion alone was significant ($b=0.35$, $R^2=0.88$, $F(1,46)=4.498$, $p<0.05$). Step 3 of the mediation process showed that the mediator of group cohesion, controlling for pre-test hope, was significant ($R^2=0.5167$, $F(2,45)=24.05$, $p<0.01$). Finally, step 4 of the analysis revealed that, controlling for the mediator of group cohesion, pre-test hope was still a significant predictor of post-test hope ($R^2=0.49$, $F(2,45)=21.87$, $p<0.01$; see Figure 6-3). For verification, a Sobel test was conducted and evidence of mediation was found in the model ($z=1.99$, $p<0.05$).

Figure 6-3

A Graphic Depiction of the Relationship Between Pre-test Climate Change Hope, Post-test Perceptions of Group (i.e., partner) Cohesion, and Post-test Climate Change Hope.



Discussion

Results from Tables 6-1 to 6-3 indicate that having paired participants take part in the Stabilization Wedge activity significantly increases climate change hope, group connection, group cohesion, and (at least when paired with the social manipulations), global warming acceptance. Taking part in the Stabilization Wedge activity by itself only significantly increased group cohesion and connection and hope about climate change (see Table 6-3), taking part in a social manipulation activity in addition to the Stabilization Wedge activity increased all four study variables (climate change hope, global warming acceptance, and group connection and cohesion) to a statistically significant extent (Table 6-2). The social manipulation, however, did not significantly improve group cohesion or connection to a greater extent compared to the

control dyads who only engaged in the Stabilization Wedge activity. This was reflected by non-significant additional increases from pre- to post-measures of group cohesion and connection for Conditions 1, 2 and 3 dyads compared to Condition 4 (e.g., no activity) dyads' increases (see Table 6-4, Table 6-5 and Table 6-6)—and also in the not-significantly-different degree of behavioral (e.g., smiling) recurrence and coupling within Condition 1, 2 and 3 dyads compared to the six randomized dyads (see Table 6-7, Table 6-8, and Figure 6-2). Qualitative and quantitative analysis (e.g., Tables 6-1 through 6-8 and Figure 6-2) jointly showed that, compared to either the Control condition or the randomized data, the effect of no single type of social manipulation (e.g., emotional sharing, joint action or highlighting similarities) was especially effective at impacting group efficacy beyond that of the wedge activity.

Despite the social manipulation not significantly boosting group efficacy beyond the boost of the Wedge activity alone, the more important results indicate that the intervention as a whole (e.g., the act of working with a partner to complete the Stabilization Wedge activity with a partner) significantly increased hope about our ability to solve climate change, global warming acceptance, group connection, and group cohesion to a significant extent (see Table 6-1 and Table 6-3). Mediation analysis also showed that perceptions of group cohesion—likely mostly caused by the wedge activity—mediated the pre-to-post increase in hope about climate change (see Figure 6-3). These results strengthen the empirical links between interventions, group efficacy, and hope—and confirm prior results from this thesis that demonstrate that hope about our ability to sole climate change is increasable over short timescales. Results also show that even in small (n=2) groups, interventions that increase group cohesion can lead to people feeling more hopeful about the large, global issue of climate change. This is crucial, given that the bulk of the literature on emotions about social issues and group efficacy focus on the scale of larger groups (e.g., football crowds), in which emotional contagion effects from the type of social manipulations tested are more pronounced.

The failure of the social manipulation pre-cursor to have any discernable impact, beyond that from the wedge activity, on perceptions of group cohesion or connection may have been for two reasons. On the one hand, the social manipulations may have been too short to be especially effective, or their effectiveness may have suffered from the fact that the interactions took place over the Zoom platform rather than in-person. On the other hand, the social manipulations may have been successful, but have had their effects dwarfed by the (longer and more involved) Stabilization Wedge activity. Overall, this experiment's conditions were overwhelmingly successful at increasing hope about climate change, global warming acceptance, and group efficacy measures.

Limitations

When teaching, it is often easy to have an intuitive sense about which groups are working well together—by using visible signals such as laughter, engaged body language, increased eye contact between partners, question asking, and fluency in conversations. Formalizing this sense can be harder. Accordingly, there are limitations associated with attempting to capture group cohesion and connection. As noted above, there are limitations associated with self-report data, as well as response shift biases associated with pre- and post-measurements (Cuijpers et al.,

2017). There are also many limitations associated with the CRQA analysis performed. Although only one type of behavior (smiling) was coded for, alternative or additional signals of group efficacy may have included postural changes, eye movements, or words exchanged in the communicative interaction—which may have revealed different or more clear-cut degrees of recurrence in behavior. Smiling was also coded relatively coarsely (e.g., by sight and not using electromyography measures) and without coding differences in smiling intensity or attempts to distinguish between Duchenne and non-Duchenne (i.e., genuine and simply polite) smiles (Gervais & Wilson, 2005). One reason such a coarse coding scheme was applied was that the interviews were recorded over Zoom. This meant that there were relatively few communicational gestures, a lack of direct eye contact between participants, varied backgrounds, lighting set ups, and orientations towards the camera. The fact that the activity was carried out over Zoom may have also made it harder for participants to form interpersonal connections, although by this point at the pandemic, the majority had extensive experience of meeting and communicating with classmates and friends in an online setting.

Conclusion

Examples exist of societies undergoing paradigmatic social change throughout history–from the French Revolution to U.S. Civil Rights marches and the Occupy movement. However, the potential for collective action does not arise spontaneously because it requires the availability of societal pathways to change—coupled with group efficacy towards achieving such change. In this study, 48 participants took part in the Stabilization Wedge Activity, in which they worked together in pairs to choose eight out of a total 15 possible solutions to climate change. The activity increased participants' hope about climate change, global warming acceptance, and even the pairs' senses of connection and cohesion. As a precursor to the activity, 32 out of the 48 participants also engaged in a short activity designed to boost group connection and cohesion. Pre-to-post measurements and qualitative assessments showed that the short social manipulations before the activity were not significantly additionally effective, but that the increase in hope observed due to the wedge activity seemed mediated by group cohesion. Ultimately, results show that hope about climate change can successfully be increased through a facilitated discussion of climate change solutions. Such results are useful for teachers and activists who seek to inspire hope about climate change and encourage participation in collective action about social issues. Equally important, this experiment indicates that using the Stabilization Wedge Activity is yet another intervention that increases acceptance/concern about global warming.

Chapter 7

General Discussion and Conclusions

A key empirical finding of this dissertation's experiments is that hope about our ability to successfully solve climate change can be increased in four ways over short timespans. A robust, replicated phenomenon, interventions that caused statistically significant increases in participants' hope involved: (1) ordering a set of pro-environmental actions in terms of those that participants were most-and-least likely to engage in (Chapter 2); (2) estimating quantities related to societal-scale climate change solutions (particularly illustrating the efficacy and uptake of each solution) and then receiving feedback on these estimates (Chapter 3); (3) reading and reflecting on climate change narratives, particularly those framed around the successful action of an individual (Chapter 4); and (4) completing Hotinski et al.'s (2007) Stabilization Wedge Activity—that is, working with a randomly assigned partner to choose eight out of a total 15 strategies that might feasibly solve climate change by 2060 (Chapters 5 and 6).

Within each individual experiment, insights into participants' perceptions of climate change solutions were revealed. For instance, in Experiment 1, participants indicated they were most likely to engage in easy-to-perform and less effective pro-environmental behaviors, and least likely to engage in behaviors involving social interaction, such as talking to an elected official or family and friends about climate change. In Experiment 2, participants were most surprised by the numerical discrepancies between their estimates and the true quantities relating to the climate change solution of reducing meat consumption, as compared to the more commonly publicized climate change solutions of either electrification or energy efficiency. In Experiment 3, interventional narratives that were centered on the experience of an individual, as opposed to a company, produced the largest increases in hope. (Qualitative analysis of participant discussions in Experiment 4 also indicated that the biases and heuristics that hamper people's ability to conceive of climate change as a threat also shape perceptions of the feasibility and effectiveness of climate change solutions.) Experiment 4 primarily showed that, although short interventions designed to enhance group cohesion did not appear to significantly enhance the increase in hope caused by the Stabilization Wedge Activity, the Wedge Activity itself was a formidable booster of four measures: group cohesion and connection, global warming acceptance, and climate change hope.

In terms of the relationship between hope and other constructs, significant correlations between climate-change hope and global warming acceptance were found in all four experiments. Pre-test global warming acceptance and pre-test hope were found to have significant weights in models for post-test hope for Experiments 1, 2, and 3, indicating the highly inter-related nature of the two constructs. Interventions 2 and 4, which both conveyed societal-level solutions to climate change, also caused statistically significant pre-to-post increases in global warming acceptance (as well as hope) in participants, adding to the ten-and-counting interventions produced by UC Berkeley's Reasoning group that have been shown to increase global warming acceptance among the American public (see Ranney & Velautham, 2021). Results from Experiments 1, 2, and 3 also indicated negative correlations between global warming acceptance and nationalism, offering more empirical evidence of Ranney's RTMD

theory (Ranney et al. 2019). Finally, pre-to-post changes in hope about climate change spawned by the Wedge Activity in Experiment 4 were shown to be mediated by post-test perceptions of group cohesion, indicating the significant role of interpersonal social relationships in enhancing hope about climate change.

Contributions

The primary contribution of this thesis is the development and empirical validation of four short and factually correct hope-inducing interventions about climate change that can either be disseminated directly to the public or integrated into study materials, public communications, talks, discussions and/or activities about climate change. Such materials would most likely be used by teachers, activists, scientists, policy makers, or indeed anyone seeking to communicate climate change in such a way as to inspire hope and action to the public. A secondary contribution of this dissertation is its discovery/demonstration of two additional ways to increase global warming acceptance (beyond those noted in Ranney & Velautham, 2021).

From a more theoretical perspective, the work in this thesis shows that Snyder's (personal) theory of hope can successfully be applied to a large-scale societal issue as well as more personalized goals. In illustrating the relationship of hope about climate change with other constructs, such as global warming acceptance, nationalism, and moral elevation, this dissertation also provides insight into the mechanism of hope change—and informs the design of future hope interventions to be used in the context of climate change. Furthermore, although the majority of climate change communications have focused around conveying the *causes* of climate change, the experiments in this thesis are unique in that they center on climate change *solutions*. These results therefore provide insights into the American public's perceptions of climate change solutions–in particular the American public's perceptions of the feasibility, uptake, and efficacy of the climate change solutions touched on in the interventions.

Limitations

A primary limitation of this work is that these empirical studies (i.e., Experiment 1, 2, 3 and 4) lack a "filler task" control group, that is, a similar group of participants completing the same pre- and post-surveys, but participating in an alternative, unrelated, activity in place of the intervention. The decision to omit this kind of control condition was taken because hope about climate change is a relatively under-characterized emotion, making it difficult to design alternative activities of the same length and content-type as the interventions under investigation that wouldn't interact with hope in any way. Another limitation of the experimental set-up was that pathways thinking and agency (sub-constructs in Snyder's 2002 theory of hope) were not able to be isolated in Li and Monroe's (2018) Climate Change Hope Scale, meaning that the precise mechanism by which each intervention increased hope (i.e., through the sub-construct of either hope or pathways thinking) is not yet clear. Another limitation of using only Li and Monroe's (2018) Climate Change Hope scale to assess hope was that no longer-term changes in hope and/or effects of hope change on pro-environmental engagement or behavior were assessed, because it was determined that investigating either would be beyond the scope of this thesis—and should be left for future research.

A further limitation regards the generalizability of these results to the wider US population. For the first three experiments, the decision was taken to test the interventions on as representative a sample of American adults as possible. Although MTurk participants are more demographically aligned with the American population than (e.g., Berkeley) undergraduates, they are also slightly more liberal and slightly younger than the average American (Huff & Tingley, 2015). Similarly, the fourth experiment's in-person participants were comprised of UC Berkeley graduate and undergraduate students who overwhelmingly accepted climate change's reality and were not selected for in terms of pre-existing hope and/or global warming denial. (It should be noted, though, that their global warming acceptance significantly increased, in spite of the high likelihood of that not happening due to a ceiling effect). The exclusive focus on American participants also raises some questions about the generalizability of these results outside of a U.S. context.

Ultimately, the work of this dissertation provides relatively straightforward ways in which hope (according to Snyder's 2002 tightly defined model of hope) can be instrumentalized for classrooms or other climate change communications. The work does not necessarily align to Bloch's (1986) or Freire's (1970) more critical sense of hope, which is rooted in acknowledging the necessity of social change. As such, this work does not markedly bolster the more transformative, experiential, or transgressive learning initiatives that specifically prepares students for (e.g., increased) democratic participation, nor does it provide guidance for more therapeutic practices for emotional resiliency such as mindfulness, peer support programs, or healing circles. An exclusive focus on positive valences, especially with issues such as climate change, has also been argued by social theorists (e.g., Ehrenreich, 2009) to be dangerous, because it may undercut the chance of people engaging in social critique or making demands for more necessary, structural, forms of change within neoliberal societies. There are questions regarding whether the kind of hope cultivated in this dissertation goes far enough in inciting the kinds of ambitious social change that has been shown to be achievable in history (e.g., Ghandi's transformation of India, Martin Luther King's transformation of racial inequality in the United States), and that appears necessary for climate change progress.

Future Work

One way in which the work in this thesis could be extended is by assessing the impact of changes in hope on participants' behavior. For instance, it might be the case that hope is more likely to activate certain behaviors (e.g., civic activism, democratic participation) than others (e.g., recycling). Future research might also examine whether hope is more likely to lead to increased creativity or willingness to engage with climate change—or even increased tolerance for having conversations about climate change. Relatedly, it would be interesting to investigate the persistence of the hope changes caused by the four interventions and any manifestations of long-term hope in longer-term changes in perceptions of climate change and/or behaviors (e.g., resilience). To better determine the relationship between hope and other emotions, it would also be valuable to have alternative data sources beyond self-report measures (e.g., focus groups, interviews, biological sampling) or to sample for a range of emotions in pre- or post-tests to better understand reactions to the interventions in a more nuanced way. In this series of studies,

MTurk was used to assess the impact of interventions on a relatively representative sample of Americans. Future research might examine whether the pattern of results found here extends to more specialized populations (e.g., environmental educators, teenagers, climate scientists, skeptics) who either have a high proclivity towards climate-relevant information and/or who are more invested in the issue compared to the average American.

One criticism of the field of positive psychology is that it privileges positive emotions over more negative ones (Ahmed, 2004; Head, 2016; Norgaard, 2011). Hope, however—especially in the way that it's been conceptualized in this work—is not a panacea, so it is possible for people to be both hopeful and worried at the same time. Indeed, Stevenson and Peterson (2015), as well as theorists such as Freire (1970), argue that despair is an important precursor to hope. Accordingly, recent theorizing suggests that leading participants through a progression of emotions (e.g., from fear to hope) may enhance persuasive success (Bennett, 2015)—particularly in instances in which the mixed emotional experiences are more positive than negative (Merchant et al., 2010). Ojala (2007) empirically found that young people with a dialectical relationship between hope and worry seemed most motivated to participate in pro-environmental action compared to young people who were only hopeful. Future work might thus involve (a) studying the dialectic between positive and negative emotions (such as between hope and worry) in relation to climate change or (b) designing interventions that stimulate both valences in a specific order to most effectively galvanize action.

Summary

Overall, this dissertation's four experiments' interventions were shown to be effective at increasing hope about our ability to solve climate change. Two of the interventions also increased acceptance /concern about global warming. The content of these interventions was not driven by falsehoods or wishful thinking and rather reflect the reality of solutions to climate change that already exist and/or progress that has already been made. In more general terms, the work in this thesis also advances theoretical perspectives of what it means for an individual to be hopeful about a large-scale, collective, issue such as climate change. It also offers insight into the relationships among hope about climate change and other constructs such as climate change acceptance, nationalism, moral elevation, and other pro-social constructs. In general terms, this research extends the fields of constructive communication and the teaching of climate change. The intention of this work is that teachers, activists, and policymakers will find this kind of empirically-supported work helpful in fostering the kind of constructive hope that leads to meaningful action and increased engagement with climate change.

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Appendix A: Items used in Pre/Post-test Surveys

Hope About Climate Change (from Li & Monroe, 2018)–used in Experiments 1, 2, 3, and 4 (1-9 scale; extremely disagree=1; strongly disagree=2; disagree=3; mildly disagree=4; neither agree nor disagree=5; mildly agree=6; agree=7; strongly agree=8; extremely agree=9)
I am willing to take actions to tackle climate change.
At the present time, I am energetically pursuing ways to tackle climate change.
Climate change is beyond my control, so I won't even bother trying to solve problems caused by climate change.
The actions I can take are too small to help solve problems caused by climate change.
I know that there are things that I can do to tackle climate change.
I can't think of what I can do to help solve problems caused by climate change.
If everyone works together, we can tackle climate change.
I believe that scientists will be able to tackle climate change.
Climate change is so complex we will not be able to tackle it.
I believe more people are willing to take actions to help tackle climate change.
Even when some people give up, I know there will be others who will continue to try to tackle climate change.
Every day, fewer people care about climate change.

GW acceptance (from Ranney & Clark, 2016)–used in Experiments 1, 2, 3 and 4 (1-9 scale; extremely disagree=1; strongly disagree=2; disagree=3; mildly disagree=4; neither agree nor disagree=5; mildly agree=6; agree=7; strongly agree=8; extremely agree=9)
The Earth isn't any warmer than it was 200 years ago.
Human activities are largely responsible for the climate change (global warming) that is going on.
I am confident that human-caused global warming is taking place.
Global warming (or climate change) isn't a significant threat to life on Earth.
If people burned all the remaining oil and coal on Earth, the Earth wouldn't be any warmer than it is today.
Global warmings, or climate changes, whether historical or happening now, are only parts of a natural cycle.
I am concerned about the effects of human-caused global warming.
I would be willing to vote for a politician who believes that human-caused global warming doesn't occur.

Nationalism (from Ranney & Clark, 2016)–used in Experiments 1, 2, and 3 (1-9 scale; extremely disagree=1; strongly disagree=2; disagree=3; mildly disagree=4; neither agree nor disagree=5; mildly agree=6; agree=7; strongly agree=8; extremely agree=9)
Generally speaking, the United States has done more harm than good.
The United States is one of the very best countries on our planet (for instance "in the top three").
The United States has had the best economy in the world for (at least) the last 100 years.
In the two World Wars, the United States basically kept much of the world from being dominated by dictators and monarchs.

Moral Elevation (from Schnall et al., 2010)–used in Experiment 3 (1-5 scale; not at all=1; a little=2; moderately=3; a lot=4; very much=5)
I feel moved.
I feel uplifted.
I feel optimistic about humanity.
I feel warm feelings in my chest.
I want to help others.
I want to be a better person.
(to assess general positive affect) I feel happy.

Prosocial Behavioral Intentions Scale (from Baumsteiger & Siegel, 2019)–used in Experiment 3 (1-7 scale; definitely would not do this=1; most likely would not do this=2; probably would not do this=3; might or might not do this=4; probably would do this=5; most likely would do this=6; definitely would do this=7)
Indicate how willing you would be to perform each behavior from 1 (Definitely would not do this) to 7 (Definitely would do this):
Comfort someone I know after they experience hardship.
Help a stranger find something they lost, like their key or a pet.
Help care for a sick friend or relative.
Assist a stranger with a small task (e.g., help carry groceries, watch their things while they use the restroom).

Cohesion (i.e., Entiativity; from Lakens, 2010)–used in Experiment 4 (1-9 scale; extremely disagree=1; strongly disagree=2; disagree=3; mildly disagree=4; neither agree nor disagree=5; mildly agree=6; agree=7; strongly agree=8; extremely agree=9)
I feel like me and my partner are a unit
I experience a feeling of togetherness between me and my partner
I think me and my partner can act in unison.

Connection (i.e., Rapport; from Puccinelli & Tickle-Degnen, 2004)–used in Experiment 4 (1-5 scale; not at all=1; slightly=2; somewhat=3; moderately=4; extremely=5)
To what extent do you and your partner like each other?
To what extent are you and your partner similar?
To what extent do you think you and your partner understand each other?
To what extent do you and your partner feel coordinated with each other?

Catch Items–used in Experiments 1, 2 and 3 (1-9 scale; extremely disagree=1; strongly disagree=2; disagree=3; mildly disagree=4; neither agree nor disagree=5; mildly agree=6; agree=7; strongly agree=8; extremely agree=9)
Please simply answer “Mildly Agree” for this item.
Please simply select the number equal to five minus three.
Please simply answer “Strongly Disagree” for this item.
Please simply select the number equal to nine minus one.

Appendix B: Demographic Questions for MTurk participants

(used after the post-tests in Experiments 1, 2, and 3)

Please enter your gender/sex

How old are you?

18-25 years old

26-30 years old

31-35 years old

36-40 years old

41-45 years old

46-50 years old

51-55 years old

56-60 years old

61-65 years old

66-70 years old

71-75 years old

76-80 years old

81+ years old

Were you born in the U.S.?

Yes

No

How many years have you been living in the U.S.?

What political party are you most affiliated with?

Democratic

Republican

Independent

Libertarian

Green

Other

None

Respond to the following question on a 1-9 scale, where 1 is "Extremely Liberal" and 9 is "Extremely Conservative": On most social issues, how liberal or conservative do you consider yourself?

Respond to the following question on a 1-9 scale, where 1 is "Extremely Liberal" and 9 is "Extremely Conservative": On most economic issues, how liberal or conservative do you consider yourself?

What is your main religious affiliation?

Atheist

Agnostic

Buddhist

Christian (Catholic)

Christian (Protestant)

Christian (Other)

Hindu

Jewish

Muslim

Spiritual but not religious

Other

If applicable, please more fully specify the religious affiliation you selected in the previous question. If applicable, what is your particular denomination?

Respond to the following question on a 1 to 9 scale, where 1 is "Not Religious" and 9 is "Extremely Religious": Indicate the extent to which you consider yourself to be religious

Which is the highest level of education you have completed?

No schooling completed

1st grade to 8th grade

Some high school, no diploma

High school graduate, diploma or the equivalent (for example, GED)

Some college credit, no degree yet

Trade/technical/vocational training

Associate degree

Bachelor’s degree

Master’s degree

Professional degree

Doctorate degree

Please state your ethnicity

White/Caucasian

Hispanic or Latino/Latina

Black or African American

Native American or American Indian

Asian American or Asian

Pacific Islander

Other

To the best of your knowledge, what is your total household income?

Under $10,000

$10,000 to $19,000

$20,000 to $29,999

$30,000 to $39,999

$40,000 to $49,999

$50,000 to $59,999

$60,000 to $69,999

$70,000 to $79,999

$80,000 to $99,999

$100,000 to $124,999

$125,000 to $149,999

$150,000 or greater

I don’t know / I prefer not to say

[Optional] Do you have any children?

Yes

No, but I probably will

No, and I'm not sure if I will

No, and I probably won't

Demographic Questions for UC Berkeley participants

(used after the Stabilization Wedge Activity in Experiment 4)

What is your name?

Please enter your gender/sex

How old are you?

What political party are you most affiliated with?

Democratic

Republican

Independent

Libertarian

Green

Other

None

Respond to the following question on a 1-9 scale, where 1 is "Extremely Liberal" and 9 is "Extremely Conservative": On most social issues, how liberal or conservative do you consider yourself?

Respond to the following question on a 1-9 scale, where 1 is "Extremely Liberal" and 9 is "Extremely Conservative": On most economic issues, how liberal or conservative do you consider yourself?

What is your main religious affiliation?

Atheist

Agnostic

Buddhist

Christian (Catholic)

Christian (Protestant)

Christian (Other)

Hindu

Jewish

Muslim

Spiritual but not religious

Other

If applicable, please more fully specify the religious affiliation you selected in the previous question. If applicable, what is your particular denomination?

Respond to the following question on a 1 to 9 scale, where 1 is "Not Religious" and 9 is "Extremely Religious": Indicate the extent to which you consider yourself to be religious

What year / program are you in at UC Berkeley?

Freshman

Sophomore

Junior

Senior

Master's degree

Professional degree

Doctoral degree

Other

What is your major/intended major?

Please state your ethnicity

White/Caucasian

Hispanic or Latino/Latina

Black or African American

Native American or American Indian

Asian American or Asian

Pacific Islander

Other

What did you think of this activity?

Appendix C: Text and Comprehension Questions Accompanying Solution Statistics (Experiment 2)

Condition 1: Sustainable Electrification

Electrification is a widely supported strategy for inhibiting climate change. It replaces technologies that use combustion–like coal heaters, gasoline vehicles, and natural gas heating–with alternatives that use sustainable electricity, such as electric vehicles and heat pumps. We have the knowledge and means to generate renewable electricity with near-zero greenhouse gas emissions (through wind, solar, or hydroelectric technology, etc.) and we already generate considerable electricity with them. So, such renewable-electricity fuel sources result in lower average carbon dioxide (CO_2) emissions than those using fossil fuels–and emissions will likely decrease further as the grid runs more efficiently. Large-scale electrifications, particularly of the transportation, building, and industrial sectors are central components of achieving net-zero emissions by 2050. Other lower-emission benefits include lower long-term energy costs for individuals and companies–and reduced air pollution from not burning fossil fuels. [138 words]

Comprehension Items:

What is an example of a technology that runs on combustion that can be replaced by an alternative that runs on sustainable/renewable electricity?

Please provide two proposed benefits of sustainable electrification.

Condition 2: Energy Efficiency

Making new products often requires extracting many kinds of material from the earth–for instance, by mining for metals, drilling for oil, or harvesting trees. These extracted materials must be moved and processed, which also requires a lot of energy. Products that are thrown away (trashed) end up in landfills, producing the largest source of human-caused methane (CH_4), a greenhouse gas molecule that traps about 23 times more heat than carbon dioxide (CO_2). Landfills, etc., also bubble out cancer-causing air pollutants known as carcinogens that contaminate groundwater–which provides drinking water for the majority of Americans (and is used to irrigate a third of our crops). Reusing our resources (recycling) is an effective way to reduce the amount of waste that must be sent to landfills, preventing pollution–and saving energy, natural resources, and money for consumers. [137 words]

Comprehension Items:

What is the largest source of human-caused methane (CH_4)?

Please provide two benefits of recycling and/or re-using resources.

Condition 3: Reducing Meat Intake

An increasing number of scientists show that reducing meat and dairy intake is the single most effective way for individuals to reduce their impacts on the planet. Livestock farming produces potent greenhouse gases, such as methane (CH_4) and nitrous oxide (N_2O), through processes such as feed production, animal digestion, manure storage, and the use of fertilizers and pesticides. Raising animals also takes up a large portion of land, and thereby contributes to deforestation, water shortages, decreased biodiversity, and agricultural pollution (due to excessive nitrogen and phosphorus from fertilizer and manure). Such pollution causes both ocean "dead zones" and the depletion of freshwater resources. Reducing humans' meat intake, even slightly, would reduce greenhouse gas emissions, and also reduce global ocean acidification, lake damage, eutrophication (e.g., algae blooms), and land use. Eating less meat would also provide health and cost benefits. [139 words]

Comprehension Items:

Please provide two concerns associated with livestock farming.

Please provide two benefits associated with reducing meat intake.

Appendix D: Comprehension and Reflection Questions Following all Versions of the Text (i.e., individual+struggle, company+struggle, individual+no struggle, company+no struggle) for Experiment 3

Comprehension Questions

In what year did production at Carter Wind Energy's 25,000 square-foot warehouse peak?

What proportion of Texas' electricity is currently being generated by wind?

Reflection Questions

Why was Carter Wind Energy founded?

Which obstacles did Carter Wind Energy/Jay Carter Sr. and Jr. overcome in order to reach their goals?

How did Carter Wind Energy/ Jay Carter Sr. and Jr. overcome these obstacles?

Appendix E: Task-Based Semi-Structured Interview Protocol (Experiment 4)

What researchers say/do	Why researchers say/do it	Possible Responses	How to respond to those responses
Hello! My name is Leela and I am from the Education department. First of all, thank you very much for agreeing to take part in this study. I hope that you will enjoy it and find it interesting.	Introduce myself	Nice to meet you. That sounds great. Are you going to publish this?	Yes, and that's why we have you sign our consent form.
You'll notice that I am recording this session. I am doing this because I don't want to miss anything that you say. If at anytime you do not wish to be recorded, please let me know and I can stop at any time. This study will take around an hour and each of you will be compensated $20 for your time, with an Amazon Gift card. Does anyone have any questions so far?	Let students know they will be filmed, how long the study will take, and how much they will be expected to be paid. Let students understand their rights as volunteer participants.	Are you going to show this to anyone?	There's a slight possibility this data might be presented at a conference, but if it is, everything will be fully anonymized.
The first thing I would like you to do is to complete a pre-test. Please indicate when you're finished with a thumbs up.	Ask participants to fill out the pre-test	What do you mean by question [x]?	Please answer the survey as best you can, and there should be a space at the end where you can note down questions or confusions.

Pair Dynamic Manipulation – a), b), c), d) or e) depending on condition

	What researchers say/do	Why researchers say/do it	Possible Responses	How to respond to those responses
a)	I would like you to talk to each other and come up with three things that all of you have in common.	Make group membership more salient	We're stuck / can't think of anything	Brothers or sisters? Pets? Live in California? Majors? Like crisps / chocolate? Been to another state?
b)	I would like each of you to share something that you are worried about. [I can go first]	Emotional Sharing (to increase group cohesion and shared perspectives)	I can't think of anything. Getting overwhelmed.	Anything in terms of schoolwork / the pandemic? I'm sorry to hear that and thank you very much for sharing – I appreciate it.
c)	I'm going to play a song and ask that all of us, me included, to clap along with it.	Interaction ritual	Concerns about internet lag	That's fine, just do the best that you can.
d)	Here is a line of poetry ["words, words were truly alive on the tongue"] and I would like you to try and read it out loud at the same time, or simultaneously. I will give you a maximum of 5 minutes to practice.	Joint Action	Concerns about internet lag What does it mean / where is this line from?	That's fine, just do the best that you can. It's from a poem called 'Little Red Cap' by Carol Ann Duffy
e)	----	Control condition		

Stabilization Wedges Game Activity

What researchers say/do	Why researchers say/do it	Possible Responses	How to respond to those responses
On the slide in front of you, there are 15 high-level strategies that can be taken to reduce greenhouse gas emissions. Each strategy or wedge corresponds to saving 1 billion tons of carbon dioxide per year. Alongside each wedge, there is a description of each strategy, and an indication of the costs and challenges associated with each.	Introduce the game.	I'm not familiar with some of these strategies / I don't know what some of these words mean.	Is there a particular word or phrase that is causing you confusion?
I would like you to work together to choose which 8 wedges out of the 15 strategies to focus on in order to reduce emissions by 2060. You can use a wedge more than once, if you want, but you can only use a whole number of wedges. You can also use a maximum of 6 electricity wedges (E), 5 transportation wedges (T) and 5 heat or direct fuel wedges (H)	Introduce the objective	Why are there limits on what wedges we can use?	That's a good question. The limits were determined by experts.
I would firstly like you to drag and drop your strategy into the table below and then secondly to guess the score that each stakeholder group would give your team's strategy on a scale of 1 to 5 (1 being very bad, and 5 being the best).	Instructions	What is a stakeholder? How do I know what score would be given by each stakeholder?	A stakeholder is someone who has a stake or involvement in an issue. You will need to put yourself in the mindset of each stakeholder group.
Is that clear? Do you have any questions?	Clarifications /	Did you design this game?	No, it was designed by

We will take a maximum of 30 minutes	Questions		a team at another University.
	Give timing estimate	How will we know when time's up?	I will give you a 15, 5, and 3 minute warning.
		Will we not get paid if we don't get an answer?	You will be paid regardless, but please try and come to a final answer.
		What if we don't finish within the time?	Please try your best to finish within the time.

Debrief / Post-test

What researchers say/do	**Why researchers say/do it**	**Possible Responses**	**How to respond to those responses**
(if time) ask participants to talk me through their strategies / stakeholder's score	Clarification of justifications (those which aren't clear when participants were communicating with each other)	We just randomly put down a number.	Why was it randomly a (e.g., 5) rather than (e.g., a 4)? What are some things this group of stakeholders value?
I would now like to ask you to fill out a post-test, which is almost identical to the pre-test. Please indicate with a thumbs up when you are done.	Present post-test		

That is the end of the experiment. Thank you very much for participating! I will send both of you an Amazon gift card for $20 at the email address you request by the end of the day. Do either of you have any questions before you go?	End experiment / debrief	What was this about?	Finding ways to increase collective hope about global warming.

Appendix F: Accompanying Materials for Experiment 4

Overview of Solutions Shown to Participants

Stabilization Wedges – 15 Ways to Cut Carbon

= Electricity Production, =Heating and Direct Fuel Use, =Transportation, = Biostorage

Strategy	Sector	Description	1 wedge could come from…	Cost	Challenges
1. Efficiency – Transport		Increase automobile fuel efficiency (2 billion cars projected in 2050)	… doubling the efficiency of all world's cars from 30 to 60 mpg	$	Car size & power
2. Conservation - Transport		Reduce miles traveled by passenger and/or freight vehicles	… cutting miles traveled by all passenger vehicles in half	$	Increased public transport, urban design
3. Efficiency - Buildings		Increase insulation, furnace and lighting efficiency	… using best available technology in all new and existing buildings	$	House size, consumer demand for appliances
4. Efficiency – Electricity		Increase efficiency of power generation	… raising plant efficiency from 40% to 60%	$	Increased plant costs
5. CCS Electricity		90% of CO_2 from fossil fuel power plants captured, then stored underground (800 large coal plants or 1600 natural gas plants)	… injecting a volume of CO_2 every year equal to the volume of oil extracted	$$	Possibility of CO_2 leakage
6. CCS Hydrogen		Hydrogen fuel from fossil sources with CCS displaces hydrocarbon fuels	… producing hydrogen at 10 times the current rate	$$$	New infrastructure needed, hydrogen safety issues
7. CCS Synfuels		Capture and store CO_2 emitted during synfuels production from coal	… using CCS at 180 large synfuels plants	$$	Emissions still only break even with gasoline
8. Fuel Switching – Electricity		Replacing coal-burning electric plants with natural gas plants (1400 1 GW coal plants)	… using an amount of natural gas equal to that used for all purposes today	$	Natural gas availability
9. Nuclear Electricity		Displace coal-burning electric plants with nuclear plants (Add double current capacity)	… ~3 times the effort France put into expanding nuclear power in the 1980's, sustained for 50 years	$$	Weapons proliferation, nuclear waste, local opposition
10. Wind Electricity		Wind displaces coal-based electricity (10 x current capacity)	… using area equal to ~3% of U.S. land area for wind farms	$$	Not In My Back Yard (NIMBY)
11. Solar Electricity		Solar PV displaces coal-based electricity (100 x current capacity)	.. using the equivalent of a 100 x 200 km PV array	$$$	PV cell materials
12. Wind Hydrogen		Produce hydrogen with wind electricity	… powering half the world's cars predicted for 2050 with hydrogen	$$$	NIMBY, Hydrogen infrastructure, safety
13. Biofuels		Biomass fuels from plantations replace petroleum fuels	… scaling up world ethanol production by a factor of 12	$$	Biodiversity, competing land use
14. Forest Storage		Carbon stored in new forests	… halting deforestation in 50 years	$	Biodiversity, competing land use
15. Soil Storage		Farming techniques increase carbon retention or storage in soils	… practicing carbon management on all the world's agricultural soils	$	Reversed if land is deep-plowed later

For more information, visit our website at http://cmi.princeton.edu/wedges.

Instructions Given to Participants:

Using the options presented on the previous slide, record your Strategies to reduce total fossil fuel emissions by using 8 wedges by 2060 on the following slide. (1 "wedge" = 1 billion tons carbon per year)

You may use a strategy more than once
You may use a maximum of

- 6 electricity wedges (E)
- 5 transportation wedges (T)
- 5 heat or direct fuel use wedges (H)

Stakeholder Table (part 2)

Stakeholder	Taxpayer/ Consumers	Energy Companies	Environmental Groups	Manufacturers	Industrialized country governments	Developing Country Governments
Score each Stakeholder would give solution (1-5):						

Instructions Given to Participants:

Estimate the score each stakeholder group would give your pair's solution on a scale of 1 to 5 (5=best).

Appendix F: Coding Scheme Developed from "Stabilization Wedge Activity" Discussions

	A	B	C	D	E	F	G
	SOCIAL CONCERNS	POLITICS / SOCIAL JUSTICE	ECONOMIC	INFRASTRUCTURE/ TECHNOLOGY	SUSTAINABILITY	ENERGY	RANGE OF SOLUTIONS
2	Consensus	Foreign dependency	Cost	Infrastructural challenges	Good for the environment	Energy production	Balance of solutions
3	Competing Interests	Geopolitical differences	Incentives to change	Improving accessibility	Concerns	Byproducts of energy consumption and production	Compatible solutions
4	Personal Concerns	Political struggle	Cost effective	Increasing efficiency	Sustainable versus. unsustainable land management	Energy storage	Conflicting solutions
5	Convenience	US vs. global	Jobs	Making improvements versus building new	Demands of growing population	Transition measure	
6	Individual vs. organizational behavior	Government	Value of land	Flexibility / ease of transition.	Competing land use	Sustainable versus unsustainable energy source	
7	Opportunity for self-efficacy	Global in scale	Switching costs	Effectiveness		Availability of land and space	
8	Perception of change		Inequitable costs	Short term versus long term consequences		Preventing versus recapturing	
9	Familiarity		Cost for business and government versus individual	Weighed consequences			
10	Belief			Natural versus mechanical intervention			
11	Social Justice						
12	Rural versus urban						