Fear and Serenity in a Changing Climate:
Emotional Reactions to Climate Exacerbated Commons Dilemmas

by

Peter M. Sugrue
B.Sc., University of Rhode Island, 2014

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We acknowledge with respect the Lekwungen peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.

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Supervisory Committee

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Abstract

The climate change mitigation targets to maintain a relatively stable climate may not be met. Even if targets are met, substantial climate change could occur. In a changing climate, how can social science facilitate composed decision making? One way is through studying emotional reactions to a changing climate. Therefore, this thesis examined how engagement with climate catastrophe scenarios influenced various emotions. Relative to other conditions, “negative” emotions (e.g., *fear*) were predicted to increase in scenarios related to climate change, and “positive” emotions (e.g., *serenity*) were predicted to decrease in the same scenarios.

Participants engaged with one of five conditions, four of which reflected environmental effects (e.g., local harmful effect from climate change). Before and after condition engagement, participants took a questionnaire of specific emotions. Conditions that described environmental harm were associated with large decreases in “positive” emotions (e.g., *serenity*) compared to other primes. However, they were not consistently associated with “negative” emotions (e.g., *fear*). Conversely, qualitative responses frequently mentioned increases in feelings of “fear” or “sadness”; however, decreases in emotions like “calmness” were rarely mentioned.

Error played some role in emotional measurement. Nonetheless, psychological research about climate change may include a blind spot: focusing on emotions that are provoked by climate change while ignoring emotions that are depleted by it. A decrease in a “positive” emotion (e.g., calmness) may be conceptually distinct from an increase in an assumed “negative” counterpart (e.g., fear). What are the implications of this distinction? Does avoidance of climate change stem from fear of the subject, or more from its perception as a “buzzkill”? Overall, research of emotional reactions to climate change could facilitate engagement, mitigative behavior, contingency planning, and a more composed transition in a changing climate.

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Dedication

This thesis is dedicated to those most affected by climate change, who are overwhelmingly those least responsible for its occurrence.

Fear and Serenity in a Changing Climate

Although the Paris Agreement represents unprecedented international cooperation in the reduction of greenhouse gasses (GHGs), the nonbinding targets are not nearly enough to reach the agreement's goals; even if every country honors its GHG reduction pledge, global temperatures will rise by more than 2° Celsius beyond preindustrial levels before the end of the century (Rogelj et al., 2016; UNEP, 2016). Additionally, temperature feedback cycles that would push climate change out of human control could occur with as little as a 2°C rise in global temperatures (Hansen et al., 2013). Given the prospect of harmful, and perhaps catastrophic, climate change effects, humans need to adapt physically, socially, and psychologically. Psychological adaptation is only recently gaining attention.

Psychological research about climate change often attempts to facilitate engagement with mitigative pro-environmental behavior (PEB) within present social contexts (APA, 2011; Clayton, Devine-Wright, Stern, Whitmarsh, Carrico, Steg, Swim, & Bonnes, 2015; Stokols, Misra, Runnerstrom, & Hipp, 2009). This is an admirable and necessary pursuit. Nonetheless, social scientists are also equipped to study strategies that help people maintain their composure in stressful contexts (van Vugt, 2009). In a changing climate, these contexts may well include dramatically increased environmental and economic impacts (e.g., food systems; Porter et al., 2014), migration (Warner, Hamza, Oliver-Smith, Renaud, & Julca, 2010), and inter-group conflict (Carleton, Hsiang, & Burke, 2016; Hsiang, Burke, & Miguel, 2013).

Together, these circumstances suggest a possible future of unprecedented chaos for which human society is not prepared. The humanitarian progress made over the past century is at risk; if such circumstances arise, humanity will attempt to adapt to staggering challenges. The emotional effects that accompany situations of threat and uncertainty may overwhelmingly influence decision making about limited and less predictable resources in the context of climate change. Therefore, this study attempted to test the following research question: *When people imagine themselves in an adverse situation in which environmental and economic impacts are caused by climate change, which discrete emotions are elicited*

In this study, climate change scenarios seemed to drive decreases in participants' "positive" emotions (i.e., *serenity*, *joviality*) more than it drove increases in "negative" emotions (i.e., *fear*, *hostility*, *guilt*, and *sadness*). Measurement error could have contributed substantially to the results. Nonetheless, this research contributes toward understanding specific emotional reactions to climate change scenarios. It also considers whether certain emotions can be treated as opposite ends on the same spectrum (i.e., *fear* and *serenity*); if this cannot be assumed, emotional engagement with climate change should not be reduced to the negative emotions with which it is frequently associated (e.g., *fear*). For example, perhaps climate change is avoided as a conversation topic because of its potential to undermine positive emotions (i.e., "climate change is such a buzzkill") rather than elicit negative emotions (e.g., *fear*).

1.1 Predicted psychosocial effects from climate change

Climate change is indicative of a social dilemma, and can also instigate social dilemmas (Clayton et al., 2015; Rachlinski, 2000; van Vugt, 2009), or situations in which individual short-term interests conflict with collective long-term interests (Van Lange, Joireman, Parks, & Van Dijk, 2013). Many social dilemmas may be harder to address as people continue to interact with climate change, especially common's dilemmas, or dilemmas with shared and scarce recourses (e.g., space for pollution buildup, fish stocks). Research about social dilemmas that might be exacerbated by climate change can inform composed decision making. As climate change unfolds, such research could focus on fundamental resources under chronic stress (e.g., water), as well as global decisions that might be made in a state of panic (e.g., geoengineering).[1]

Climate change can clearly influence how people interact with social dilemmas through physical pressures (e.g., the available amount of a shared resource). Additionally, psychological pressures that accompany climate change can influence social dilemma decision making. Specific physical climate change effects (e.g., large and unseasonal hurricanes, fish stock shortages) may carry signature psychological impacts, and the accompanying psychological impacts may influence how social dilemmas are further addressed.

The psychological effects of climate change are beginning to be comprehensively considered (Doherty & Clayton, 2011; Gifford, 2008; Reser & Swim, 2011; Trombley, Chalupka, & Anderko, 2017) particularly for those affected by acute and diversified impacts (e.g., natural disasters, floods, droughts, species extinction, increased disease propensity, loss of place; see APA, 2011). Personal experience with temperature anomalies seems to influence climate change belief (Kaufmann et al., 2017); perhaps the same anomalies influence emotions related to climate change. Conversely, the baseline at which the public considers a temperature anomalous seems to be driven by recent experience, and other research suggests that temperature anomalies become normalized over time (Moore, Obradovich, Lehner, & Baylis, 2019).

Beyond personal experiences with weather indicative of climate change, it may come with pervasive psychological effects, such as widespread anxiety (Trombley et al., 2017) and solastalgia (i.e., “the distress or desolation caused by the gradual removal of solace from the present state of one’s home environment”; Albrecht, 2011, p. 50). Particularly in the context of a

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[1] This includes various plans to artificially cool Earth’s climate (e.g., solar radiation management; see Barrett, 2008)

sensationalist media paradigm, climate change could broadly trigger increased engagement with existential threat (Adams, 2016), with chronic stress, insecurity, and feelings of helplessness (Stokols et al., 2009), and with uncertainty and limits to personal control (Barth, Masson, Fritsche, & Ziemer, 2018).

Many of these effects are essential elements of anxiety (Lazarus, 1991), which has already been documented as a symptom of current and anticipated ecological crises (Gifford & Gifford, 2016; Doherty & Clayton, 2011). An adversely changing environment results in diminished predictability, and therefore, control over one's life: "A perceived lack of personal environmental control is one of the most ubiquitous determinants of aversiveness, anxiety, and distress" (Reser & Swim, 2011, p. 283). Further, anxiety is fundamentally theorized to cause immobilization, indecision, and—depending on the magnitude and centrality of the source—"a personal crisis of major proportions" (Lazarus, 1991, p. 234). If such effects occur, what are the implications for human decision making and social conduct in a radically changing climate?

Increased ideological polarization, intergroup animosity, ingroup conformity, and resource mismanagement are expected to follow from both salient existential threat (Fritsche, Jonas, Kayser, & Koranyi, 2010; Kasser & Sheldon, 2000; Solomon, Greenberg, & Pyszczynski, 1991), and increased uncertainty (Hopfensitz, Mantilla, & Miquel-Florensa, 2018; Hogg, 2014; Smith, Hogg, Martin, & Terry, 2007; Hine & Gifford, 1996). Given the current expansion of political polarization around the world (see Somer & McCoy, 2019), and the exacerbated environmental and economic impacts expected from climate change (e.g., Gregory, Ingram, & Brklacich, 2005), ignorance about social and psychological interactions within such contexts is worrisome.

Overall, humans are already undermining their collective interest in the climate change social dilemma: As climate change continues and humans are forced to engage with it, how will decisions about new and exacerbated social dilemmas be influenced? One source of influence is through the emotional effects that accompany situations of threat and uncertainty.

1.2 Exploring emotional reactions to climate change

The predicted psychological effects from climate change should be tested rather than assumed. Their importance as potential mediators through which climate change influences human interaction makes empirical confirmation even more essential. Research around the question of how people psychologically react to climate change induced threat can critically inform subsequent questions about how people behaviorally, socially, economically, and ethically react to such circumstances.

Climate change threat has frequently been studied under the subject of risk perception (e.g., Leiserowitz, 2005; van der Linden, 2014), which has matured in recent decades in its understanding of influences from affect and emotion (Loewenstein, Weber, Hsee, & Welch, 2001), particularly for environmental risks (e.g., Böhm, 2003; Leiserowitz, 2006; Weber, 2006). Research on the emotional aspects of climate change has increased, including its associations with fear (e.g., van Zomeren, Spears, & Leach, 2010) and distress (e.g., Hornsey, Fielding, McStay, Reser, Bradley, & Greenaway, 2015). Such studies often attempt to elicit an emotion (e.g., fear) and climate change threat simultaneously by employing a threatening prime. Then, the effects of that prime are compared on a variety of dependent variables (e.g., risk perception, pro-environmental behavior, acknowledgment of climate change, etc.).

These manipulations have been disparate and far from uniformly effective (e.g., Barth et al., 2018; Fritsche et al., 2012; Feinberg & Willer, 2011; Hornsey et al., 2015; Pyszczynski, Motyl, Vail, Hirschberger, Arndt, & Kesebir, 2012; O'Neill & Nicholson-Cole, 2009; Scannell & Gifford, 2013; van Zomeren et al., 2010). Unfortunately, some of these studies assume specific emotional reactions or evaluate them with manipulation checks that are unstandardized and psychometrically questionable. Even when manipulation checks are used, only a single emotional reaction is usually assessed (e.g., fear). Comparisons between emotions (e.g., fear, guilt, sadness, anger) are usually absent (but see, Böhm, 2003; Hornsey & Fielding, 2016), as are inquiries into possible effects on "positive" emotions (e.g., happiness, calmness). Additionally, individual and contextual moderators for such associations have scarcely been explored (e.g., individual values, local vs. global climate change effects; but see Scannell, & Gifford, 2013). Therefore, human adaptation to climate change would greatly benefit from research about emotional reactions to climate change, emotional reactions to the types of situations climate change is expected to foster, and behavioral implications from those emotional reactions.

1.3 Emotional reactions to climate exacerbated commons dilemmas

This thesis compared the emotional reactions of several groups, which corresponded to climate change related primes. Several emotions were measured with a questionnaire, including specific negative emotions, such as *fear*, *hostility*, *guilt*, and *sadness*, as well as positive emotions, such as *joviality* and *serenity*. The primes were constructed to compare emotional reactions and isolate the effect of climate change (see section 2.3.1). Also, environmental attitudes were assessed for potential interactions. Overall, when participants engaged with climate change, negative emotions were expected to increase substantially, and positive emotions were expected to reciprocally decrease. *Fear* was expected to increase more than the other negative emotions. Specific hypotheses of effect size and direction can be found below (see

Table 1). Accordingly, this study evaluated how various aspects of climate change influenced multiple dependent variables, which included emotional states and environmental attitudes?

As in previous studies, several primes, or scenarios, were developed to investigate the hypothesized effects. Multiple factors were considered in the primes' construction. First, communication of scientific certainty is thought to facilitate prime engagement (see Myers, Maibach, Peters, & Leiserowitz, 2015); however, climate change has been notorious for the scientific uncertainty about specific future scenarios (Hollin & Pearce, 2015). Informing participants of scientific predictions without a factual basis could be unethical; however, the future could not be perfectly predicted by researchers. How, then, could participants engage with the future in a way that was scientifically legitimate, yet was not restricted to the most confident scenarios, which often necessarily constitute the least threatening for climate change (for conservative tendencies in the drafting of the IPCC report, see Brysse, Oreskes, O'Reilly, & Oppenheimer, 2011; Mann, 2014)?

In one climate change threat manipulation, Pyszczynski et al., (2012) first asked participants to set aside their scientific beliefs about climate change and consider the possibility of specific scenarios. Similarly, in his radio series 'Climate Wars', Dyer (2010) asked his audience to acknowledge that the future is unpredictable, but also to temporarily engage in a plausible narrative about what the world could look like if global temperature targets were not met. Simply because scientists cannot guarantee future occurrences that are consistent with the worst aspects of climate change does not mean such occurrences are not worth consideration. Hence, this study's primes (see Appendices A-E)[2] were largely based on Pyszczynski's et al., (2012) manipulation, in which participants were asked to consider the following: "Regardless of

[2] See Appendices Folder at this website: https://osf.io/esvta/

whether global climate change is real and happening, or will happen sometime in the future, think about what it would be like if it DID happen."

A second crucial consideration for facilitating prime engagement was the activity itself. In previous studies, many primes used to elicit climate change threat were passive. For example, some posed as news articles or educational videos (e.g., Feinberg & Willer, 2011), and others posed as information posters (e.g., Scannell & Gifford, 2013): Participants usually were not required to actively engage with the prime. Other primes provoked minimal engagement by asking participants to respond to dichotomous items (i.e., yes or no) designed to elicit climate change related threat (e.g., "Rising sea levels will make some coastal areas uninhabitable"; Barth et al., 2018; Fritsche et al., 2012).

Pyszczynski et al. (2012) addressed this problem by drawing on terror management theory (TMT; Solomon, Greenberg, & Pyszczynski, 1991), which has often attempted to elicit *mortality salience* as an independent variable in related research. Specifically, in a climate change threat prime, Pyszczynski et al., (2012) asked participants to write about the ways in which individuals and groups would react to the prime's scenario. Asking participants to take time to reflect and write about such details should increase their engagement more than passive manipulations. Accordingly, a similar request was made in this study's primes (see Appendices A-E).

Notably, a growing number of digital manipulations for future engagement with climate change have been used (e.g., Groulx, Lemieux, Lewis, & Brown, 2017; Schroth, Angel, Sheppard, & Dulic, 2014). For example, Shepard (2012) developed a comprehensive guide for visualizing climate change that includes future scenarios. Some research has demonstrated the utility of 3D visualization for practicing climate change decision makers (e.g., Reiter, Meyer, Parrott, Baker, & Grace, 2018; Schroth, Pond, & Sheppard, 2015). Others have demonstrated the effect of proximity to a visualization and the subsequent effect on climate change risk perception (Retchless, 2018).

Such instruments can be immersive, and thus, might be substantially more engaging than others mentioned above. These manipulations often attempt to directly engage participants in future contexts *within* a changed climate rather than asking them to consider *future* changes. Such manipulations tend to be very localized, and they should be considered for future studies.

A third consideration was the scale of the prime's scenario. Specifically, perceived local climate impacts have been more impactful for a variety of outcomes (e.g., pro-environmental behavior) than global climate impacts (e.g., Gifford et al., 2009; Scannell & Gifford, 2013; Stokols et al., 2009). However, the influence of geographic scale on associations between climate change and various emotions has not been tested; therefore, both local and global scenarios were tested as separate conditions in this study (see Appendices C & D).

This study's conditions also included a separate prime with an exceedingly similar threat that was not attributed to climate change (see Appendix B). Also, another prime included a non-threatening scenario that was attributed to climate change (see Appendix A), and a final prime—considered a control scenario—simply asked participants to write about their day and did not mention anything about climate change or the environment (see Appendix E). These primes, along with measures of emotion and environmental attitudes, were used to further inform how people emotionally engage with scenarios in which climate change threatens shared resources.

1.4 Hypotheses

To reiterate, five primes were constructed to elicit and compare climate change-related threat (see Appendices A-E). These included engagement with (1) a benign local climate change-triggered effect, (2) a deleterious local effect not triggered by climate change, (3) a deleterious local effect triggered by climate change (primary condition of interest), (4) a deleterious global effect triggered by climate change, and (5) a control condition in which participants were asked to write about their day. These groups were compared on several outcomes of discrete emotions and environmental attitudes. Between-condition hypotheses used the third condition, the deleterious local effect triggered by climate change (see Appendix C), as the meaningful reference group in the analyses (i.e., all other conditions were compared to this one for confirmatory outcomes). With this reference group, the research questions could be best informed with the fewest a-priori predictions, which helped to attenuate type-1 error. Other between-condition comparisons were done later in an exploratory fashion. MANOVA and discriminant function follow-up analyses were also used to more fully explore these data.

Hypotheses of effect size direction and magnitude were preregistered before data collection (see osf.io/gqpuw) and can be viewed in Table 1. Overall, negative emotions—*fear* in particular—were predicted to increase in conditions related to climate change, and positive emotions (i.e., *joviality* and *serenity*) were predicted to decrease in conditions related to climate change. However, some exceptions to that trend were predicted (see emotional sections below). Also, comparisons were expected to yield stronger effects for different emotions (see Table 1 and sections below). Effect sizes were also specified for environmental attitudes (i.e., fear of climate change, perceived risk of climate change), which were used as manipulation checks in studies with related conditions (i.e., van Zomeren et al., 2010; Hornesy et al., 2015).

1.4.1 Fear

The largest emotional effects between conditions are expected for *fear*. Climate is traditionally associated with fear: Although societies and humans have cultivated various emotional discourses around climate, themes of anxiety and fear occur throughout the human experience, particularly in relation to future climates (Hulme, 2009; Hulme, 2008). This fear can even be existential on a societal level, with associations between climate, catastrophe, and even societal destruction. Historically, extreme weather events were often associated with divine justice or judgement in reaction to sin (e.g., the biblical flood; see Boia, 2005; Hulme, 2008); and currently they are often seen as deserved irony considering humanity's abuse of the natural world (see Boia, 2005). The vastness and awe that come with climatic events can also produce fear prompted by one's powerlessness to resist them (e.g., hurricanes, tornadoes). Additionally, the attribution of volatility and 'capriciousness' to climate is almost necessarily a source of anxiety and fear through its unpredictability.

Table 1.
Cohen's d Predicted for CC_Local Condition Compared to All Other Conditions

	Control	Benign	Non-CC	Global
Fear	> 0.70[a]	> 0.70[a]	0	0.20-0.39[c]
Hostility	0.40-0.69[b]	0.40-0.69[b]	0.20-0.39[c]	0
Guilt	0.40-0.69[b]	0.40-0.69[b]	0.40-0.69[b]	0.20-0.39[c]
Sadness	0.40-0.69[b]	0.40-0.69[b]	0	0.20-0.39[c]
Joviality	- 0.40-0.69[b]	- 0.40-0.69[b]	0	0
Serenity	< - 0.70[a]	< - 0.70[a]	0	0
CCFear	> 0.70[a]	> 0.70[a]	> 0.70[a]	0.20-0.39[c]
CCRisk	> 0.70[a]	> 0.70[a]	> 0.70[a]	0.40-0.69[b]

Note. All effect sizes predicted above are Cohen's *d*. Positive values indicate that outcomes will be higher in the CC_Local condition compared to other conditions, negative values indicate that outcomes will be lower in the CC_Local condition compared to other conditions. < -0.70 indicates the effect size will be -.71 or lower (i.e., it would be a large effect size in the opposite direction). Lower bound sample size requirements of the smallest group to detect a significant standardized mean difference assuming $\alpha = .05$ and $1-\beta = .80$: [a]($n = 33$), [b]($n = 99$), [c]($n = 393$).

Media discourse surrounding climate change, when present, frequently has been "alarming" (Risbey, 2008), fear-inducing (O'Neill & Nicholson-Cole, 2009), and focused on danger and vulnerability (Manzo, 2009). Carvalho and Burges (2005) studied three phases of climate change media coverage in Britain. When it was present, it was frequently characterized by danger. Nerlich and Jaspal's (2014) analysis of media covering the IPCC's 2011 extreme weather report found multiple emotional associations with media imagery; particularly, "the theme of threat and danger from extreme weather" recurred between various extreme weather events (e.g., flooding, hurricanes, drought, depletion of animal life), particularly when those images pertained to the audience's locality and perceived in-group. "Extreme weather images are, it seems, mainly symbols of threat, fear and vulnerability, which is consistent with established iconographies of climate change (Manzo, 2009)" (as cited in Nerlich & Jaspal 2014, p. 272). Conversely, repeatedly reported narratives of fear around climate change could be overwhelming for some, and diminish the seriousness of the issue for others.

Studies that have analyzed the relation between climate change and emotions frequently concentrated on fear and anxiety; however, these were often studied in relation to pro-environmental behavior (PEB; e.g., Chen, 2016; Feldman & Hart, 2016; Hornsey & Fielding, 2016; Koenig-Lewis, Palmer, & Dermody, 2014; van Zomeren, Spears, & Leach, 2010) and did not always quantify the reaction of fear to climate change. Effects on fear in some studies may be analogous to the current one, in which experimental manipulations were administered. In Hornsey's et al. (2015) study, one group was exposed to a low threat condition, and the other a high threat condition. These included reading an article that considered more optimistic estimates of climate change projections from the IPCC (although still negative), or an article that considered more pessimistic estimates from the same source. Significant differences for *perceived risk of climate change* were detected between conditions, $t(1, 210) = 3.61$, $p < .001$, Cohen's $d = 0.50$.

Van Zomeren et al. (2010) tested their manipulation in two experiments. In their first study, one group read a brief summary about how fossil fuels increase atmospheric temperature. A second group also read this summary, but additionally read about negative effects anticipated from climate change. Significant differences for *fear of climate change* were found, $t(1, 101) = 2.13$, $p = .036$, Cohen's $d = 0.42$. In their second study, the fear group also watched a video clip from *An inconvenient truth*, and viewed pictures of local impacts from previous extreme weather events. Increased differences were observed between this group and the first group, $t(1, 74) = 3.05$, $p = .003$, Cohen's $d = 0.71$.[3]

Chen (2016) also used manipulations meant to elicit fear of climate change and tested their effect on *evoked fearful emotion*. Chen's low fear condition was the no fear condition from Van Zomeren, Spears, and Leach (2010). The moderate condition featured an additional description of local (i.e., Taiwan) anticipated climate change effects. The high fear condition built upon the previous two by including a picture of a starving polar bear and a caption citing climate change as the cause. Strangely, the effects on *evoked fearful emotion* were the opposite of what was anticipated; the moderate fear condition was associated with less climate change risk perception than the low fear condition, $t(1, 141) = -2.15$, $p < .034$, Cohen's $d = 0.36$, and the high fear condition was associated with insignificantly less *evoked fearful emotion* than the moderate fear condition, $t(1, 143) = -0.64$, $p < .53$, Cohen's $d = 0.11$.

In the studies above, every group interacted with climate change in some way; however, the current study included the comparison of a threatening climate change prime to one in which climate change is absent. Therefore, for that comparison, the effect on *fear* was predicted to be

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[3] The Cohen's *d*s were not reported in Hornsey et al., (2015) and Van Zomeren et al., (2010), but calculated using Lakens's (2013) spread sheet.

larger than those mentioned above. Conversely, the studies above compared differences in *fear of climate change* and *climate change risk perception* specifically, which could be expected to be more pronounced than differences in *fear* generally. Nonetheless, the effect on *fear* was expected to be *high* between the local climate change condition and the control condition in the current study (i.e., Cohen's $d > .70$) because of the level of engagement with the prime and the absence of climate change in the control condition.

1.4.2 Other emotions

The primes were expected to have some effect on *hostility*, *guilt*, and *sadness*, because they are mentioned frequently in relation to climate change (e.g., Carvalho & Burges, 2005), and they have been studied in relation to environmental risk (e.g., Böhm, 2003). However, effects on these emotions were not expected to be as strong as the effects on fear. Also, in relation to climate threat, previous literature has found that these emotions could be particularly influenced by individual qualities such as gender (du Bray, Wutich, Larson, White, & Brewis, 2019) or political disposition (Myers, Nisbet, Maibach & Leiserowitz, 2012).

Anger and hostility. One reason hostility was considered is because of its prevalence within current political discourse. The politicization of climate change through media coverage (see Carvalho, 2010) could enable responses of hostility towards the issue (Bamberg, Rees, & Seebauer 2015), such as "who is to blame." Several studies have considered anger towards the self (Lu & Schuldt, 2015), a pro-environmental behavior (Meneses, 2010), and the perceived culprits of climate change (Reese & Jacob, 2015; Bamberg et al., 2015; Rees & Bamberg, 2014; Harth, Leach, & Kessler, 2013). Notably, many of these studies examined the effect of anger on pro-environmental behavior; they did not necessarily provide effects for how climate change influences anger. Therefore, because their statistical effects were not directly comparable to those tested in this study, and because anger is regularly examined as an assumed reaction to climate change, medium effect sizes were predicted for *hostility*.[4] Also, helplessness and cynicism associated with climate change can facilitate frustration (Cross, Gunster, Marcelina, & Daub, 2015; Immerwahr, 1999), which could be associated with hostility, but which is not within the PANAS-X framework.

Guilt. Nerlich and Jaspal's (2014) analysis of media imagery also suggested that guilt and blame may be salient when climate change images are related to anthropocentric causes (e.g., automobiles, high-rise buildings); although these emotions were not as pronounced as fear. Some studies mentioned above also considered guilt as a potential motivator for pro-environmental behavior (e.g., Rees & Bamberg, 2014; Harth, Leach, & Kessler, 2013), and several more have investigated guilt as a primary predictor of PEB (e.g., Antonetti & Maklan, 2014; Bissing-Olson, Fielding, & Iyer, 2016; Ferguson, & Branscombe, 2009).

However, is guilt initially elicited from engagement with climate change? Böhm (2003) compared different levels of specific emotions elicited by twenty environmental risks. Although guilt and shame were reportedly less intense than many other emotions (e.g., fear) across all environmental risks, some risks for which they were the highest relate directly to climate change (i.e., vehicle air pollution, fossil fuel consumption). Also, in the current study, participants were asked whether they acknowledged climate change, including anthropogenic sources. Those who did not were screened out in the analyses; therefore, the degree to which denial of climate change and misattribution of its causes would attenuate guilt should be partialed-out, resulting in an overall stronger effect. Therefore, the estimated effect sizes for the elicitation of guilt in the local

[4] This construct is called hostility in this study because of the PANAS-X characterization; however, it is called anger in most studies cited here.

climate change condition, compared to that of the control, the benign, and the non-climate change condition, were medium (Cohen's d > 0.40-0.69, see Table 1), and less than those expected for fear.

Sadness. In the current study, the species extinction element of the local climate change scenario may elicit some degree of sadness compared to the control and the benign scenarios. Indeed, of a variety of environmental risks, species extinction has elicited greater sadness than other emotions (Böhm, 2003); and these items concentrated on the loss of species rather than the causes of such losses. Therefore, the cause of extinction (e.g., climate change) is not expected to influence the effect of sadness. However, this effect is expected to be more pronounced in the local condition compared to the global climate change prime because participants may be more attached to local species than to others around the globe. Therefore, the climate change local prime is predicted to elicit somewhat more sadness than the control and benign primes (Cohen's d = 0.40-0.69), a similar degree of sadness to the non-climate change prime (Cohen's d = 0), and a little more sadness than the global climate change prime (Cohen's d = 0.20-39).

Joviality. *Joviality*, or similar emotions such as happiness, are rarely discussed in relation to climate change, both in popular media (Gunster, 2011) and academic literature. Therefore, a large effect on *joviality* is not anticipated. However, some level of *joviality* may be attenuated by engagement with climate change; therefore, a medium effect was specified above. In this study, the decrease in *joviality* is expected to function as a reciprocal effect from the increase in assumed opposites, particularly *sadness* within the PANAS-X framework (see Ready, Vaidya, Watson, Latzman, Koffel, & Clark, 2011).

When comparing the climate change local condition to the control and the benign conditions, effect sizes for *joviality* were predicted as reciprocals of those predicted for *sadness*

(Cohen's *d* = 0.40-69). The decrease in *joviality* may fundamentally stem from describing environmental destruction rather than engagement with climate change; therefore, an insignificant difference was predicted when comparing the climate change local and non-climate change conditions. Also, no reason was anticipated for the global scale scenario to differentially influence *joviality* than the local scale scenario, and an insignificant difference was also predicted for this comparison (see Table 1).

Serenity. *Serenity* is measured by how much one feels *calm*, *at ease*, and *relaxed*. These items are presumed opposites to many of the constructs predicted to increase from climate change in the literature described above (e.g., *fear*, *distress*, *anxiety*). With similar reasoning to that for effect size predictions for *joviality*, *serenity* is predicted to decrease in reciprocation with *fear* for the climate change local condition; however, when comparing the climate change local condition to the control and the benign conditions, a large effect is expected (Cohen's $d > 0.70$). Compared to the description of environmental destruction, no reason was found for an additional decrease in *serenity* from the mention of climate change; therefore, an insignificant difference was predicted when comparing the climate change local and non-climate change conditions. Similarly, no reason was found for a substantial decrease in *serenity* in global scale scenario relative to that of the local scale scenario, and an insignificant difference was also predicted for this comparison (see Table 1).

1.4.3 Previously measured variables

Two variables in the current study were constructed from previous manipulation checks in two studies mentioned above (i.e., Hornsey et al., 2015; Van Zomeren et al., 2010). Overall, the effects for the current study on the outcomes (i.e., *fear of climate change* and *climate change risk perception*) were expected to be higher than those of the respective studies because engagement with the primes in this study are not passive: they are assumed to be more engaging than previous manipulations. Also, unlike previous studies, the primary scenario of interest in the current study—local climate change condition—was compared to conditions in which climate change and environmental degradation are not mentioned. Overall, large effects are expected for the previous manipulation checks (see Table 1).

Chapter 2: Methods

2.1 Research design

To test the hypotheses, a pre-posttest, between-subjects design with one factor that has five conditions (i.e., benign, non-climate change, climate change local, climate change global, & control) was employed. First, planned comparisons were tested by OLS regression with categorical predictors; the conditions were dummy coded as the independent variables and change in emotion was the dependent variable. All comparisons for dependent variables of interest were later tested in an exploratory manner under the framework of MANOVA.

The invitation to participate (see Appendix J) warned participants that the study could be mildly stressful for those concerned about the environment.[5] Participants were asked to come to a university computer lab classroom to take the survey. First, they signed into the study, then chose a computer at which to take the survey. They were then sent an email with the survey link and proceeded to take the survey. During the survey, participants were first be asked to complete a questionnaire purported to measure emotions (PANAS-X; Watson & Clark, 1999; see section 2.3.2). Second, they were randomly assigned to one of the five primes (see Appendices A – E). Third, they were asked to complete the PANAS-X again. Fourth, they were asked to answer a series of questions about environmental attitudes and concerns (see Appendix F). Participants were subsequently asked about a series of demographic questions, the degree to which they are attached to the local region (i.e., place attachment), and some qualitative questions about the study (see Appendix H).

[5] Although this may have primed participants, warning participants of potential stress was considered ethically necessary. Additionally, this warning was provided for every participant, and because of random assignment to groups, it should not interfere with group comparisons. Admittedly, it might influence evaluations of within-group change.

Each participant was randomly assigned to only one of the five conditions (i.e., primes) Research personnel who interacted directly with the participants were not aware of the assigned conditions during participation. Item sequences within the first, third, and fourth measurement blocks (i.e., PANAS-X time 1, PANAS-X time 2, and environmental attitudes) were randomly generated for each participant.

2.2 Participants

Data collection. A sampling and an analysis plan were preregistered on September 10th, 2018 (see http://osf.io/gqpuw).[6] This was prior to the collection of data, which started on September 14th, 2018. For convenience, the target recruitment population was undergraduate students, mostly psychology majors, at a university in southern British Columbia. The participants were predominantly young adults enrolled in psychology classes at the university. The participants voluntarily signed-up for this study through SONA, a psychology research participation system. Participants were granted a small amount of class credit in exchange for their participation. The invitation that was posted on the SONA website can be found in Appendix J.

Participant characteristics. All sample characteristics were evaluated after exclusion criteria (see section 3.1.6) were applied (n = 139). For gender identification, 27 participants identified as *male* (19%), 112 as *female* (81%), and no participant identified as *other*. The reported year of birth fell between 1955 and 2000 (M = 1996; SD = 4.93). Very strong concentration was observed between the years 1994 and 2000 (*kurtosis* = 37.20, see Figure 1.1).[7]

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[6] Registration title: Equanimity in a Changing Climate
[7] See Figures folder at this website: https://osf.io/esvta/

Note, these values reflect the sample after one outlier value (*YoB* = 198) was replaced with a missing value.

Political orientation was measured with the following item: “Please rate your political orientation from -5 (extreme left) to +5 (extreme right)”. Although this is not an ideal measure of political orientation, this variable was not central to our research questions. Instead, it was meant to serve as a covariate or control variable in exploratory analyses. Only one participant did not respond to this item. A response frequency histogram (see Figure 1.2) shows a slight right skew (*skewness* = 0.35), indicating that the overall sample identifies as “center-left” politically (*M* = -1.06, *SD* = 2.04). This is consistent with the assumed population political orientation (i.e., undergraduate college students residing in a coastal city in British Columbia).

Southern Vancouver Island is a largely middle-to-upper class region. Socioeconomic status was measured with a self-report of subjective social status developed by Singh-Manoux, Adler, and Marmot (2003). Participants were shown a 9-point, vertical scale and asked to think of it as a ladder that represented aspects of socioeconomic status. The “best-off” were represented by the top of the ladder and the “worst-off” were represented by the bottom, and then participants were asked to indicate where they thought they stood. The responses were consistent with the area demographic: most responses were concentrated in the middle-to-upper portion of the scale (see Figure 1.3), and this was consistent with descriptive statistics, *mean* = 5.94, *SD* = 1.46, *skewness* = -0.42, *kurtosis* = -0.30. Use of this measure as a covariate or as an additional predictor in exploratory studies does not initially seem statistically problematic. For national identity, 115 participants (82.73%) identified as “Canadian”, and exactly half of the remaining participants mentioned Canada in their national identity description (e.g., Taiwanese-Canadian).

2.3 Variables

2.3.1 Manipulated conditions

Five primes were constructed to probe and compare emotional reactions. The primary prime of interest described a local and deleterious effect on the environment that was causally attributed to climate change. To maximize the emotional effect, the local scenario may have been exaggerated to a magnitude that might be seen in other parts of the world. Nonetheless, all scenarios were based on locally applicable resource issues and sound climate projections (CRD, 2017). After completing the study, participants were debriefed about regionally specific credible risk assessments for the topics considered in the prime scenarios and provided resources to investigate further (see Appendix I).

The primes' structure was loosely derived from Pyszczynski et al. (2015). In each prime, participants were asked to give a written response: "Please, list and describe some of the consequences global climate change would have on people living near you. Specifically, we are interested in the scenarios for how individual people, governments, and other groups might react if the following events were to actually happen. Also, describe some situations that would arise; what would they look and feel like. Please be as descriptive as possible." The request for elaborate, written responses served two purposes: first, to facilitate maximum participant engagement with the scenario, and second, to provide narrative data for qualitative analysis.

Fish production was the resource chosen for scenarios featured in this study. Fisheries are a significant resource for the population's region and culture. Also, marine life plays a vital part in the culture's economy. This effect is also commensurate with the anticipated dependent measure for sustainable behavior in subsequent studies, which is a computer simulated fishery common's dilemma (i.e., FISH 5.0, see Chen & Gifford, 2015; Hine & Gifford, 1996). Because of these factors, the following scenarios were constructed:

In the first condition (i.e., benign prime), participants engaged with a non-threatening environmental scenario with positive climate effects: "Small, but stable increases in fish production around Vancouver Island because of increased seagrass growth that is directly facilitated by climate change and ocean acidification" (see Appendix A). In the second condition, participants engaged with a resource threat that was not triggered by climate change: "Extreme and sudden fishing shortages around Vancouver Island from the mass extinction a of critical species in the marine food-web, which was directly caused by epidemic disease occurrence" (see Appendix B).

In the third condition—the primary condition of interest—participants engaged with a climate change effect that had deleterious effects on the resource considered for the local population: "Extreme and sudden fishing shortages around Vancouver Island from the mass extinction of a critical species in the marine food-web, which was directly caused by climate change and ocean acidification" (see Appendix C). The fourth condition was very similar to the previous one, but had a global focus: "Extreme and sudden fishing shortages around the globe because of the mass extinction of a critical species in the marine food-web, which was directly caused by climate change and ocean acidification" (see Appendix D). Local and global threats may differentially influence people’s emotional reactions to climate change; for example, local effects may be more engaging (Scannell & Gifford, 2013).

Finally, as a control condition, a fifth group was asked to describe their day and how they felt about it: "Please take a few minutes to describe your day so far. What happened and how did the events of today make you feel?" (see Appendix E).

2.3.2 Standardized instruments

Emotions were measured before and after the prime administration with the PANAS-X (Watson & Clark, 1999; see Table 2 & Appendix G). This is a 60-item instrument designed to measure both, general positive and negative affect, as well as eleven discrete emotions: fear, hostility, guilt, sadness, joviality, self-assurance, attentiveness, shyness, fatigue, serenity, and surprise. Hypotheses for condition comparisons on several of the discrete emotions can be found above (see Table 1).

Table 2
Item Composition of the PANAS-X Scales

General Dimension Scales	
Negative Affect (10)	afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset, distressed
Positive Affect (10)	active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, strong
Basic Negative Emotion Scales	
Fear (6)	afraid, scared, frightened, nervous, jittery, shaky
Hostility (6)	angry, hostile, irritable, scornful, disgusted, loathing
Guilt (6)	guilty, ashamed, blameworthy, angry at self, disgusted with self, dissatisfied with self
Sadness (5)	sad, blue, downhearted, alone, lonely
Basic Positive Emotion Scales	
Joviality (8)	happy, joyful, delighted, cheerful, excited, enthusiastic, lively, energetic
Self-Assurance (6)	proud, strong, confident, bold, daring, fearless
Attentiveness (4)	alert, attentive, concentrating, determined
Other Affective States	
Shyness (4)	shy, bashful, sheepish, timid
Fatigue (4)	sleepy, tired, sluggish, drowsy
Serenity (3)	calm, relaxed, at ease
Surprise (3)	amazed, surprised, astonished

Note. Reprinted from *The PANAS-X: Manual for the Positive and Negative Affect Schedule - Expanded Form,* by Watson and Clark (1999). Latent constructs are featured in the first column, and the respective survey items are featured to the right. The number of items comprising each latent construct is shown in parentheses. Items were rated on a five-point scale: “indicate to what extent you feel this way *right now*. Use the following scale to record your answers. 1 = very slightly or not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely.”

A primary reason why this instrument was chosen was because of its temporal flexibility. For a given item, the time frame can be changed in many ways: ‘please indicate to what extent you feel/felt this way (e.g., right now, today, over the past few weeks, over the past year, generally): cheerful.' All PANAS-X items asked about the current state a given participant was feeling (i.e., right now).

The effect between conditions on a general measure of environmental attitudes was also tested. This was accomplished with the New Ecological Paradigm (NEP; Dunlap et al., 2000; see Appendix F). This is perhaps the most widely used measure of environmental concern, and its structure has been verified in multiple contexts (Hawcroft & Milfont, 2010). However, the specific construct(s) that this instrument measures is still debated. Overall, it is used here to measure what Dunlap et al., (2000) describe as an "ecological worldview".

2.3.3 Previously measured variables

The manipulation checks from previous studies were both measured by combining values from multiple 5-point Likert scale items. *Climate change risk perception (CC_Risk;* Hornsey et al., 2015; Kellstedt et al., 2008) was measured with six items. Three items that pertained to personal risk perception (e.g., Climate change will have a noticeably negative impact on the environment in which my family and I live: 1 = strongly disagree, to 5 = strongly agree) and three items pertained to state risk perception (e.g., What is the risk of climate change exerting a significant impact on the environment in your state? 1 = no risk, to 5 = high risk). *Fear of climate change* (*CC_Fear*; Van Zomeren et al., 2010) was measured with the following items on a 5-point Likert scale: (1) I am fearful of the negative future consequences of the climate crisis; (2) I am afraid of the negative future consequences of the climate crisis (see Appendix F).

2.3.4 Additional measures (see Appendix H)

Acknowledgement of anthropogenic climate change was also measured. Ultimately, this line of research aims to address emotional engagement with climate change related environmental stressors. Denial of climate change's contribution to such stressors is likely to continue, but measuring emotional reactions from those who do not acknowledge climate change could confound the aim of this research. This study attempted to measure the emotional reaction from those who openly engage with the primes; those dismissive of climate change's effects may also dismiss several of these primes, and therefore, would likely muddle these effects. Therefore, the effects from those who do not acknowledge anthropogenic climate change were excluded. The measure was constructed by the researcher based on the fifth IPCC report (Collins et al., 2013). Three items were included to assess whether participants believed (1) that the climate is rapidly warming, (2) that humans are the primary cause, and (3) that these changes pose risks to human and natural systems.

Also, three items were selected from a measure of place attachment (Jorgensen & Stedman, 2001) and were included for exploratory analyses. Place attachment may help explain differences found between the third (local) and fourth (global) conditions. Finally, several demographic questions were also asked: gender, year of birth, socioeconomic status, political orientation, whether English was their first language, and nationality.

2.3.5. Qualitative responses

All the primes required a written response from participants, which can be seen in the conditions' descriptions above. These responses were qualitatively evaluated through thematic analysis, and then compared for nuances in emotional differences between conditions. Several other qualitative questions were asked at the end of the study: (1) participants were asked what they thought the purpose of the study was; (2) if they thought the scenario was threatening; (3) if they thought the scenario changed the way they felt in the moment; (4) whether people would generally try to preserve the resource if "extreme fishing scarcity were to happen", or if they would more rapidly deplete it; and (5) to consider leaving general comments about the study (see Appendix H).

2.4 Index procedures

Condition dummy coding. The prime featuring a localized climate change threat was of primary interest. Therefore, the categorical predictor was dummy coded with the primary condition of interest as the meaningful reference group (i.e., local climate change prime with negative consequences) to which the four other groups were compared.

PANAS-X. Items from the PANAS-X were asked twice, directly before and directly after the prime administration. Therefore, dependent variables (e.g., *fear*) was the *change* in fear from time one to time two. The responses in time one (e.g., *fear*: item 18, item 44, item 53, item 34, item 40, item 21) were added, and then subtracted from the sum of the corresponding items in time two to calculate the change in the discrete emotion (e.g., *change in fear*). These variables (i.e., change scores for discrete emotions) were used as the dependent variables in PANAS-X analyses. The indicators specific to each emotion, which correspond to the items in Appendix G, can be seen in Table 2.

Environmental attitudes. For the NEP (see Appendix F), responses were summed and then divided by the number of items, which resulted in a composite score of adherence to the new ecological paradigm (NEP) worldview. NEP even items (i.e., 2, 4,…14) were reverse coded. Participants in this study observed items in a random order that was idiosyncratic for each participant. The minimum possible NEP score was 1, in which all item responses were 1, or 5 on reverse coded items. A score of 1 represents a complete lack of the NEP worldview and a score of 5 represents complete adherence to it.

Responses for six items were added for a composite measure of climate change risk perception (Hornsey et al., 2015; see Appendix F). None of these items were reverse coded. A differentiation was not made between the sub scales of ‘personal’ and ‘state’ risk perceptions because of high correlations found between them in Hornsey et al. (2015). Finally, responses for two items were added for a composite measure of fear of climate change (Van Zomeren et al., 2010; see Appendix F).

2.5 Sample size rationale and stopping rule

A required sample size estimate was preregistered; however, it was based on an incorrectly executed power analysis. The effect size that was used (i.e., f^2) is for omnibus tests; however, these tests do not directly inform the hypotheses. Hypotheses were specified for group comparisons, and Cohen’s *d* was preregistered as the effect size of interest. Therefore, sample size requirements should have been calculated with respect to Cohen’s *d*.

The omnibus test power calculation yielded a total of 160 observations needed to observe a medium effect ($f^2 = .15$) across 5 groups at acceptable levels for statistical power ($1-\beta = .8$) and significance ($\alpha = .0021$). A Bonferroni adjustment was made to the alpha-level because of the potential for multiple comparisons to inflate type-1 error. Data from 204 individuals were gathered to account for the impact of exclusion criteria once they were applied (see Table 3). Nonetheless, once these criteria were applied, the sample decreased to 139, and the group specific samples ranged from 25 to 30. Even for the omnibus tests, the sample-one design was somewhat underpowered.

However, this design did not only attempt to test whether any pair of groups differed on any of the variables measured, but it attempted to predict very specific comparisons of directionality and magnitude for a series of outcome measures. To detect a medium Cohen’s *d* (i.e., *d* = 0.5) with an alpha level of .05 and power at .80, a two-sample group comparison requires 64 observations (i.e., individuals) in the smallest group (see Cohen, 1992; Champely, 2018). For the first sample, the primary group of interest was much smaller (*n* = 25); And because every comparison is made in reference to this group, and because it had the smallest subsample of all the groups, this is the sample size to be considered in power calculations. For an attempt to detect a Cohen's *d* of 0.5, with an alpha at .05 and a group sample size of 25, the resulting power is .41 (i.e., a 'medium' effect is more likely to be missed than found if it truly exists). Therefore, a second round of data were collected later and added to the first round for a better powered and more comprehensive analysis, which will be considered in a subsequent manuscript. Analyses and data collection were preregistered before this power miscalculation was noticed; therefore, that initial design was carried out as specified for the first round of data collection.

Chapter 3: Analyses

3.1 Statistical models

This study featured several, preregistered confirmatory analyses and used the Benjamini and Hochberg (1995) procedure to correct for the false discovery rate (FDR) from multiple tests. These analyses can be split into three categories: (1) emotional outcomes, (2) environmental outcomes, and (3) a mediation test to explain any group differences on the NEP. The first two sets of analyses estimate univariate, simple linear regression models (see Equation 1) with the prime conditions dummy coded as the independent variables. The dependent variable was the raw score on a given outcome of interest (e.g., difference scores for fear).[8] The primary condition of interest was coded as the meaningful reference group (i.e., local climate change prime with negative consequences).

$$Y_i = b_0 + b_1(Control_i) + b_2(Benign_i) + b_3(Non\_CC_i) + b_4(CC\_Global_i) + r_i \quad (1)$$

For all confirmatory models, the predicted outcome value of for the climate change local condition is b_0 (i.e., the regression intercept), which is simultaneously the mean outcome value for the reference group. For emotional outcomes, this is the mean change score for the climate change local condition. Hypothetically, if the control condition were to have a value of one for its slope (i.e., b_1), this would represent difference in the value of the control mean and the climate change local mean on the outcome variable raw score. Accordingly, a value of one for the benign slope (i.e., b_2) represents the difference in the value of the benign mean and the

[8] For several decades, the debate over whether Likert scales can be used as interval outcomes has followed psychology and social sciences (e.g., Carifio & Perla, 2008; Jamieson, 2004). These hypotheses were formulated and registered under the following assumption: Although a single item on a one to five scale is an ordinal measure, the summation of closely related items into a single measure can be treated as an interval outcome, or will act like an interval variable except in the case of extreme skewness (Norman, 2010).

climate change local mean on the outcome variable; and this pattern follows for the non-climate change condition (i.e., b_3), and the global climate change condition (i.e., b_4).

3.1.1 Emotional outcomes

Changes in six discrete—or specific—emotions (i.e., *fear*, *hostility*, *guilt*, *sadness*, *joviality*, & *serenity*) were tested as dependent variables in separate regression models, all of which had the same categorical predictor (i.e., Control, Benign, Non_CC, CC_Local, CC_Global). Four group comparisons were made in each model: the emotional outcome for the CC_Local group was compared once to each other group.

Given the number of separate conditions and outcome variables, adjustment for type-I error was paramount. If no planned comparisons had been declared, and every comparison was considered at the onset, 60 statistical tests would be needed for the emotional variables. This design is already underpowered for one comparison; running a multivariate test at the onset, then applying adjustments to 60 statistical tests could dramatically underpower the overall design. Instead, several univariate models were declared a priori, which reduced the number of tests needed to carry out the initial analysis. Also, this lends credence to any significant group comparisons observed: in the context of dozens of statistical tests, planning comparisons beforehand will better protect against type-I error than an initial, multivariate omnibus test. Therefore, MANOVA and all possible comparisons were reserved until after all planned comparisons were tested.

Four group comparisons multiplied by six models produces a total of 24 group comparisons for emotional outcomes. However, this is assuming that the omnibus test for each model is significant. Once group comparisons were made, the *p*-values for each comparison were listed in a single data-frame (provided their respective omnibus test was significant), and the

FDR correction was applied in R (R Core Team, 2019). After this correction, differences that maintained a *p*-value below .05 were considered significant.

3.1.2 Environmental outcomes

These outcome measures constitute manipulation checks from previous studies and, in the case of a large correlation, may be redundant. However, for direct comparison with those studies, they were still tested as separate outcomes. The procedure was very similar to the one above. Three environmental outcomes were tested as dependent variables (i.e., fear of climate change, climate change risk perception, and the new ecological paradigm (NEP)).

Four group comparisons were made for each model with the same reference group as above. Four group comparisons multiplied by three models produces a total of 12 group comparisons for environmental outcomes. Once the comparisons were made, the FDR correction was applied. Because 24 comparisons were made prior to these analyses, the correction was applied with consideration of the emotional outcomes as well (24 + 12 = 36). After this correction, differences that maintained a *p*-value below .05 were considered significant.

3.1.3 Mediation model.

Additionally, the environmental outcomes can be used to inform whether the distinct primes are influencing temporary states, or more persistent traits. Therefore, if any variance in the NEP were explained by the categorical predictor (i.e., group membership), a mediation model was to be employed to test whether fear of climate change and climate change risk perception account for that association. Because of the high correlation expected between fear of climate change and climate change risk perception, they were combined as a single variable for this contingency, resulting in a single mediation model. Prior to data collection, the plan to test this model included use of the *mediation* package in R (Tingley, Yamamoto, Hirose, Keele, &

Imai, 2014), and use of a nonparametric bootstrapped confidence interval with 10,000 Monte Carlo draws.

3.1.4 Follow-up and exploratory analyses

Anticipated follow-up analyses included MANOVA to consider all group comparisons for the emotional outcomes of interest and a discriminat function analysis to assess if specific emotional combinations best discriminated the groups (see section 4.5.8). Also paired samples tests were used evaluate standardized change of emotions within groups (see section 4.6).

The PANAS-X measures several other discrete emotions, which were tested for group differences subsequent to the analyses described above. Several have implications for relevant literature (e.g., self-assurance, fatigue, attentiveness). Also, any variance detected in shyness should not be explained by group membership. Once the group comparisons were made, the Benjamini and Hochberg (1995) correction for FDR was again applied to the cumulated *p*-values, which included those from previous analyses.

As stated before, three items from a measure of place attachment were included in the questionnaire (Jorgensen & Stedman, 2001). Several demographic variables (i.e., gender, nationality, political orientation, socio-economic status, year of birth, and English as first language) could influence the analyses described above and could have implications for related literature. Beyond those uses, they could be considered as covariates to confirm the influence of the categorical predictor over and above the influence of key demographics.

The analyses above, which include ancillary PANAS-X emotions, place attachment, and demographics, do not carry specific hypotheses and were analyzed in an exploratory manner. This was done primarily to bolster any evidence gathered in the confirmatory analyses. The mediation model was NOT considered exploratory and carries with it a clear a priori hypothesis.

Also, multivariate analysis (e.g., MANOVA) may be more appropriate for some combination of outcome measures; however, this was difficult to anticipate without considering correlations between dependent variables. Therefore, multivariate analyses were employed to further examine these data.

3.1.5 Data exclusion and missingness

First, participants' data were excluded (see Table 3) from analysis if the participant (1) did not complete at least 80% of the questionnaire, and (2) completed the questionnaire in at least two standard deviations below the mean duration. Here, the concern was not with participants who took a long time, but only with participants who rushed through the questionnaire. Participants' data were also excluded from analyses if the participant (3) answered one or more check questions (out of six) incorrectly (for check questions, see Appendix H), and (4) did not acknowledge anthropogenic climate change and that it has some negative consequences for humans.

Table 3.
Data Exclusion Criteria and Application

Criterion	Required Response	Participants Eliminated[1]	Sample Remaining	Applicable Participants[2]
Completion Rate	$\geq$ 80%	4	200	4
Duration	> (M – 2*SD)	0	200	3
Check Questions	All	47	153	51
Q80: Please validate your continued participation by selecting extremely as how you feel *right now*:	5			39
Q81: Please validate your continued participation by selecting very slightly or not at all as how you feel *right now*:	1			30
Q82: I have eaten a plant at some point in my life.	$\geq$ 4			15

Table 3. cont.
Data Exclusion Criteria and Application

Check Questions	All	47	153	51	
Q83: To validate your continued participation, please strongly agree with this statement.	5				7
Q84: Please validate your continued participation by selecting very slightly or not at all as how you feel *right now*:	1				22
Q85: Please validate your continued participation by selecting extremely as how you feel *right now*:	5				22
Climate Change Acknowledgement:	All	14	139*	22	
Q130: Do you believe that the earth's climate is rapidly warming?	Yes				13
Q131: Do you believe that human influences are the primary cause of rapid warming in the earth's climate observed in recent decades?	Yes				14
Q132: Do you believe that that climate change will amplify existing risks and create new risks for natural and human systems?	Yes				7

Note. Original sample (*N* = 204).
[1]Participants eliminated after previous exclusion criteria were applied.
[2]Number of applicable participants including those who had previously been excluded.
*Final sample
Response options for Q80, Q81, Q84, Q85: 1 = very slightly or not at all; 2 = a little; 3 = moderately; 4 = quite a bit; 5 = extremely. Response options for Q82, Q83: 1 = Strongly Disagree; 2; 3; 4; 5 = Strongly Agree.

Missing data were not anticipated. Participants were required to respond to many items before moving onto subsequent items. Some responses were optional, but these were qualitative inquiries about the study and did not pertain to quantitative confirmatory analyses. In the case that a participant completed 80% of the questionnaire without completing the items required for confirmatory analyses—a scenario that seems unfeasible—their data were subject to listwise deletion.

Chapter 4: Results

4.1 Outcome descriptive statistics across groups

Table 4.

Descriptive Statistics and Internal Consistencies Across Conditions

Outcome	Mean	SD	Possible Range Min	Possible Range Max	Skew	Kurt	α[a]	95% CI Lower	95% CI Upper
Fear_t1	8.24	2.64	6	30	1.60	2.52	0.76	0.69	0.82
Hostility_t1	7.98	2.79	6	30	2.23	6.06	0.81	0.76	0.86
Guilt_t1	8.71	4.03	6	30	2.19	5.30	0.91	0.89	0.93
Sadness_t1	8.99	3.84	5	25	1.29	1.66	0.86	0.82	0.89
Joviality_t1	18.56	6.06	8	40	0.54	0.24	0.92	0.9	0.94
Serenity_t1	9.79	2.50	3	15	0.03	-0.56	0.78	0.72	0.83
Fear_t2	9.33	3.63	6	30	1.29	1.41	0.84	0.79	0.88
Hostility_t2	9.12	3.82	6	30	2.02	5.86	0.88	0.85	0.91
Guilt_t2	9.83	4.27	6	30	1.28	1.26	0.91	0.89	0.93
Sadness_t2	9.22	3.88	5	25	1.22	1.64	0.87	0.83	0.90
Joviality_t2	15.02	5.80	8	40	0.96	0.81	0.92	0.9	0.94
Serenity_t2	8.31	2.95	3	15	0.37	-0.38	0.89	0.85	0.92
Fear	1.09	2.94	-24	24	1.08	2.11	0.71	0.62	0.78
Hostility	1.14	3.03	-24	24	1.23	2.63	0.78	0.72	0.84
Guilt	1.12	3.17	-24	24	0.67	2.49	0.77	0.71	0.83
Sadness	0.24	2.38	-20	20	-0.10	3.40	0.60	0.49	0.70
Joviality	-3.54	4.37	-32	32	-0.41	0.46	0.77	0.70	0.82
Serenity	-1.48	2.31	-12	12	-0.41	0.25	0.71	0.61	0.78
CCFear	8.89	1.56	2	10	-1.69	3.17	0.91	0.87	0.93
CCRisk	24.63	3.57	6	30	-0.55	0.30	0.78	0.72	0.83
NEP[b]	4.01	0.42	1	5	-0.37	0.25	0.75	0.68	0.81

Note. $n = 139$.

[a] Raw Cronbach's α.

[b]Outcome is the mean of item scores. All other outcomes are the sum of item scores.

t1 is time one, or before primes; t2 is time two, or after primes, other emotions indicate difference scores.

Table 4 features several descriptive statistics across all groups. They correspond to emotions at each occasion of measurement, the difference scores for those emotions, and environmental attitudes. Below, notes on these descriptive statistics are also featured. The corresponding histograms for each outcome can be seen in Figures 2.1.1—2.9. For a more comprehensive evaluation of the descriptive statistics, please see Appendix K.1. In Table 6,[9] all within-group descriptive statistics, including means, standard deviations, Cronbach alphas, skewness, and kurtosis, can be found for specific measures at time one, time two, and for their difference scores.

Internal consistencies for the negative emotions—*fear*, *hostility*, *guilt*, and *sadness*—ranged from adequate to very consistent at both time one and two. However, the change scores for negative emotions were not as consistent (Cronbach's α = .60—.78). Internal consistencies for positive emotions—joviality and serenity—were like those of negative emotions: they were high at each occasion of measurement but were not as consistent for the change scores (Cronbach's α = .71—.77). Fear of climate change (i.e., CC_Fear) only had two items that were very highly correlated, r = .83, 95% CI [.73, .90]. Climate change risk perception (i.e., CC_Risk) and the NEP demonstrated mediocre internal consistencies (Cronbach's α = .68—.72) for further analysis.

Change scores for negative emotions were all positive, indicating a net increase in negative emotions across groups; however, change in *sadness* was close to zero. A potential floor effect was detected, but these scores had substantial room to increase during the second occasion of measurement. Therefore, their distribution should not necessarily undermine this study's ability to detect increases in *fear* at the second occasion of measurement. *Fear* did not seem to

[9] See Tables Folder at this website: https://osf.io/esvta/

change for many participants, but increases were more frequent than decreases (see Figure 2.1.3). Histograms of score frequencies for other negative emotions (see Figures 2.2.1—2.4.3) showed similar patterns to *fear*.

The means for serenity and joviality were high at time one compared to those of the negative emotions, even when accounting for the differences in possible responses.[10] Scores for both emotions are close to normally distributed, and they occur across the range of possible outcomes (see figures 2.5.1 to 2.6.3). Overall, *joviality* and *serenity* exhibit more variability and normality in their distributions than the negative emotions; therefore, effects for these emotions may be more pronounced, or easier to detect. The NEP response distribution (see Figure 2.9) is very close to normal. However, this distribution resides within the higher range of possible scores (range = 2.67—5.00). This could stem from a population-level characteristic (i.e., this population shows high adherence to the New Ecological Paradigm). If engagement with a given scenario were to increase environmental attitudes, the effect might be difficult to detect.

4.2 Outcome correlation matrix.

Correlations between outcomes of interest (see Table 5) were low to medium in magnitude with one exception; *fear* and *hostility* were moderately to highly correlated (r = .62). Despite the size of this correlation, testing both emotions was not seen as redundant. The structure of this measure's factors will be addressed when an adequate sample size is collected.

[10] One can deduce this from taking the mean, then dividing it by the minimum possible response (i.e., number of items), both of which are featured in Table 4.

Table 5.
Correlation Matrix for all Confirmatory Outcomes.

	Fear	Hostility	Guilt	Sadness	Joviality	Serenity	CCFear	CCRisk	NEP
Fear	1.00								
Hostility	0.62	1.00							
Guilt	0.44	0.52	1.00						
Sadness	0.38	0.34	0.46	1.00					
Joviality	-0.20	-0.33	-0.44	-0.43	1.00				
Serenity	-0.49	-0.49	-0.40	-0.23	0.45	1.00			
CCFear	0.22	0.22	0.12	0.09	-0.04	-0.15	1.00		
CCRisk	0.16	0.05	0.07	0.16	-0.09	-0.04	0.45	1.00	
NEP	0.23	0.29	0.15	0.24	-0.03	-0.10	0.49	0.43	1.00

Note. All emotion outcomes are change scores. The correlations between two given emotions indicate the degree to which they changed in tandem across all conditions.

4.3 Confirmatory analyses: Assumptions

Several statistical assumptions were assessed before running the confirmatory models. For a more comprehensive evaluation of these assumptions, see Appendix K.2. Individual independence was assumed for all observations. Normality of the outcome residuals were evaluated visually and inferentially (see Table 7). Overall, violations of residual normality are suspected to detract power to observe effects for the following outcomes: *fear*, *hostility*, and *CC_Fear*.

Overall, the number of observations in each group are similar enough to eliminate concern of type-I error inflation from heterogeneity of sample variances. Nonetheless, the assumption was assessed visually (see Figures 5.1—5.9) and inferentially. Levene's test is only significant for outcomes of *fear* and *hostility* (see Table 8). The larger outcome variances correspond to smaller group sample sizes in most group comparisons for *fear* and *hostility*. In all but one comparison, the small effect that heterogeneity of variance could have on the result would be underestimation of the *F*-statistic significance level (i.e., it would underpower the ability to detect a significant omnibus effect). In the comparison for which this is not the case (i.e., the larger group sample size has the larger variance), the variances are very similar. Heterogeneity of sample variances will not contribute to type-I error inflation, and it may negligibly influence type-II error inflation.

Table 7.
Normality for Confirmatory Outcomes Across Groups

Outcome	Shapiro-Wilk (*W*)	*p*-value	Skew	Kurtosis	QQ_Judgement
Fear	0.94	< .001	1.08	2.11	heavy-tailed
Hostility	0.89	< .001	1.23	2.63	heavy-tailed
Guilt	0.95	< .001	0.67	2.49	light-tailed
Sadness	0.93	< .001	-0.10	3.40	light-tailed
Joviality	0.98	= .049	-0.41	0.46	normal
Serenity	0.98	= .035	-0.41	0.25	normal
CCFear	0.80	< .001	-1.69	3.17	left-skew heavy; ceiling
CCRisk	0.97	= .003	-0.55	0.30	normal; ceiling
NEP	0.99	= .165	-0.37	0.25	normal

Note. $N = 139$
Emotions refer to change scores

The use of change scores as an outcome variable does not account for differences in baseline scores, which could emphasize, or obfuscate, observed effects. To test for group differences at the first occasions of measurement, separate regression analyses were conducted with time one emotional outcome scores as the dependent variable, and the condition groups as dummy coded predictors. Boxplots for emotions at time one (see Figures 4.1-4.6) were also evaluated to identify any baseline group differences.

Inferentially, no group differences were found for *fear*, *sadness*, *joviality*, or *serenity* on the first occasion of measurement. The omnibus test for *hostility* at time one was significant, $F(4, 134) = 2.77$, $p = .030$. Although no significant differences were detected, some group comparisons are worth mentioning: The climate change global group featured higher hostility scores than the control group and the non-climate change group. If the hostility happened to be provoked more strongly in the CC_Global group relative to the other groups, the effect might be more difficult to detect.

Table 8.
Homogeneity of Variance Evaluation: Levene's Test and Outcome Variances by Group

Outcome	Levene's Test	*p*-value	CC_Local (*n* = 25)	Control (*n* = 30)	Benign (*n* = 29)	Non_CC (*n* = 26)	CC_Global (*n* = 29)
Fear	$F(4, 134) = 3.78$	< 0.01	*13.08*	3.84 (-)	4.21 (-)	7.44 (-)	12.61 (-)
Hostility	$F(4, 134) = 4.97$	< 0.01	*13.71*	4.32 (-)	6.36 (-)	5.16 (-)	14.97 (+)
Guilt	$F(4, 134) = 2.44$	= 0.05	*7.76*	3.94 (-)	12.18 (+)	11.88 (+)	14.64 (+)
Sadness	$F(4, 134) = 1.34$	= 0.26	*4.86*	2.46 (-)	3.85 (-)	6.99 (+)	9.79 (+)
Joviality	$F(4, 134) = 0.21$	= 0.93	*15.52*	14.45 (-)	21.44 (+)	15.36 (-)	21.6 (+)
Serenity	$F(4, 134) = 0.64$	= 0.63	*6.08*	3.06 (-)	5.62 (-)	3.95 (-)	4.28 (-)
CCFear	$F(4, 134) = 1.21$	= 0.31	*2.12*	3.41 (+)	2.33 (+)	1.42 (-)	2.93 (+)
CCRisk	$F(4, 134) = 1.09$	= 0.37	*12.66*	17.13 (+)	13.61 (+)	6.48 (-)	14.26 (+)
NEP	$F(4, 134) = 1.63$	= 0.17	*0.13*	0.29 (+)	0.12 (-)	0.17 (+)	0.18 (+)

Note. -/+ signs next to the group specific variances indicate whether that variance was greater or less than the variance of the reference group, which had the smallest sample size out of all groups. Reference group variances are italicized. Emotional outcomes refer to change scores.

A boxplot group comparison (see Figure 4.3) shows that the control group reported a lower level of *guilt* at time one. Although the omnibus test was not significant, one significant group comparison was detected; a lower level of *guilt* was observed at time one for the control group compared to the benign group. Overall, the control group may have started with artificially lower scores than the other groups, which can lead to an overstated change in guilt in two ways: (1) If guilt for the control group rises in tandem with other groups, the degree of change might be overstated. Also, (2) if the control group's guilt at the second occasion of measurement is similar to the baseline-level in other groups, an artificial increase in guilt could be detected for the control group.

4.4 Confirmatory analyses: Results

Group specific means and standard deviations can be found in Table 6 for all outcome variables considered.[11] Note, for the following analysis, only comparisons to the local climate change group are considered, and these are summarized in Table 9.[12] For a more comprehensive evaluation of the confirmatory results, see Appendix K.3. Table 10. mirrors the hypotheses from Table 1. It shows the observed Hedges' *g* for the comparison and the FDR adjusted *p*-value from the confirmatory analyses. It also shows a judgement of whether the null hypothesis (i.e., equal means) was retained, rejected, or whether the design was too underpowered (i.e., .80 $\geq$ 1-β) to detect the comparison's hypothesized effect.

Table 10.
Hedges' g *and FDR Adjusted* p*-values for Planned Comparisons to CC_Local Condition*

	Control			Benign			Non_CC			CC_Global		
Emotion	*g*	*p*	HYP	*g*	*p*	HYP	*g*	*p*	HYP	*g*	*p*	HYP
Fear	0.34	0.76	Retain	0.46	0.60	Retain	0.12	0.99	UND*	0.34	0.60	UND
Hostility	0.31	0.86	UND	0.01	0.99	UND	0.00	1.00	UND	0.38	0.60	UND
Guilt	0.31	0.99	UND	0.28	0.92	UND	0.15	0.99	UND	0.16	0.99	UND
Sadness	0.67	0.56	UND	0.39	0.76	UND	0.40	0.60	UND	0.02	0.99	UND
Joviality	0.84	0.09	UND	0.02	0.99	UND	0.03	0.99	UND*	0.03	0.99	UND*
Serenity	1.12	0.00	Reject	0.39	0.60	Retain	0.04	0.99	UND*	0.03	0.99	UND*
CCFear	0.19	0.99	Retain	0.13	0.99	Retain	0.14	0.99	Retain	0.03	0.99	UND
CCRisk	0.14	0.99	Retain	0.11	0.99	Retain	0.12	0.99	Retain	0.05	0.99	UND
NEP	0.24	0.92	NA	0.15	0.99	NA	0.22	0.99	NA	0.14	0.99	NA

Note. HYP refers to the hypothesized effect, which can be found in Table 1. The HYP columns show rejection or retention of the null hypothesis of equal means for planned comparisons. Planned comparisons that were underpowered to observe the predicted effect size are denoted with UND. Comparisons that were not planned are denoted with NA. Specific hypotheses for the NEP were not registered; however, CC_Local comparisons to other groups for the NEP were included in the FDR adjustment. Therefore, their effect sizes and FDR adjusted *p*-values are included in this table. *Predicted to be 0 and *g* < .2

[11] See Tables Folder at this website: https://osf.io/esvta/
[12] See Tables Folder at this website: https://osf.io/esvta/

With the dummy coded prime as the only predictor, significant omnibus tests were detected for the *fear* model—$F(4, 134) = 3.52$, $p = 0.009$, $\eta_p 2 = .095$—and the *hostility* model—$F(4, 134) = 2.45$, $p = 0.049$, $\eta_p 2 = .068$. Omnibus tests for *guilt* and *sadness* were insignificant. Nonetheless, *p*-values for all preregistered group comparisons were considered when applying the FDR correction. Significant omnibus tests were detected for the *joviality* model—$F(4, 134) = 3.58$, $p = 0.009$, $\eta_p 2 = .096$—and the *serenity* model—$F(4, 134) = 7.03$, $p < 0.001$, $\eta_p 2 = .173$. Omnibus tests for environmental attitudes were insignificant. Specifically, the following tests were executed: fear of climate change—$F(4, 134) = 0.48$, $p = .75$, $\eta_p 2 = .014$—climate change risk perception—$F(4, 134) = 0.34$, $p < .85$, $\eta_p 2 = .01$—and the NEP—$F(4, 134) = 0.74$, $p < 0.57$, $\eta_p 2 = .02$.

Despite the significant omnibus test for *fear* or *hostility*, those exposed to the local climate change prime did not significantly differ from any other group changes according to the FDR adjusted *p*-values. After the FDR adjustment was applied, the hypothesized effect was observed in only one case: compared to the control condition, the group in the local climate change condition dropped significantly in *serenity* Hedges' $g = 1.12$, 95% CI [0.29, 1.69], FDR adj. *p*-value < 0.005. Compared to the climate change local condition, the benign, the non-climate change, and the climate change global did not significantly change in *serenity* and *joviality*: no comparison *p*-values were below .05, even before applying the FDR adjustment. The climate change local condition also did not differ on any measure of environmental attitudes compared to other groups.

4.5 Exploratory analyses: MANOVA

4.5.1 MANOVA assumptions

First, a MANOVA was considered for appropriately correlated outcome variables (see Tables 11.1 and 11.2, and Appendix K.4). Then, all comparisons were made between groups for the variables above and the FDR adjustment was applied. Finally, discriminant function analysis was employed to find specific combinations of outcome variables that best separated the groups. With these post-hoc analyses, one can consider whether groups varied in one emotional response (e.g., *serenity*) or some meaningful combination of them (e.g., *fear* and *hostility*). One can also consider the relative contribution of various outcomes to group differences (e.g., *serenity* explains group differences more than *fear*).

Based on Tabachnick and Fidell's (2001) suggestions for compatible MANOVA outcomes, blocks of compatibility were observed between the emotional outcomes and the environmental attitude outcomes. A theoretical selection of MANOVA outcomes would also point to these same blocks, which is encouraging. Therefore, two MANOVAs were executed: the first featured the emotional outcomes (i.e., Fear, Hostility, Guilt, Sadness, Joviality, and Serenity) and the second featured environmental attitude outcomes (Fear of Climate Change, Climate Change Risk Perception, and the New Ecological Paradigm). Statistical assumptions were assessed for each block of dependent variables separately.

Multivariate normality. Within-group multivariate normality was assessed with the Mardia tests of skewness and kurtosis, which was calculated with the *MVN* package in R (Korkmaz, Goksuluk, & Zararsiz, 2014). For the emotional outcomes, the primary condition of interest—CC_Local—demonstrated multivariate normality, as did the non-climate change condition. The other conditions showed high and significant levels of multivariate skewness and kurtosis (see Table 13.1[13] and Appendix K.4). When considering the environmental outcomes, the primary condition of interest—the local climate change condition—was significantly skewed, but did not demonstrate significant kurtosis. The global climate change condition demonstrated the same pattern. The control condition demonstrated significant skew and kurtosis. The benign and the non-climate change conditions demonstrated multivariate normality (see Table 13.2[14] and Appendix X.4). For evaluations of univariate normality of residuals across groups, see Appendix X.2, Table 7, and Figures 3.1—3.9. Tables 12.1—12.5[15] can be used to evaluate within-group univariate normality with outcome specific values for Shapiro-Wilk tests.

Homogeneity of variance-covariance matrices. Any heterogeneity of the variance-covariance matrices was predicted to have minimal influence on these analyses because of similarly sized groups, which ranged from 25 to 30. Also, violation of this assumption is sensitive to departures of normality (Tabachnick & Fidell, 2001, p. 330), which have been demonstrated above. Nonetheless, the assumption of equal covariance matrices across groups was tested for emotional outcomes, Box's M (84) = 138.79, p = .00016, and for the environmental outcomes, Box's M (24) = 29.45, p = .2036. Because Box's M is notoriously sensitive, a significant departure from matrix equality is indicated when the test's p-value < .001 (Tabachnick & Fidell, 2001, p. 330). Therefore, a significant departure was detected for the emotional outcomes, but not detected for the environmental outcomes. The observed departure should a minimal influence on the emotional omnibus test. For a more comprehensive review of linearity, see Appendix K.4

[13] See Tables Folder at this website: https://osf.io/esvta/
[14] See Tables Folder at this website: https://osf.io/esvta/
[15] See Tables Folder at this website: https://osf.io/esvta/

Linearity MANOVA assumes linearity between each pair of dependent variables within groups (Tabachnick & Fidell, 2001). Violation of this assumption will reduce the power to detect differences between groups. To evaluate linearity, each outcome was regressed onto each other outcome in separate multiple regressions, and this was repeated within each group. These models were used to create curvature tests: an outcome of interest was considered in isolation with each other outcome as a predictor, and the square of that predictor was then tested for additionally explained variance in the outcome of interest. Also, a linear combination of the other outcomes (e.g., all the other outcome variables in a MANOVA) was tested for an effect, and the square of that linear combination was also tested for additionally explained variance. For the emotional variables, 216 curvature tests were calculated and 41 were significant. The curvilinear relations might undermine detecting a significant omnibus MANOVA test for emotions. For the environmental attitude outcomes, 54 curvature tests were calculated and six were significant. The curvilinear relations are unlikely to influence the omnibus MANOVA test for environmental attitudes. For a more comprehensive review of linearity, see Appendix K.4 and Tables 14.1 and 14.2.[16]

Multicollinearity and singularity. For MANOVA, if variance in a dependent variable is substantially explained by the other dependent variables, or a near-linear combination of the other dependent variables, the original dependent variable may provide redundant information, and the standard error of that variable may be unstable (Tabachnick & Fidell, 2001). To investigate further, the multiple regression models calculated from the linearity assumption were used to calculate the total variability explained in each dependent variable. Condition indices and variance proportions for outcomes were also assessed for collinearity, which was done with the

[16] See Tables Folder at this website: https://osf.io/esvta/

perturb package in R (Hendrickx, 2019). No indications of unacceptable multicollinearity or singularity were found when evaluating outcome squared multiple correlations[17] (see Tables 15.1 and 15.2). No condition indices above 30 were observed in the emotion model (MAX = 3.85), or in the environmental attitude model (MAX = 24.05). Collinearity should not be a problem for these data (see Tables 16.1 & 16.2). For a more comprehensive evaluation of multicollinearity and singularity, see Appendix K.4.

4.5.1 MANOVA results

Omnibus results. A one-way multivariate analysis (MANOVA) was executed to test the hypothesis of no mean differences between groups in emotional change for six emotions: *Fear*, *Hostility*, *Guilt*, *Sadness*, *Joviality*, and *Serenity*. A statistically significant effect was detected, $F(4, 134) = 2.12$, $p = .002$, Wilks' $\Lambda = 0.689$, $\eta^2 = 0.089$. The MANOVA omnibus test for environmental outcomes—*CCFear*, *CCRisk*, and the *NEP*—was not significant, $F(4, 134) = 0.58$, $p = .858$, Wilks' $\Lambda = 0.949$.

Multiple comparisons. All multiple comparisons for emotional outcomes (i.e., 60) were tested for exploratory analyses. Six univariate ANOVA models were constructed, each of which corresponded to an emotional outcome. Each model was estimated using type III sum of squares to eliminate the influence of group order. A contrast scheme was constructed that specified every group comparison absent the combination of any groups (10 total comparisons). The intercept for each model was dropped and the coefficients for each group (i.e., group means for a given emotional outcome) were saved. Then, the means were compared via the contrast scheme for every emotion. Descriptive statistics, *t*-values, and raw *p*-values were saved, and the FDR correction was applied to every comparison. Finally, Hedges' *g* coefficients and confidence

[17] These can easily be converted into variance inflation factors (VIFs) or tolerances

intervals were calculated for each comparison. Results for comparisons with an FDR adjusted *p*-value below .05 can be found in Table 17.1: If the data were randomly generated from null distributions, one could expect three significant comparisons—out of 60—from chance alone. Results for all comparisons can be found in Table 17.2.[18]

Table 17.1

All Emotional Comparisons Retaining Statistical Significance After FDR Adjustment

Conditions		Emotion	*SE*	*t*	*p*	*p*	Hedege's	95% CI	
G1	*G2*				(raw)	(FDR)	*g*	*LL*	*UL*
Control	CC_Global	Serenity	0.56	4.45	.000	.001	1.28 ⁻	0.819	1.735
Control	CC_Local	Serenity	0.58	4.15	.000	.002	1.12 ⁻	0.657	1.591
Control	Non_CC	Serenity	0.57	4.05	.000	.002	1.23 ⁻	0.757	1.693
Control	Benign	Joviality	1.10	3.05	.003	.028	0.78 ⁻	0.347	1.214
Control	Non_CC	Joviality	1.13	2.99	.003	.028	0.86 ⁻	0.415	1.313
Control	CC_Local	Joviality	1.14	2.87	.005	.030	0.84 ⁻	0.382	1.288
Control	CC_Global	Joviality	1.10	2.86	.005	.030	0.73 ⁻	0.299	1.162
Control	CC_Global	Hostility	0.77	3.08	.002	.028	0.76 ⁺	0.328	1.193
Control	CC_Global	Fear	0.74	2.96	.004	.028	0.76 ⁺	0.324	1.189
Benign	CC_Global	Fear	0.75	3.42	.001	.012	0.87 ⁺	0.428	1.309

Note. Hedge's *g* calculated via Laken's (2013) spreadsheet. It can essentially be interpreted as Cohen's *d*. *p* (FDR) refers to the adjustment for all 60 comparisons, not just the ones in the table. ⁺ For the respective effect, this indicates that the second group (i.e., *G2*) reported a *higher* level of the respective emotion than group one. ⁻ For the respective effect, this indicates that the second group (i.e., G2) reported a *lower* level of the respective emotion than group one.

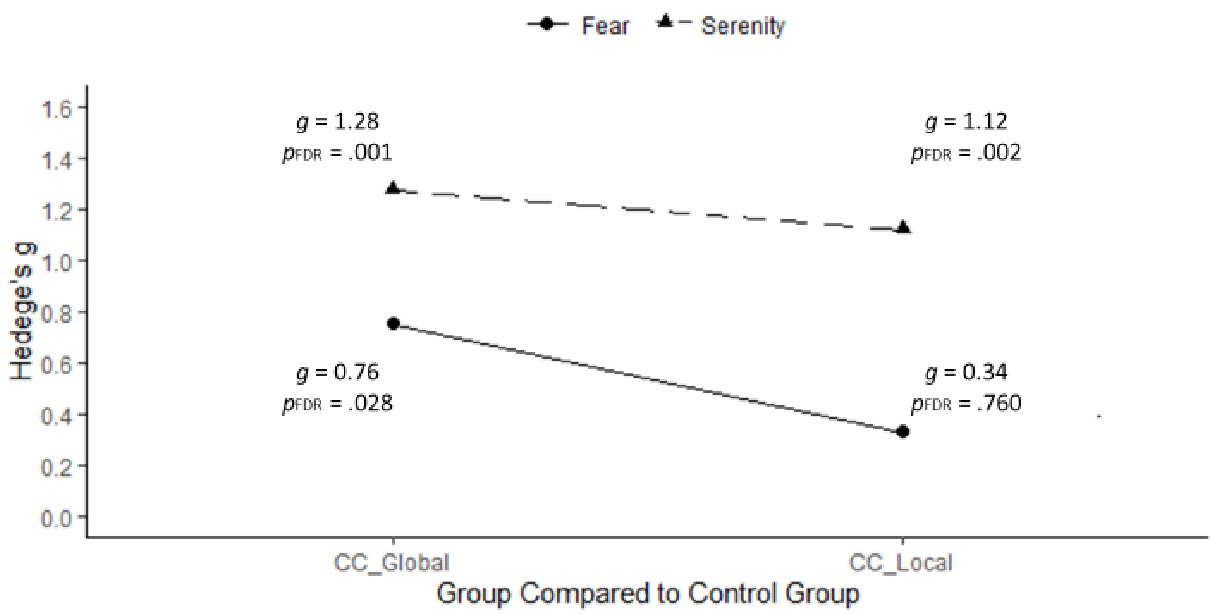
These comparisons can also help examine the possible distinction between *fear* and *serenity*. Figure 8 compares four effects: the Control vs. CC_Local effect on (1) *serenity* and (2) *fear*, and the Control vs. the CC_Global effect on (1) *serenity* and (2) *fear*. Temporarily, assume that *fear* and *serenity* fundamentally operate as a reciprocal function of one another (i.e., two sides of the same coin, or opposing ends on one continuum). Even if *serenity* was subject to less

[18] See Tables Folder at this website: https://osf.io/esvta/

measurement error than *fear*, the difference between the groups in one emotion should mirror that of the other emotion (i.e., if *serenity* and *fear* are reciprocal forms of one another, the lines in Figure 8. should be parallel). Random variation and measurement error could interfere with a parallel relation. Nonetheless, a significant effect for *serenity* was found in both group comparisons, but a significant effect for *fear* was found in only one group comparison. Therefore, this serves as very tentative evidence that *fear* and *serenity* did not operate in the same way between the local and global conditions, at least from questionnaire measurement; perhaps they are not opposite ends of one continuum, or “two sides of the same coin”.

Figure 8.

Hedge’s g*s for Change in* Fear *and* Serenity *Compared to the Control Group*



Note. The CC_Local and CC_Global groups had higher *Fear* raw scores than the control group. The CC_Local and CC_Global groups had lower *Serenity* raw scores than the control group. For the CC_Local vs Control effect (i.e., bottom right), the raw *p*-value was insignificant ($p = 0.211$). All other effects were significant, even after the FDR adjustment.

Discriminant function analysis. A discriminant analysis was executed after the MANOVA. It used change scores from the same six emotions as predictors (i.e., *fear*, *hostility*, *sadness*, *guilt*, *joviality*, and *serenity*). The same five groups were also considered, but they were used as the *dependent* variables in this analysis. The same sample was used from the MANOVA analysis (N = 139). Also, the same statistical assumptions were addressed before evaluation of the MANOVA (see sections 4.5.2 to 4.5.7).

Four discriminant functions were calculated. The omnibus test, which corresponds to the omnibus MANOVA test above, generated the combined effect, $F(1, 451.24) = 2.12$, $p < .002$, $\eta^2 = .089$. About 9% of all the variability within the *predictors* can be explained by between group differences. For the first discriminant function, Canonical $R^2 = .20$; therefore, the first function accounted for about 20% of the variability across the predictors that can be explained by between group differences. After removal of the first function, the association between groups and predictors wasn't significant, $F(15, 359.27)$, $p = .21$, Canonical $R^2 = .09$; although, the second function seemingly accounted for 9% of the shared variance between predictors and between groups that wasn't already explained, it was not significant. The third and fourth functions did not explain a significant amount association between predictors and between groups.

Table 18.1

Structure Matrix of Emotional Loadings onto Discriminant Functions

	Function			
Predictor	DF1	DF2	DF3	DF4
Fear	-0.32	0.87	0.23	-0.12
Hostility	-0.37	0.45	0.76	0.11
Sadness	-0.31	0.36	-0.05	0.84
Guilt	-0.18	0.46	0.07	0.11
Joviality	0.63	0.19	-0.22	-0.15
Serenity	0.89	-0.29	0.07	0.21

Note. Pooled within- groups correlations between discriminating variables and standardized canonical discriminant functions. DF stands for Discriminant Function. Values below .50 were ignored, in line with Tabachnick and Fidell's (2014) example.

Table 18.2

Standardized Canonical Discriminant Function Coefficients

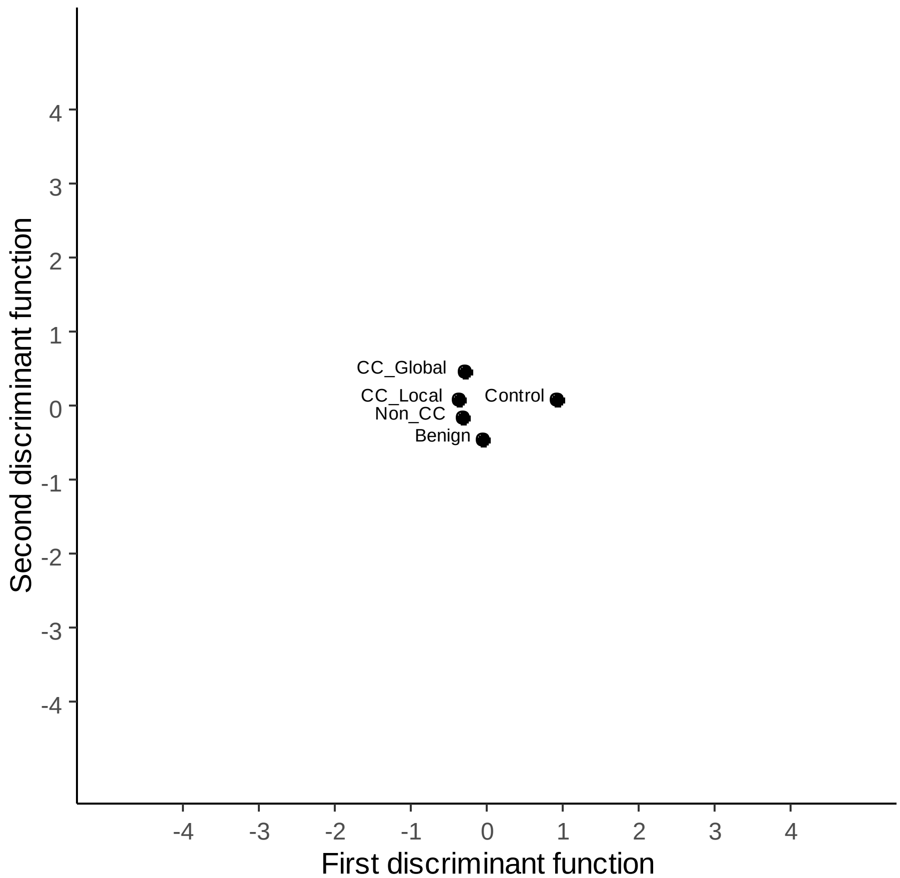
	Function			
Predictor	DF1	DF2	DF3	DF4
Fear	0.10	0.84	0.05	-0.48
Hostility	-0.05	-0.11	-1.19	0.27
Sadness	-0.19	0.18	0.32	1.10
Guilt	0.41	0.33	0.32	-0.17
Joviality	0.39	0.53	0.35	0.17
Serenity	0.88	0.01	-0.55	0.17

Note. Essentially, these are the standardized beta coefficients in the linear equation of predictors that composes the discriminant function. A discriminant score is attached to each observation for every function, and these are the standardized weights on the predictors that create that score.

As shown in Figure 9, the first function maximally separates the control group from all other groups. Table 18.1 shows the structure (i.e., loadings) matrix between the predictors and the functions, or rather, the within-group pooled correlations between the functions and the predictors. The first function was primarily composed of *serenity*, Canonical $r^2 = .79$; however, *joviality* also demonstrated a notable loading, Canonical $r^2 = .40$. Therefore, some combination of *serenity* and *joviality*—mostly *serenity*—maximally discriminate between the control group and the rest of the sample.

Figure 9.

Centroids of Five Experimental Groups on the First Two Discriminant Functions



Note. Plot of group centroids, or group specific means of the discriminant functions, for the first (i.e., x-axis) and second (i.e., y-axis) discriminant functions. Distance between groups along a given axis indicates the ability of the respective discriminant function to differentiate between the groups. For example, this figure indicates that the first discriminant function distinguishes the control group from the rest of the groups.

The multiple comparisons computed after the MANOVA, show that the mean level of *serenity* in the control group differs significantly from means in the CC_Global group, the CC_Local group, and the Non_CC group, Hedges' *g*s ranged from 1.12 to 1.28., all FDR adjusted *p*-values were $\leq$ .002.[19] Additionally, the mean level of *joviality* in the control group differed from the mean level in every other group, but the effects were consistently smaller, Hedges' *g*s ranged from .73 to .86., all FDR adjusted *p*-values were $\leq$ .03. Despite its ability to distinguish the control group, the first function did not seem to discriminate between the other groups (see Figure 9).

The second discriminant function did not significantly differentiate the groups; nonetheless, it is worth considering for several reasons. The treatment groups seemed to be furthest separated by the second discriminant function, which is composed of *fear* (Canonical R^2 = .76, see Table 18.1), and perhaps a bit of *hostility* and *guilt*. First, the only significant group comparison in the MANOVA follow-up that did not involve the control group was the mean level of *fear* observed in the benign group compared to the CC_Global group (Hedges' $g = 0.87$, FDR $p = .012$). Although the second function was not significant, one can see the difference between these two groups in Figure 9. For further comments on the MANOVAs and discriminant function analysis, see Appendix K.4.

[19] FDR *p*-value refers to an FDR adjustment for every group comparison, on the six emotions mentioned and three measures of environmental attitudes.

4.6 Exploratory analyses: Paired samples tests or change scores

Although they may seem redundant, exploratory paired samples tests were also executed. At this point, the cumulative number of inferential tests undermines the inferential value of these analyses. Nonetheless, a common application of planned comparisons (i.e., within a given participant, how much did the dependent variable change from one time point to the next?) may be more consistent with the research question than the preregistered analyses. When assessing which emotions were elicited by a given scenario, examining the emotional change within a scenario may be a more direct method of assessment than comparing the change between two scenarios. Also, visualizing within group effects (see Figure 10) may be interpreted more intuitively than between group effects. Therefore, the paired sample tests were explored: Instead of asking whether the emotional change was different between groups, these tests examine the degree of emotional change that occurred within a given group. Inferential assessment should be treated with extreme caution, or even dismissed, for paired samples results in this sample.

Table 19.1

Paired Samples Tests for Emotional Change Within Groups.

Emotion	*Group*	*t*	*n*	*p*	*SE*	*r*	d_z
Fear	Control	1.21	30	0.24	0.36	0.80	0.22
Hostility	Control	0.35	30	0.73	0.38	0.50	0.06
Guilt	Control	1.93	30	0.06	0.36	0.82	0.35
Sadness	Control	-1.40	30	0.17	0.29	0.91	-0.26
Joviality	Control	-1.39	30	0.17	0.69	0.78	-0.25
Serenity	Control	0.63	30	0.54	0.32	0.37	0.11
Fear	Benign	0.18	29	0.86	0.38	0.75	0.03
Hostility	Benign	2.14	29	0.04	0.47	0.69	0.40
Guilt	Benign	0.85	29	0.40	0.65	0.74	0.16
Sadness	Benign	0.19	29	0.85	0.36	0.89	0.04
Joviality	Benign	-5.01	29	0.00	0.86	0.78	-0.93
Serenity	Benign	-2.82	29	0.01	0.44	0.36	-0.52

Table 19.1 cont.

Paired Samples Tests for Emotional Change Within Groups.

Emotion	*Group*	*t*	*n*	*p*	*SE*	*r*	d_z
Fear	Non_CC	1.87	26	0.07	0.53	0.59	0.37
Hostility	Non_CC	2.33	26	0.03	0.45	0.43	0.46
Guilt	Non_CC	1.42	26	0.17	0.68	0.63	0.28
Sadness	Non_CC	-0.22	26	0.83	0.52	0.78	-0.04
Joviality	Non_CC	-5.66	26	0.00	0.77	0.81	-1.11
Serenity	Non_CC	-5.43	26	0.00	0.39	0.00	-1.06
Fear	CC_Local	1.94	25	0.06	0.72	0.30	0.39
Hostility	CC_Local	1.40	25	0.17	0.74	0.24	0.28
Guilt	CC_Local	2.59	25	0.02	0.56	0.53	0.52
Sadness	CC_Local	2.00	25	0.06	0.44	0.64	0.40
Joviality	CC_Local	-5.38	25	0.00	0.79	0.71	-1.08
Serenity	CC_Local	-4.46	25	0.00	0.49	0.29	-0.89
Fear	CC_Global	3.98	29	0.00	0.66	0.67	0.74
Hostility	CC_Global	3.50	29	0.00	0.72	0.73	0.65
Guilt	CC_Global	2.81	29	0.01	0.71	0.70	0.52
Sadness	CC_Global	1.42	29	0.17	0.58	0.79	0.26
Joviality	CC_Global	-4.76	29	0.00	0.86	0.72	-0.88
Serenity	CC_Global	-5.93	29	0.00	0.38	0.38	-1.10

Note. *t* is the paired sample *t*-statistic for change for a given emotion, within a given group. *n* is the sample size for the respective group and *p* is the raw *p*-value for the *t*-test. *SE* is the standard error of the difference (i.e., change) scores. *r* is the correlation between emotional scores at time one, and time two. d_z is the paired samples Cohen's *d*, and the sign signifies the direction of change (i.e., negative means reduction and positive means increase).

Table 19.1 includes the paired Cohen's d_z for specific emotions within groups.[20] Descriptive statistics can be found in an extended version of this table, Table 19.2.[21] The paired samples tests demonstrated a higher proportion of significant results—as judged by the raw *p*-values—compared to the between group comparisons. This was expected within the paired sample framework (i.e., reduced individual-level variability when measuring the same individual

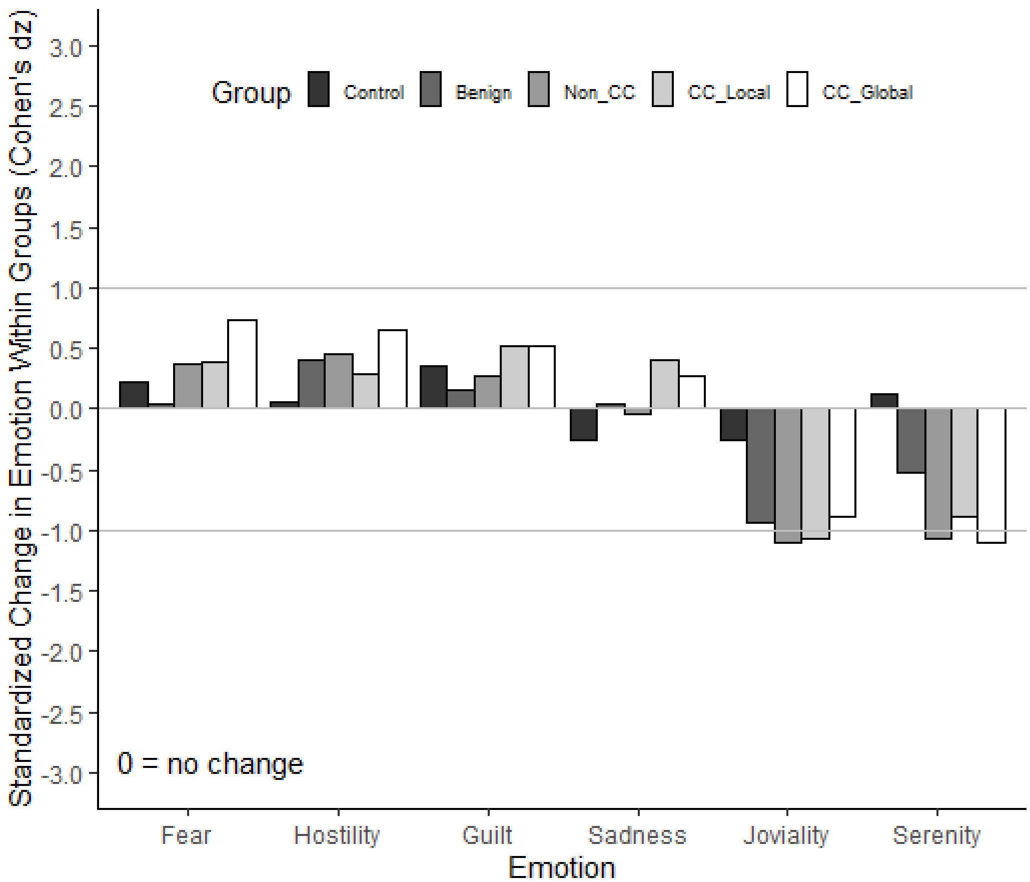
[20] Cohen's d_z is the Cohen's *d* for paired samples (see Lakens, 2013): "The Z alludes to the fact that the unit of analysis is no longer X or Y, but their difference, Z."

[21] See Tables folder at this website: https://osf.io/esvta/

at two time points). Many of the effects are unsurprising given the previous results: *joviality* and *serenity* decreased significantly in every group besides the control. Nonetheless, if one were to consider these *p*-values, some surprising effects can be observed; for example, *guilt* increased significantly in the CC_Local and the CC_Global conditions, but in no other conditions.

Figure 10.

Standardized Mean Change for Emotional Change Within Groups



Note. These values represent the standardized mean change (i.e., Cohen's d_z effect size) of a given emotion, within a given group. Currently, these effects have not been subject to type-I error corrections and should not be inferentially interpreted. Confirmatory analyses reflect comparisons to the CC_Local group, or the light grey group. For example, the only significant effect found in the confirmatory analyses could be represented by the *serenity* level of the black group (i.e., the control group) and the *serenity* level of the light grey group (i.e., the CC_Local group). Several other comparisons were found to be significant when all group comparisons were considered (e.g., *serenity* level of the control group vs. *serenity* level of the CC_Global group). Those comparisons are different inferential hypotheses than testing whether these effects are different than zero.

Figure 10 is perhaps more informative for understanding these effects: it shows the paired samples Cohen's d_z for every effect in a bar graph, and each effect is grouped by emotion. As stated before, the *p*-values in Table 19.1 could be considered uninformative because of the number of previous inferential tests executed. In Figure 10, however, we can visually assess these effect sizes relative to one another.

Chapter 5: Discussion

The primary purpose of this study was to evaluate how various aspects of future climate change influence *fear*, as well as several other emotions (e.g., *guilt*, *sadness*, and *hostility*). Additionally, the “positive” emotions *joviality* and *serenity* were considered. Overall, the five manipulations tested—a control scenario, a scenario with harmful effects that did not involve climate change, a climate change scenario with benign effects, a local climate change scenario with harmful effects, and a global climate change scenario with harmful effects—did have an effect on questionnaire measured emotions.

Planned comparisons were preregistered, and hypotheses of direction and effect size can be found in Table 1. All comparisons between individual groups were subsequently considered in exploratory analyses. Overall, positive emotions (i.e., *serenity* and *joviality*) decreased substantially in manipulated groups when compared to the control group. However, these same comparisons did not demonstrate many significant effects for the negative emotions (i.e., *fear*, *hostility*, *guilt* and *sadness*): Only the global condition demonstrated a significant increase in *fear* and *hostility* compared to the control condition.

A recurring question throughout these analyses concerned the distinction between *fear* and *serenity*. Engagement with global climate change seems to deplete *serenity* and evoke *fear*; however, local climate change only seems to deplete *serenity*. Additionally, discriminant analyses seemed to indicate *fear* and *serenity* as two separate emotions. Is the distinction between *fear* and *serenity* important? Is this result simply a case of measurement error? Also, do these two emotions constitute the ends of an emotional spectrum, or are these emotions distinct? If they are distinct, do they have separate implications for behavior and engagement with climate change?

5.1 Planned comparisons

Twenty four hypotheses of effect size direction and magnitude were preregistered for specific emotions (see https://osf.io/GQPUW/) and can be viewed in Table 1. However, medium and small effect size predictions were severely underpowered. Rather than the control group, the primary group of interest (i.e., the local climate change group) was selected as the reference group to which all other groups were compared. This was done to test more theoretically relevant distinctions (e.g., local vs. global effects) than available with a control reference group. Also, a reference group was picked to limit the initial number of comparisons. An FDR (Benjamini & Hochberg, 1995) correction was applied to the cumulated preregistered comparisons, which included those concerning environmental attitudes; statistical significance was assessed based on the FDR adjustment.

Negative emotions. Out of the 16 comparisons predicted for the negative emotions, 14 were too underpowered to find their hypothesized effect (see Table 10). For *fear*, large effects were predicted for the comparisons between the CC_Local and control conditions, and the CC_Local and benign conditions. Neither comparison showed statistical significance. A large change in *fear* was not detected by engagement with a climate change related commons dilemma when compared to the control and benign groups. The other planned comparisons tested for *fear* were underpowered and did not show significant differences.

Compared to the local climate change group, no other group demonstrated a comparatively large difference in the change of negative emotions (i.e., *fear*, *hostility*, *guilt*, and *sadness*). Although these comparisons were underpowered, large differences had a reasonable chance at being detected. Four explanations for lack of effect follow: (1) The theoretical effect was not present (i.e., engagement with a local, hypothetical common’s dilemma caused by climate change did not increase negative emotions). (2) The primes did not adequately capture the negative emotional effect from a local, hypothetical common's dilemma caused by climate change. (3) The differences in negative emotional change were only of a medium or small effect, and the design was not able to detect them. (4) The emotions were measured poorly.

Overall, this study was to underpowered to find most of the hypothesized effects, to examine exploratory models, and to evaluate measurement. After more data are collected, the first subsequent step is to evaluate the measurement of the emotions; specifically, the PANAS-X needs to be evaluated within the framework of CFA or EFA, which would require a substantially larger sample. Once measurement is evaluated, and if it is found to be satisfactory, these effects should be reevaluated with adequate power.

The primes could also be qualitatively informed. Participants could be asked about their emotional reactions to climate change in an open response format. Further, participants could be asked whether climate change makes them feel a given emotion (e.g., *fear*), and what specifically about climate change makes them feel that emotion (see O'Neill & Hulme, 2009). Then, these responses could be used to generate primes that are more engaging. Rather than making informed assumptions about the aspects of climate change that are emotionally engaging, a population of interest could be directly asked about such aspects.

The climate change scenarios were also hypothetical and temporally distant, which could have undermined the effect. They did have strengths compared to previously cited climate change related emotional manipulations (e.g., level of engagement, utility of the control condition); however, more visceral scenarios could be tested (e.g., virtual reality) that more closely capture emotional reactions to effects of climate change rather than hypothetical effects of climate change. Despite this limitation, imagining future climate change is a primary way in which people currently engage with it, and these scenarios were still informative.

Positive emotions. Initially, positive emotions were investigated as reciprocal effects to the negative emotions; for example, *serenity* was expected to decrease as a function of the degree to which *fear* increased: If *fear* did not increase, *serenity* was not expected to decrease. However, among the planned comparisons, the only significant effect found was a large decrease for *serenity* in the local climate change group compared to the control group (Hedge's g = 1.12). Also, if considering the standardized change scores for emotions within their respective groups, the positive emotions ostensibly have larger effects than the negative ones (see Figure 10).

Multiple factors could have contributed to the large and significant effect size found for *serenity*. Most obviously, this could be a Type I error: If there were truly no differences between any groups on any emotion or environmental attitude, and the FDR correction was applied to the 32 comparisons above (including environmental attitude group comparisons), one would expect between one and two false positive detections (around 1.6). However, the effect is large, and the direction and magnitude were previously hypothesized.

Another possibility is that effect exists, and *serenity* was measured well. Why, then, are the effects of *fear* and *serenity* inconsistent? Assuming both constructs are two sides of the same coin, perhaps *serenity* was measured well, and *fear* was measured poorly; in this case, refining the measurements and replicating the procedure should yield similarly sized effects in the opposite direction.

The more interesting possibility, however, is that *fear* and *serenity* are not two sides of the same coin. They could be distinct emotions, and further, engagement with climate change could influence positive emotions distinctly, and not just as a reciprocal function of the influences on negative emotions. A brief review of qualitative responses shows that participants in climate change conditions frequently reported increases in negative emotions, but they usually did *not* mention decreases in positive emotions. One revealing *exception* to these responses can be found below:

> *Participant 33*: “The scenario made me feel a bit anxious and scared, and I was relaxed before so it definitely had and impact”

Increases in negative emotions were expected, but decreases in positive emotions may constitute a distinct, and perhaps larger effect. Moreover, they may also reveal a blind spot: when one is asked about how climate change makes them feel, they may concentrate on increased *fear*, but remain unaware of the *serenity* or calmness that was lost because of the engagement with climate change. This relation also carries implications for behavioral reactions: does an increase in *fear* carry the same behavioral propensities as a decrease in *serenity*?

The prospect of distinctness between positive and negative emotions (e.g., *fear* and *serenity*) is a compelling reason to further investigate measurement, and perhaps to pair these self-report measures with other plausible emotional indicators (e.g., blood pressure, heart rate, pupil dilation). Further, understanding the implications of this distinction can be facilitated by considering an untenable assumption: no measurement error for emotions in this study. In this scenario, these data demonstrate that a reduction in *serenity* does not necessitate an increase in *fear*. Although they should be inversely correlated (r = -.49 for change scores across groups), they do not define one another. As measurement is refined, one can continue to examine whether these emotions operate as a function of one another. A similar case can be made for *sadness* and *joviality*: one should not necessarily claim, “he is not jovial; therefore, he must be sad.” Instead, one detects cues specific to sadness (e.g., crying) to infer the emotion or lack thereof. One can apply this idea to many “pairs” of emotions: is one necessarily awestruck in the absence of its opposite (e.g., boredom, disinterest)?

These claims can be further explored with formal logic, philosophy, and linguistics. In this study, however, the focus is on the possible distinction in the following questions: How does the presence of fear predispose people to act? How does the absence of serenity, or calmness, predispose people to act? Further, this distinction might be a ubiquitous blind spot. If these are distinct, informing both questions will be important for the study of emotions and behavior generally, as well as the mitigation of, and adaptation to, climate change specifically.

Environmental attitudes. Significant differences between groups were not found for *CCFear*, *CCRisk,* or the *NEP*. The distributions of *CCFear* and *CCRisk* were skewed left (see Figures 2.7—2.8, Figures 6.1—6.4, & Table 6), and a celling effect was suspected, especially for *CCFear*. Given these distributions and the number of observations in each group, finding the predicted effects for these measures would have been challenging.

A potential celling effect may be explained by the sampled population (i.e., university students in a “left” leaning Canadian province), which may have generally high levels of fear and risk perception in relation to climate change. However, some variation in environmental attitudes should have been observed; perhaps *CCFear* and *CCRisk* were simply measured poorly.

Despite a possible celling effect, *CCRisk* scores in the control group demonstrated some room for higher scores in group comparisons; therefore, the celling effect may not have been the only explanation for a lack of difference between the control group and the local group for *CCRisk*. Group differences might have been small or medium in effect; however, this is inconsistent with previous literature (Hornsey et al., 2015; Van Zomeren et al., 2010). Perhaps the hypothetical scenarios did not influence participants' risk perceptions of future events.

The *NEP* did not show signs of a celling effect and demonstrated substantial variation; if a large difference between groups on the *NEP* was present, it probably would have been detected. Nonetheless, no significant differences between groups were detected for the *NEP*: Engagement with these primes is unlikely to have had a large influence on the *NEP*. The *NEP* is described as measuring an ecological worldview (Dunlap et al., 2000), and therefore, may reflect a more trait-like than a state-like attribute. In that case, one would not expect a large change in the *NEP* from the temporary and hypothetical engagement with the constructed primes.

Notably, the change in environmental attitudes was not measured; they were only measured after the primes were administered. Perhaps differences would have been detected for a change in environmental attitudes. However, compared to emotions, environmental attitudes may have been more susceptible to social desirability given the environmental content in the items. Measuring them prior to the primes also may have interfered with change in emotions.

Theoretical explanations for the lack of differences in environmental attitudes are elusive, especially for fear of climate change. If some emotional change were to occur because of the primes, then at least some of that change should be associated with climate change. Notably, an effect for *fear* was not found when the local climate change group was compared to any other; so, an effect for *CCFear* should not necessarily be expected. A strong effect for *serenity* was found, however. If *fear* and *serenity* are distinct emotions, perhaps a measure of "serenity towards climate change" could be constructed. However, this seems like a strange construct: does *serenity* have a "target" in the way that *fear* does?

Before such avenues are considered, additional data should be gathered for measurement evaluation. In an exploratory fashion, one could use all the indicators of environmental attitudes, preform a factor analysis, and then explore whether a factor specifically pertains to fear of climate change. This might shed light on the lack of effect in the current analysis, as well as inform the development of a better measure for fear of climate change.

5.2 Exploratory analyses

The MANOVA omnibus test revealed that the group manipulations can explain around 9% of the total variance in all the emotional outcomes. After the FDR adjustment, 10 significant comparisons were detected, which involved four emotions: *serenity*, *joviality*, *hostility*, and *fear* (see Table 17.1). Nine comparisons involved the control group, and five comparisons involved the global group. The benign group, the local group, and group not related to climate change were each involved in two comparisons.

The differences between the control group and the global group were significant for change in *serenity*, *joviality*, *hostility*, and *fear*. The effect size magnitudes for *serenity* and *joviality* were close to those for the control and local group comparison: Whether the climate change scenario was local or global, positive emotions decreased by a similar degree compared to the control group. However, this is not the case for *fear* and *hostility*. Compared to the control scenario, the global scenario demonstrated moderate-to-large increases in both, *fear* and *hostility* (see table 17.1). Significant differences for these emotions were not detected between the control and the local group.

Other group comparisons differentially influenced *fear*, *serenity*, and *joviality*. The global group also demonstrated a large increase in *fear* compared to the benign group. Relative to the control group, *serenity* decreased significantly in the local group and the group unrelated to climate change. Relative to the control group, *joviality* also decreased significantly in the local group, the benign group, and the group unrelated to climate change. *Fear* seems to be particularly associated with a global and deleterious effect from climate change. No significant effects were found for *guilt* and *sadness* when all comparisons were considered.

Additional exploratory analyses were done: Discriminant function analysis was also conducted to see if specific combinations of emotions best discriminated the groups. The first function was primarily composed of *serenity*, and this was the only function for which significant group differences were observed: Overall, this function was able to distinguish the control group from the other groups (see Figure 9). The second function—orthogonal to the first—was primarily composed of *fear*. Although it did not significantly distinguish between groups, it might indicate a distinction between how *fear* and *serenity* distinguish groups, which could be tested in a larger sample. Lastly, standardized change scores were considered, calculated, and visualized, but they were not evaluated for significance.

Fear vs. serenity. Compared to the control group, the local and global groups seem to operate similarly on *serenity*, but differently on *fear*. This was described above, and the differences for *fear* and *serenity* hold important implications. These four effects were compared in Figure 8. Notably, when testing direct comparisons between the local and global groups, no significant effects were observed for *fear* or *serenity*. Nonetheless, differences in each group's comparison to the control group are worth consideration. Although these four effects were not compared with an inferential test, their inconsistencies indicate a potential difference in how *fear* and *serenity* operate. Multiple comparisons show that *fear* and *serenity* distinguish the global group from the control group; however, *serenity* is the only emotion that distinguishes the local group from the control group.

One can also consider the discriminant analysis when assessing the distinction between *fear* and *serenity*. The first discriminant function was associated with *serenity*, and the orthogonal second function was associated with *fear*. When examining the group specific function means (i.e., the centroids), which are visible in Figure 9, one can see that *serenity* distinguishes the control group from the rest. And although second function was insignificant, the global group scored highest on this function; perhaps *fear* is the emotion that that distinguishes the global group from the rest. Overall, these orthogonal functions, which correspond to *serenity* and *fear,* differentially distinguish the groups.

Although *fear* and *serenity* do not seem to operate in the same way between conditions, the claim of their distinction remains inconclusive. It can be further tested, however, with a larger sample and a more careful evaluation of measurement. First, one could subject the combined indicators of *fear* and *serenity* to measurement evaluation with methods such as factor analysis and taxometrics. How well do *fear* and *serenity* distinguish themselves as factors, and are the emotions better conceptualized as constructs of degree, or of kind?

Given adequate measures of *fear* and *serenity*, one could test the degree to which *fear* mediates the effect of group membership on *serenity*. If the effect is not fully mediated, then the primes have some effect on *serenity* that is not explained by *fear*; and this provides further evidence that the two emotions are not two sides of the same coin, at least insofar as how they are measured by a questionnaire.

For these data, *fear* seems to be particularly associated with a global and deleterious effect from climate change; and although this group also shows a large decrease in *serenity*, so do other groups, including the group that does not mention climate change. Overall, exploratory analyses suggest that *fear* and *serenity* may be distinct emotional constructs, and that *fear* is particularly associated with globally focused climate change.

Fear. Examining *fear* was the primary and initial aim of this study. So, why would the global scenario provoke "more" *fear*; or rather, compared to the control group, why would the global group elicit significant change in *fear* when the local group did not? The local scenario was predicted to elicit relatively more *fear* than the global scenario. This was primarily based on the assumption that proximal threats should be more engaging than distant ones (Scannell & Gifford, 2013; Spence, Poortinga, & Pidgeon, 2012; O'Neill & Hulme, 2009). However, the opposite was observed.

Perhaps the global prime was reflective of salient climate change media, which is often described on global scales and associated with *fear* (Gunster, 2011). Exposure to such media may have already primed participants to respond more strongly to the global group.

Additionally, the distinction between a globally distant and a globally encompassing scenario may explain this discrepancy. In this study, the global scenario did not necessarily represent a distant threat as would a similar scenario isolated in a faraway region. The global scenario described an all-encompassing threat; a threat not only to one's local resource supply, but to the global resource supply. This includes resources that could ameliorate scarcity in one's local supply. Therefore, the differences for *fear* and *hostility* between the local and global groups might be a function of threat to one's resources: distant threats may be the least engaging because they do not threaten resources; local threats may be more engaging because they do threaten resources; all-encompassing threats may be the most engaging because scarcity of local resources cannot be ameliorated by outside resources. In future studies, all three of these scenarios could be tested and compared directly for small, but meaningful differences in how they influence negative emotions such as *fear* as well as *hostility*, *sadness*, and *guilt*.

Positive emotions. Notably, group differences in the decrease of positive emotions were substantial. Compared to the control group, *joviality* decreased significantly in every other group, and the comparison Hedge's *g*s ranged from 0.73 to 0.86. Engagement with any environmental resource scenario, whether it was related to climate change, whether it had a benign or deleterious effect, and whether it had local or global implications, seemed to "deplete" *joviality*. Also compared to the control group, *serenity* decreased significantly in the local condition, the global condition, and the condition that did not mention climate change (the comparison Hedge's *g*s ranged from 1.12 to 1.28).

Comparing the degree of decrease in positive emotions to the degree of increase in negative emotions is tenuous, especially without more informed measurement. Nonetheless, the decrease in positive emotions was evident and substantial. In contrast to negative emotions, perhaps changes in positive emotions were better measured, and their effects were more obvious. Maybe participants initially responded in the way they would like themselves to feel unprompted. However, participants also could have come to the experiment with some level of *serenity* and *joviality*. Why did these emotions have "room" to decrease? Participation in a psychology experiment on a weekday morning does not seem particularly serene or jovial. Why else would these emotions decrease, and from what starting level of positive emotion did the conditions prompt the observed decrease? Perhaps some "normative" levels of positive emotion were depleted, and the negative emotions needed to be activated.

That explanation is consistent with the histograms for the positive emotions at time-one (see Figures 2.5.1 & 2.6.1), especially for *serenity*. Joviality has a somewhat uniform distribution, this is slightly skewed right, and *serenity* has a more normal distribution without any skew. In contrast, *fear*, *hostility*, *guilt*, and *sadness* featured high right skew on the first occasion of measurement, and all their modes landed on the lowest possible response; the most frequent response could be interpreted as a self-reported absence of these emotions. These histograms are also consistent with participants' responding in the way they would like themselves to feel. Therefore, the previous points do not constitute convincing evidence that some emotions have normative levels, and others need to be activated. Nonetheless, perhaps some emotions, such as *fear*, are activated upon interaction with an appropriate stimulus, but are not normatively present. And alternatively, perhaps other emotions, such as *serenity*, are associated with more normative states, and these emotions can be depleted given certain environmental interactions.

In addition to theoretical considerations, these results may indicate reasons for the avoidance of topics like climate change. Are environmental issues avoided because people implicitly want to avoid the depletion of emotions like *serenity* or *joviality* (i.e., is climate change a "buzzkill")? Is that loss more important, but less salient, than avoiding the activation of emotions like *fear*? These questions would be difficult to study; one would need to confirm the distinction between these emotions, how they are anticipated, and then find a way to distinguish their prior levels under the assumption that participants are unaware of their prior levels. Nonetheless, engagement with climate change and similar issues could benefit from such research. For example, instead of choosing between fearful or hopeful messages about a topic with dire implications (e.g., O'Neill & Nicholson-Cole, 2009), one might be able to facilitate engagement with such issues by reinforcing emotions such as *serenity* before presenting important information that necessarily evokes *fear*.

Guilt, sadness, and hostility. No significant effects were found for *guilt* and *sadness* when all comparisons were considered. Perhaps the design was simply underpowered, the measurement for these emotions was relatively poor, or these emotional responses are more idiosyncratic. For example, perhaps those who show high adherence to the NEP feel *guilt* when they engage with climate change scenarios, or those with strong place attachment feel *sadness*.

However, a significant increase in *hostility* was associated with the global condition compared to the control condition. Notably, a difference in the time one measurement of hostility could have undermined the ability to detect effects (see section 4.3.3). *Hostility* is a confusing emotion to interpret without knowledge of the target to which the emotion is directed (e.g., governments, corporations, people in general). *Hostility* and anger were not usually mentioned in the qualitative responses to how this scenario made participants feel. The emotions "sadness" and "futility" were mentioned frequently. This could indicate poor measurement of *sadness*, or perhaps participants were reluctant to elaborate on feelings of *hostility*. This emotional reaction may also be idiosyncratic: perhaps the relation is moderated by participants' political identification, or some other individual characteristic.

5.3 Limitations

The generalizability of this study is lacking in key areas. Although aspects of this convenience sample are consistent with related psychological studies, the lack of generalizability is also consistent. Psychological studies often involve WEIRD samples: the participants are western, educated, industrialized, rich, and democratic (Henrich, Heine, & Norenzayan, 2010). Even more idiosyncratic, most participants in this sample took psychology courses. Some awareness about climate change was essentially assumed for the sample, and the results would probably be very different in populations that do not acknowledge climate change, or that are unfamiliar with the topic.

Additionally, because of the geographic and cultural setting, this sample may have cared more about the issue than other WEIRD people, which is consistent with the environmental attitude responses. Perhaps these participants were more familiar with environmental degradation scenarios, and that influenced their emotional reactions. Overall, if this procedure were repeated, and the sample was drawn from a different population, the emotional effects might be different if that population showed less concern about the topic.

Regular interaction with the subject of environmental degradation could plausibly reduce emotional reactions, and therefore effect sizes: Familiarity, and perhaps numbness, boredom, and fatigue towards environmental issues, may have helped students to regulate and diminish their emotional reactions, especially negative ones like fear and hostility. Conversely, familiarity could have inflated the effects. Perhaps participants who regularly engage with similar content see these scenarios as less hypothetical, and therefore, as more emotionally engaging. Also, participants might feel less neutral and ambivalent towards a topic with which they regularly engage. Finally, these scenarios may have triggered previous emotional reactions to related content, which might be relatively more intense for those who show concern about environmentally related issues.

Notably, one could test this by examining whether environmental attitudes were moderators of the main effects. Ideally, this would be done across samples, which would help inform whether environmental attitudes explain the inconsistency between samples. Even within a sample, however, one could test the moderating effect of environmental attitudes: For example, are the emotional reactions to the scenarios even larger for those who demonstrate relatively high

NEP scores? Additionally, exploring the emotional reactions of those who do not acknowledge climate change could be beneficial, given enough data. Perhaps they have very little emotional reaction to the scenarios, or perhaps they have specific emotional reactions for different reasons (e.g., increase in joviality from laughing at the scenario, or an increase in hostility towards the researcher for doing research related to climate change).

Generalizability can also be considered in relation to the psychological distance of the scenarios. Do the observed effects reflect emotional reactions to *only* hypothetical climate change scenarios in the future, or do they reflect potential reactions to literal and direct engagement with such scenarios? One can almost necessarily assume that the emotional reactions would be different in either case. Unfortunately, these data do not indicate the nature of those differences. For example, the difference in psychological distance could influence emotions by degree (e.g., *serenity* decreases even further for the local and global scenarios with more direct engagement), or in kind (i.e. *serenity* decreases if the scenario is abstract and distant, but *fear* increases if the scenario is concrete and proximal). The use of virtual reality manipulations could help test a more concrete experience. Also, qualitative and quantitate research about experiences analogous to those expected with extreme climate change could be theoretically informative, practically invaluable.

The questionnaire featured additional concerns, especially pertaining to the PANAS-X (see Appendix G). Fundamentally, the PANAS-X proports to measure a latent variable, something that is considered only indirectly observable. "Measuring a person's emotional state is one of the most vexing problems in affective science" (Maus & Robinson, 2009, p. 209) and a questionnaire may not be sufficient to accomplish the task. The insufficiency of the questionnaire to capture a given emotion is difficult to estimate; however, it will almost certainly decrease the observed effect compared to a “perfect” measure. Again, the inclusion of additional indicators (e.g., physiological, behavioral, neurological) could help to capture a given emotion, test theoretical claims of dimensionality, and refine measurement.

The length of the PANAS-X is also a problem. The 60-item instrument was administered twice over the course of the questionnaire. With the addition of the other items and the prime, the length of the questionnaire may have prompted fatigue; the questionnaire’s mean duration was about 22 minutes, and the maximum time taken was about 45 minutes. Under the assumption that an emotion dissipates after a provocative stimulus, larger temporal distance from the scenario to a given PANAS-X item at time two should decrease the observed effect. Therefore, the overall length of the PANAS-X will probably result in decreased effects given this design. This could be remedied by measuring only a few emotions, and therefore decreasing the total number of items needed.

Another flaw in the PANAS-X stems from the measurement structure. Although the emotion internal consistencies were noted (see Table 4), the measurement structure was not evaluated within the factor analysis framework for this sample. However, several items on the PANAS-X were suspected of poorly representing their factor, or latent variable. For example, the items “jittery” and “shaky” are included in the factor of fear. If these items do not represent fear, they will introduce measurement error, which will result in a decreased observed effect for fear.

Additionally, not all feelings related to climate change were considered. Although the PANAS-X measures several distinct emotions, it should not be taken as a complete measure of all available emotions, even if one were to reduce the gamut of specific emotions to a parsimonious set. Individuals who are not represented in this sample might experience emotions very differently in relation to climate change, and their experiences may not be captured by the procedure (e.g., boredom).

Furthermore, not every PANAS-X emotion was tested (e.g., fatigue) in order to limit type-1 error rates. Nonetheless, they may be important (e.g., is engagement with climate change accompanied by fatigue)? Additionally, engagement with climate change could be improved by assessing different emotional profiles in reaction to the issue. Upon engagement with climate change, some people might be aroused and hostile towards those they deem responsible, but others may be saddened and fatigued. Perhaps emotional consistencies are associated with distinct climate change audiences (e.g., Hine et al., 2009; Yale Climate Change Project, 2009) and can further inform how to engage these audiences. Knowing how people differentially react to climate change can help with coping and adaptation, especially as “climate anxiety”, solastalgia, and similar repercussions continue to develop (e.g., Gifford & Gifford, 2016).

Another issue with this questionnaire is the lack of a “don’t know” (DK) or a “no opinion” response for emotional items. Arguably, this is relevant information that is being excluded out of the item by the response scale’s structure. Krosnick and Presser (2010) argue that the quality of data does not unusually improve with the inclusion of a DK response. However, some items may be theoretical improved; for example, if items were facts to which respondents indicated a level of agreement, a DK response would indicate a lack of information to properly assess the fact. In this thesis, perhaps a participant could feasibly not know whether they feel a certain way. However, this seems unlikely, and the inclusion of such an option would not necessarily add a lot of information. Nonetheless, how would such a response be modeled?

Appendix L features a brief consideration of the DK response prospect. Essentially, widely used and robust methods of assessing missing data (see Schafer & Graham, 2002) could be used to asses DK responses, particularly multiple imputation. However, that is under the assumption of randomness in the DK responses, which is probably not the case; and if it were the case, one could argue that the DK response holds little additional information. If a DK response needed to be modeled, and it was not missing at random, one could model it though latent variable analysis (e.g., Liu & Wang, 2016); however, these procedures have not been widely implemented and are very advanced. In a widely administered questionnaire with a large sample size, such methods could be very beneficial. For a small sample, such as the one in this thesis, such methods would be unstable.

5.4 Wider Implications

Overall, *fear* is an extremely important emotion to study in relation to climate change; however, other emotions could be just as valuable to consider. First, exploring emotional engagement with climate change can be theoretically fruitful for those studying emotions and their interactions with behavior. The numerous practical applications could be even more consequential.

Although this study has limitations, the findings and the continued line of research has implications for policy makers. Clearly, some questions of emotional engagement with climate change can be applied to mitigative efforts. For example, what are the implications for discrete emotions towards climate change related policy support? Ferguson and Branscombe (2010) found that collective guilt mediated the relation between climate change acknowledgement and mitigative behavior, including policy support for green taxes. Also, groups might predominantly express policy support with different emotions: perhaps younger adults tend to express anger towards lack of governmental policy implementation, but older individuals may typically express sadness.

The knowledge deficit model seems insufficient to explain lack of climate change policy support (Rhodes & Jaccard, 2014). Perhaps researching the negative consequences of climate change that do lead to policy support, as well as the mechanisms through which they do so, can help generate support. Therefore, emotional research could inform the reasons citizens support even controversial policies, like green taxes. Additionally, ignoring the phrase “climate change” may better generate support for some policies (e.g., Province of British Columbia, 2018). Of course, informing citizens about climate science and policy may be inadequate for effective climate policy implementation altogether (Rhodes & Jaccard, 2014). More broadly, emotions may help explain the avoidance of climate change as a conversation topic, or a topic that is sought in news media.

In the context of adaptation, how does one cope with rapid change in their natural surroundings and the accompanying sense of loss? How does one manage anger and guilt that develop as the crisis becomes more serious? For policy makers specifically concerned with mental wellbeing, research on climate change and emotion could be invaluable over the next few decades. Determinants of mental health (e.g., social, economic, and environmental) have already been influenced by climate change, especially for disadvantaged populations (Fritze et al., 2008). Specific effects from climate change on mental health are already being noticed, such as climate anxiety (McCunn, Bjornson, & Gifford, 2020), eco-anxiety (Gifford & Gifford, 2016), and solastalgia (Albrecht, 2011). And the psychological effects should increase from natural disasters (APA, 2011).

Do the effects of climate change on mental health require specific types of counseling and support for those affected? Can policy makers who concentrate on mental health provide support to their localities for such concerns, and if so, how? Perhaps regularly distributing the climate change anxiety scale (Clayton & Karazsia, 2020) and related measures can inform policy makers about the prevalence in their locality. Also, for policy makers specifically concerned with climate change, studying emotional reactions to the issue could help them cope with regular engagement, address their own mental health concerns, and let them know they are not alone in how they feel about the subject (e.g., a collection of scientists' letters about climate change; Duggan, 2015). The predicted gradual effects on emotions, such as widespread anxiety (Trombley et al., 2017), will likely apply more to those who engage most with the issue.

Perhaps the most important implication concerns how individuals emotionally react in a climate exacerbated common's dilemma. Do these reactions push individuals towards more altruistic, or more selfish tendencies? How do emotions facilitate these behavioral tendencies, and do observed dynamics work differently over time (e.g., see responses to natural disasters, Gifford, 2014; Maki et al., 2019)? Overall, this research indicates that fear is not the only factor; perhaps a shared sense of loss can help people cooperate even when resources are scarcer. On the other hand, perhaps anger can lead to discrimination of various groups in deciding how scarcer resources are used (e.g., ageism). Admittedly, these data do not directly inform this line of questioning. Nonetheless, before the implications for emotional influences on behavior in climate change exacerbated common's dilemmas are tested, researchers should consider how to measure those emotions, and which emotions to measure: fear and anxiety are not the only emotions with behavioral implications in a changing climate.

Chapter 6: Conclusion

This study evaluated how various aspects of future climate change influence *fear* and several other emotions. Most strikingly, almost all conditions demonstrated a large decrease in both *joviality* and *serenity* compared the control condition. Only one condition demonstrated a significant increase in *fear* and *hostility* compared the control condition, the global climate change condition. One might expect *serenity* and *fear* to work inversely, as two ends on a single continuum. Although they were negatively correlated, several analytical signals indicate these may be distinct emotions. Overall, decreases in *serenity* distinguished all other groups from the control group, and an increase in *fear* seemed to distinguish the global climate change group.

Further, participants' qualitative responses to environmental scenarios that happened to mention emotion tended to focus on increased negative emotions; the decrease in positive emotions was rarely mentioned. Decreases in positive emotions are also rarely measured in relation to climate change. Assuming that emotions like *fear* and *serenity* are distinct, this may indicate a ubiquitous blind-spot in which people notice increases in emotions like *fear*, but overlook decreases in emotions like *serenity*.

Additionally, the presence of a stimulus activated emotion may be more salient compared to the depletion of a previously experienced, but presently absent emotion. This supposition also implies the normative presence of certain emotions, such as *serenity* or calmness, that one experiences by default, and a normative lack of other emotions, such as *fear* and *hostility*, which may require environmental interaction to activate. The previous claim cannot be convincingly supported by the data in this study, and testing it would be difficult; however, considering the implications for the theoretical study of emotions and affect, it is worth exploration.

In addition to their theoretical implications, the points above hold promise for studying engagement with climate change. Perhaps reinforcing *serenity* can make the *fear* that comes with climate change engagement more tolerable, and perhaps it can lead to less avoidance of the issue. Perhaps idiosyncratic emotional reactions to climate change can help facilitate mitigative behaviors and require specific coping strategies.

Overall, how humans emotionally engage with the gargantuan context of a rapidly changing climate will critically influence our behavior, both mitigative and adaptive. Humanity may very well redefine itself with respect to climate change over the next century; our emotional and behavioral reactions will heavily influence our identity. Studying and anticipating how these reactions unfold may help humanity to maintain what we value most in ourselves during the tribulations ahead.

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Appendix A

The Environmental Attitudes Assessment

This is an environmental attitudes assessment that will help us to understand how people consider specific environmental scenarios. Your responses to this survey will be content-analyzed and your honest responses to the following questions will be appreciated.

There are differing viewpoints on global climate change these days. Most scientists agree that it is occurring or will occur, but nobody can predict the future. Regardless of whether global climate change is real and happening, or will happen sometime in the future, think about what it would be like if it DID happen.

The sentence below contains a plausible scenario that stems from climate change. Please list and describe some of the consequences global climate change would have on people living near you. Specifically, we are interested in scenarios about how individuals, governments, and other groups might react if the following events were to actually happen. Also, describe some situations that would arise; what would they look and feel like. Please be as descriptive as possible.

a. Small but stable increases in fish production around Vancouver Island because of increased seagrass growth that is directly facilitated by climate change and ocean acidification

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Appendix B

The Environmental Attitudes Assessment

This is an environmental attitudes assessment that will help us to understand how people consider specific environmental scenarios. Your responses to this survey will be content-analyzed and your honest responses to the following questions will be appreciated.

There are differing viewpoints on the likelihood of epidemic disease occurrences in marine organisms around Vancouver Island. Most scientists agree that it will occur at some point, but nobody can predict the future. Regardless of whether an epidemic disease occurrence in marine organisms around Vancouver Island is a real risk and will happen, think about what it would be like if it DID happen.

The sentence below contains a plausible scenario that stems from an epidemic disease occurrence in a critical marine species. List and describe some of the consequences the occurrence would have on human beings living on Vancouver Island. Specifically, we are interested in scenarios about how individuals, governments, and other groups might react if the following events were to actually happen. Also, describe some situations that would arise; what would they look and feel like. Please be as descriptive as possible.

a. Extreme and sudden fishing shortages around Vancouver Island from the mass extinction a of critical species in the marine food-web, which was directly caused by epidemic disease occurrence

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Appendix C

The Environmental Attitudes Assessment

This is an environmental attitudes assessment that will help us to understand how people consider specific environmental scenarios. Your responses to this survey will be content-analyzed and your honest responses to the following questions will be appreciated.

There are differing viewpoints on global climate change these days. Most scientists agree that it is occurring or will occur, but nobody can predict the future. Regardless of whether global climate change is real and happening, or will happen sometime in the future, think about what it would be like if it DID happen.

The sentence below contains a plausible scenario that stems from climate change and ocean acidification. Please list and describe some of the consequences global climate change would have on people living near you. Specifically, we are interested in scenarios about how individuals, governments, and other groups might react if the following events were to actually happen. Also, describe some situations that would arise; what would they look and feel like. Please be as descriptive as possible.

a. Extreme and sudden fishing shortages around Vancouver Island from the mass extinction of a critical species in the marine food-web, which was directly caused by climate change and ocean acidification

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Appendix D

The Environmental Attitudes Assessment

This is an environmental attitudes assessment that will help us to understand how people consider specific environmental scenarios. Your responses to this survey will be content-analyzed and your honest responses to the following questions will be appreciated.

There are differing viewpoints on global climate change these days. Most scientists agree that it is occurring or will occur, but nobody can predict the future. Regardless of whether global climate change is real and happening, or will happen sometime in the future, think about what it would be like if it DID happen.

The sentence below contains a plausible scenario that stems from climate change and ocean acidification. Please list and describe some of the consequences global climate change would have on people living near you. Specifically, we are interested in scenarios about how individuals, governments, and other groups might react if the following events were to actually happen. Also, describe some situations that would arise; what would they look and feel like. Please be as descriptive as possible.

a. Extreme and sudden fishing shortages around the globe from the mass extinction a of critical species in the marine food-web, which was directly caused by climate change and ocean acidification

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Appendix E

Control prime

Please take a few minutes to describe your day so far. What happened and how did the events of today make you feel?

Appendix F

Environmental and Climate Change concern items

Personal risk perception (1 = strongly disagree, 5 = strongly agree: Hornsey et al., 2015)

1. Climate change will have a noticeably negative impact on my health (over the next 25 years).
2. Climate change will have a noticeably negative impact on my economic and financial situation (over the next 25 years).
3. Climate change will have a noticeably negative impact on the environment in which my family and I live.

State risk perception (1= no risk, 5 = high risk: Hornsey et al., 2015)

1. What is the risk of climate change exerting a significant impact on public health in your state?
2. What is the risk of climate change exerting a significant impact on economic development in you state?
3. What is the risk of climate change exerting a significant impact on the environment in your state?

Fear of future impacts (1 = not at all, 5 = very much: Van Zomeren et al., 2010)

1. I am fearful of the negative future consequences of the climate crisis.
2. I am afraid of the negative future consequences of the climate crisis.

New ecological paradigm (1 = strongly disagree, 5 = strongly agree: Dunlap, Van Liere, Mertig, & Jones, 2000)

1. We are approaching the limit of the number of people the earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will insure that we do NOT make the earth unlivable.
5. Humans are severely abusing the environment.
6. The earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities humans are still subject to the laws of nature.
10. The so–called ''ecological crisis'' facing humankind has been greatly exaggerated.
11. The earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course, we will soon experience a major ecological catastrophe.

Appendix G

Positive and negative affect schedule-X (PANAS-X, Watson & Clark, 1994)

This scale consists of a number of words and phrases that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way *right now*. Use the following scale to record your answers.

1 =	2 =	3 =	4 =	5 =
very slightly or not at all	a little	moderately	quite a bit	extremely

1. ______ cheerful
2. ______ disgusted
3. ______ attentive
4. ______ bashful
5. ______ sluggish
6. ______ daring
7. ______ surprised
8. ______ strong
9. ______ scornful
10. ______ relaxed
11. ______ irritable
12. ______ delighted
13. ______ inspired
14. ______ fearless
15. ______ disgusted with self
16. ______ sad
17. ______ calm
18. ______ afraid
19. ______ tired
20. ______ amazed
21. ______ shaky
22. ______ happy
23. ______ timid
24. ______ alone
25. ______ alert
26. ______ upset
27. ______ angry
28. ______ bold
29. ______ blue
30. ______ shy
31. ______ active
32. ______ guilty
33. ______ joyful
34. ______ nervous
35. ______ lonely
36. ______ sleepy
37. ______ excited
38. ______ hostile
39. ______ proud
40. ______ jittery
41. ______ lively
42. ______ ashamed
43. ______ at ease
44. ______ scared
45. ______ drowsy
46. ______ angry at self
47. ______ enthusiastic
48. ______ downhearted
49. ______ sheepish
50. ______ distressed
51. ______ blameworthy
52. ______ determined
53. ______ frightened
54. ______ astonished
55. ______ interested
56. ______ loathing
57. ______ confident
58. ______ energetic
59. ______ concentrating
60. ______ dissatisfied with self

Appendix H: Other items

Other items

Qualitative response to prime

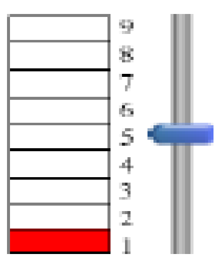
1. How did responding to the last scenario make you feel?

Acknowledgement of climate change (Derived from the IPCC fifth assessment)

1. Do you believe that the earth's climate is rapidly warming?
   Yes No Other
2. Do you believe that human influences are the primary cause of rapid warming in the earth's climate observed in recent decades?
   Yes No Other
3. Do you believe that that climate change will amplify existing risks and create new risks for natural and human systems?
   Yes No Other

Demographics

1. With which gender do you identify?
   Male, Female, Other
2. In what year were you born?
3. Think of this as a ladder representing where people stand in society. At the top of the ladder are the people who are best off—those who have the most money, most education and the best jobs. At the bottom are the people who are worst off—who have the least money, least education and the worst jobs or no job. The higher up you are on this ladder, the closer you are to people at the very top and the lower you are, the closer you are to the bottom. Where would you put yourself on the ladder? Please slide the slider on the right to the rung where you think you stand



1
2
3
4
5
6
7
8
9

4. Please rate your political orientation from -5 (extreme left) to +5 (extreme right).
5. Is English your first language (yes or no)
6. Please name the nationality with which you identify (e.g., Canadian).
7. What do you think was the purpose of this study?
8. Do you think the scenario in the study was threatening?
9. Do you think the scenario significantly changed the way you felt in the moment?
10. If extreme fishing scarcity were to happen, do you think people would try harder to preserve the resource, or attempt to collect as much of the resource as possible as quickly as possible?

11. Please consider providing general comments about this survey and your experience during it. These comments will be confidential.

Place Attachment (1 = strongly disagree, 5 = strongly agree)

1. I feel that Vancouver Island is a part of me
2. I feel happiest when I'm in Vancouver Island
3. Vancouver Island is the best place for doing the things I enjoy most
4. How long have you lived on Vancouver Island in months?

Check Questions (1 = strongly disagree, 5 = strongly agree)

The first two were administered in both rounds of the PANAS_X

1. Please validate your continued participation by selecting extremely as how you feel *right now*:
2. Please validate your continued participation by selecting very slightly or not at all as how you feel *right now*:
3. I have eaten a plant at some point in my life.
4. To validate your continued participation, please strongly agree with this statement.

Appendix I Debrief

Project Title: Equanimity in a Changing Climate: Study One

In this study, we wanted to see how participants emotionally reacted to specific climate change scenarios. We predicted that negative scenarios would facilitate negative emotions compared to neutral, or slightly positive scenarios. We asked participants to engage with four scenarios: one featured a slightly positive effect facilitated by climate change, one featured a negative effect facilitated by climate change, one featured a negative effect facilitated by a disease, and another featured a negative effect facilitated by climate change on a global scale. A fifth group of participants were asked to describe their current day and how they felt about it.

All participants received the same questionnaire except for the scenarios listed above. The questionnaire included a measure for specific emotions, a measure for environmental attitudes, and demographic questions. The emotion questionnaire were administered first, and then repeated after the scenarios to see if the scenarios changed the responses.

The scenarios listed varied in their probability of coming to fruition, some were unduly optimistic while others were unduly pessimistic:

Scenario one: “small, but stable increases in fish production around Vancouver Island because of increased seagrass growth that is directly facilitated by climate change and ocean acidification” – In this scenario, climate change may have positive benefits for sea grass around Vancouver Island, but the effect on fish-populations is unknown. There may be marginal benefits.

Scenario two: “Extreme and sudden fishing shortages around Vancouver Island from the mass extinction a of critical species in the marine food-web, which was directly caused by epidemic disease occurrence”– In this scenario, it is difficult to tell the extent to which a disease would interrupt marine ecosystems. This was mainly used to test if participants responded with different emotions based on the cause of the environmental threat. However, diseases can undermine ecosystems, especially if they become widespread in critical species. One example of this is the sea-star wasting syndrome seen throughout the North American west coast. For more information on this disease, visit the following website: https://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/index.html

Scenario three: “Extreme and sudden fishing shortages around Vancouver Island from the mass extinction a of critical species in the marine food-web, which was directly caused by climate change and ocean acidification” –Threats to critical species are an anticipated source of threat to fishing populations around Vancouver Island in the context of climate change. More specifically, harmful algae blooms have already caused damage to fisheries and may cause more. However, the extent of this harm is uncertain. At least locally, ‘extreme and sudden’ fishing shortages have not been predicted from this stressor; however, the extent to which fishing populations will be harmed by such stressors is unknown.

Scenario four: "Extreme and sudden fishing shortages around the globe because of the mass extinction of a critical species in the marine food-web, which was directly facilitated by climate change and ocean acidification" – This scenario was meant to create a global comparison to the previous local scenarios. Species critical to marine food-webs may be at risk from climate change, and these are likely points of vulnerability for Vancouver Island and other places around the globe. However, I found no evidence that one species is critical to a global marine food-web, or that species critical to individual marine ecosystems would be simultaneously subject to mass extinction from climate change. Our oceans are in very precarious situations around the world because of our influence; however, this scenario could be characterized as exaggerated because it is not based on grounded scientific literature.

The reason all the scenarios focused on fish was for applicability in future studies that will involve a fishing simulation.

For more information about the effects of climate change projected for Vancouver Island, see the following report:

Capital Region District. (2017). Climate Projections for the Capital Region. Retrieved from the Capital Region District for British Columbia website: https://www.crd.bc.ca/about/data/climate-change

For more information about how people emotionally engage with climate change, see the following sources:

Doherty, T. J., & Clayton S. (2011). The psychological impacts of global climate change. *American Psychologist, 66,* 265-276.

Reser, J. P., & Swim, J. K. (2011). Adapting to and coping with the threat and impacts of climate change. *American Psychologist, 66*, 277-289.

Trombley, J., Chalupka, S., & Anderko, L. (2017). Climate change and mental health: An evidence-based review of the emotional health risks associated with a changing climate. *AJN, 117,* 44-52.

If you have any questions or comments, feel free to ask me now. If you have any further questions or comments, please contact Peter Sugrue at peter_sugrue@my.uri.edu. Because other students may be participating in this study in the future, we ask that you not discuss the details of this study with your friends or classmates.

Thank you for your participation!

Appendix J Invitation to Participate

Invitation to Participate for Psychology Research Participation Posting

A Study About Environmental Opinions

The purpose of this study is to investigate students' environmental opinions. Participants will respond to a prompt and respond to a series of questions in a survey. Please note, the prompt might be mildly distressing, especially for those who are concerned about their environment. **If you wish to avoid such stress, please do not participate in this study.**

Compensation for participants will equal the typical amount of points awarded toward class credit; participants will receive 1.5 SONA points for participating in a 45-minute study. For any questions contact the following researchers:

Peter Sugrue at peter_sugrue@my.uri.edu or petersugrue@uvic.ca

Appendix K.1 Outcome descriptive statistics across groups

Descriptive statistics for outcome variables across all conditions can be found in Table 4. These include emotions on the first occasion of measurement, emotions on the second occasion of measurement, emotion change scores, and environmental attitude variables. Histograms of response frequency for each outcome can be found in figures 2.1.1—2.9.[22] For emotional outcomes, histograms for scores at time one, at time two, and their differences are featured. Within-group descriptive statistics will be considered when evaluating assumptions for individual models and can be found in Table 6.[23]

Negative emotions: Fear, hostility, guilt, and sadness. At time one, negative emotion measure's internal consistencies range from adequate (*fear* Cronbach's α = .76) to very consistent (*sadness* Cronbach's α = .91). These measures were also consistent at time two, (Cronbach's α = .84—.91). The change scores for negative emotions were not as consistent, (Cronbach's α = .60—.78), which indicates that the items for negative emotions did not change very consistently.

Table 4.
Descriptive Statistics and Internal Consistencies Across Conditions

Outcome	Mean	SD	Possible Range		Skew	Kurt	α[a]	95% CI	
			Min	Max				Lower	Upper
Fear_t1	8.24	2.64	6	30	1.60	2.52	0.76	0.69	0.82
Hostility_t1	7.98	2.79	6	30	2.23	6.06	0.81	0.76	0.86
Guilt_t1	8.71	4.03	6	30	2.19	5.30	0.91	0.89	0.93
Sadness_t1	8.99	3.84	5	25	1.29	1.66	0.86	0.82	0.89
Joviality_t1	18.56	6.06	8	40	0.54	0.24	0.92	0.9	0.94
Serenity_t1	9.79	2.50	3	15	0.03	-0.56	0.78	0.72	0.83
Fear_t2	9.33	3.63	6	30	1.29	1.41	0.84	0.79	0.88

[22] See Figures folder
[23] See Tables Folder

Hostility_t2	9.12	3.82	6	30	2.02	5.86	0.88	0.85	0.91
Guilt_t2	9.83	4.27	6	30	1.28	1.26	0.91	0.89	0.93
Sadness_t2	9.22	3.88	5	25	1.22	1.64	0.87	0.83	0.90
Joviality_t2	15.02	5.80	8	40	0.96	0.81	0.92	0.9	0.94
Serenity_t2	8.31	2.95	3	15	0.37	-0.38	0.89	0.85	0.92
Fear	1.09	2.94	-24	24	1.08	2.11	0.71	0.62	0.78
Hostility	1.14	3.03	-24	24	1.23	2.63	0.78	0.72	0.84
Guilt	1.12	3.17	-24	24	0.67	2.49	0.77	0.71	0.83
Sadness	0.24	2.38	-20	20	-0.10	3.40	0.60	0.49	0.70
Joviality	-3.54	4.37	-32	32	-0.41	0.46	0.77	0.70	0.82
Serenity	-1.48	2.31	-12	12	-0.41	0.25	0.71	0.61	0.78
CCFear	8.89	1.56	2	10	-1.69	3.17	0.91	0.87	0.93
CCRisk	24.63	3.57	6	30	-0.55	0.30	0.78	0.72	0.83
NEP [b]	4.01	0.42	1	5	-0.37	0.25	0.75	0.68	0.81

Note. *n* = 139.
[a] Raw Cronbach's α.
[b]Outcome is the mean of item scores. All other outcomes are the sum of item scores.
t1 is time one, or before primes; t2 is time two, or after primes, other emotions indicate difference scores.

Across groups, the negative emotions have similar means at time one (*M* = 7.98—8.99), and surprisingly at time two (9.12—9.83). At time one, *guilt* and *sadness* have relatively larger standard deviations than *fear* and *hostility* (see Table 4), despite *sadness'* relatively smaller range of possible of scores: At time one, *guilt* and *sadness* may have demonstrated more variability than *fear* and *hostility*. At time two, the standard deviations between negative emotions are closer together, (*SD* = 3.63—4.37).

Change scores for negative emotions were all positive, indicating a net increase in negative emotions across groups; however, change in *sadness* was close to zero, and change in other negative emotions were slightly higher than one (*M* = 1.09—1.14). The standard deviation for sadness was also lower (*SD* = 2.38) than for other negative emotion's change scores (*SD* = 2.94—3.17).

The *fear* scores at the first occasion of measurement (see Figure 2.1.1) were moderately right-skewed (*skewness* = 1.60). A potential floor effect was detected, but these scores had substantial room to increase during the second occasion of measurement. Therefore, their distribution should not necessarily undermine this study's ability to detect increases in *fear* at the second occasion of measurement.

Fear scores for the second occasion of measurement (see Figure 2.1.2) were also moderately skewed right (*skewness* = 1.29), and high kurtosis was seen for change scores (see Figure 2.1.3; *kurtosis* = 2.11), which were centered around zero. Therefore, little change in *fear* is expected for the overall sample. Change scores also demonstrated some right-skew (*skewness* = 1.08). A meaningful proportion of change scores was positive, and this proportion was larger in frequency and magnitude than those that were negative. If change in *fear* is detected, it should be a net increase, and this change could still be substantial for specific groups.

Histograms of score frequencies for other negative emotions (see Figures 2.2.1—2.4.3) showed very similar patterns to *fear*. At the first occasion of measurement, scores of *hostility* and *guilt* demonstrated very high skewness (*skewness* = 2.23 & 2.19 respectively) and extreme kurtosis (*kurtosis* = 6.06 & 5.30 respectively). These scores were concentrated at the very lowest of possible outcomes. Frequencies of change scores for both emotions were concentrated on zero with mild-minimal right skewness (*skewness* = 1.23 & 0.67 respectively) and high kurtosis (*kurtosis* = 2.63 & 2.49 respectively). Similar to *fear*, little change is expected in *hostility* and *guilt* across the sample; however, small increases may be observed, and substantial increases may still be detectable in specific groups. A similar trend holds for *sadness*, but statistics of skewness and kurtosis are less extreme for this emotion on all occasions of measurement (see Figures 2.4.1—2.4.3).

Positive emotions: Serenity and joviality. The scales of measurement for positive emotions were different than for negative emotions: at time one and two, possible response scores for *joviality* ranged from 8 to 40, and those for serenity ranged from 3 to 15. Their means at time one are high compared to those of the negative emotions, even when accounting for the differences in possible responses.[24] Also, change scores for *joviality* and *serenity* were both negative (M = -3.54 & -1.48 respectively), indicating an overall decrease in these emotions across conditions.

Statistics of skewness and kurtosis for *joviality* are less than the absolute value of one for each occasion of measurement. Unlike the negative emotions, scores for *joviality* are widely distributed on the first occasion of measurement (*kurtosis* = 0.24), and their distribution looks close to normal, if not, uniform (see Figure 2.5.1). On the second occasion of measurement, the distribution becomes right skewed (*Skewness* 0.96) and a slight concentration can be seen around the lowest scores (*kurtosis* = 0.81; see Figure 2.5.2). The change score histogram looks normally distributed (see Figure 2.5.3), with a mean less than zero. Overall, a net decrease in *joviality* is expected.

On the first occasion of measurement, statistics of skewness and kurtosis for *serenity* were even closer to zero. A small concentration of scores can be seen between the mean and the highest potential score (see Figure 2.6.1). Nonetheless, the distributions at both occasions of measurement were wide, and the change score histogram (see Figure 2.6.3) indicates a net drop

[24] One can deduce this from taking the mean, then dividing it by the minimum possible response (i.e., number of items), both of which are featured in Table 4.

in *serenity*. Overall, these positive emotions exhibit more variability and normality in their distributions; therefore, effects for these emotions may be more pronounced compared to those for *fear*, *hostility*, *guilt*, and *sadness*.

Fear of climate change. Fear of climate change (i.e., *CC_Fear*) only has two items that are very highly correlated, $r = .83$, 95% CI [.73, .90]. Although the Cronbach's α for this construct is high, confidence that these items capture the purported construct cannot be assumed. The frequency of *CC_Fear* scores demonstrated heavy left-skew (-1.69) and heavy kurtosis (3.17). In accordance with these statistics, the frequency histogram (see Figure 2.7) shows a strong concentration of scores near the maximum possible response, and most scores were disproportionally concentrated at high responses of *CC_Fear*. For this outcome, the demonstrated celling effect could obfuscate any true effects: if the population sampled consistently scored at the highest response for this measure, then increases in fear of climate change in specific conditions may not be detectable. Indeed, a frequency histogram for this outcome specific to the control group (see Figure 2.7.2) shows a very similar distribution, which indicates that *CC_Fear* scores are concentrated around the maximum without influence from the primes. Any conditional increases on fear of climate change are probably not detectable for this procedure and in this population.

Climate change risk perception. *CC_Risk* features some similar problems to *CC_Fear*, but to a lesser extent. Although the concentration of scores is not as disproportionately near the maximum possible score as *CC_Fear*, the frequency of *CC_Risk* is left-skewed (*skewedness* = -0.55) and the vast majority of scores are above the measure's midpoint (see Figure 2.8). Increases in climate change risk perception may be difficult to detect; however, they should not be impossible to detect given the observed variation for this measure (*M* = 24.63, *SD* = 3.57, *kurtosis* = 0.30).

New ecological paradigm. Environmental attitude outcomes contain different scales of measurement than previous variables. Possible scores on this measure range from 1-5; every score is based on the mean of fifteen items, which were administered on a 5-point Likert scale. The *NEP* response distribution (see Figure 2.9) is very close to normal, which is consistent with its scores on skewness (-.037) and kurtosis (0.25). However, this distribution resides within the higher range of possible scores (range = 2.67—5.00). This could stem from a population-level characteristic (i.e., this population shows high adherence to the New Ecological Paradigm). If engagement with a given scenario were to increase environmental attitudes, the effect might be difficult to detect.

Appendix K.2 Confirmatory analyses assumptions

In Table 6, all within-group descriptive statistics, including means, standard deviations, Cronbach alphas, skewness, and kurtosis, can be found for specific measures at time one, time two, and for their difference scores.[25]

4.3.1 Individual independence

For dependency, all individuals are assumed to be independent in their responses to survey items and in their interactions with experimental conditions. Participants were surveyed in waves: one form of dependency that could be tested is the time of day, and the day of the week, during which the procedure occurred. Emotional reactions could vary as a function of this dependency, and these variables were recorded. Therefore, these variables may be considered when a larger sample is collected. Dependency may also reside between dependent variables; however, this will be addressed in exploratory analyses, which may involve multivariate analyses that depend on correlation magnitudes between dependent variables.

4.3.2 Normality of outcome residuals

Only a few models demonstrated normality of residuals for predicted outcomes. Table 7 has Shaprio-Wilk tests and judgements of normality based on QQ-plots (see Figures 3.1-3.9). The variables that approached residual normality were *joviality*, *serenity*, and the *NEP*. Residuals from *CC_Risk* also approached normality (see Figure 3.8); however, a slight ceiling effect was also suspected from the corresponding histogram (see Figure 2.8).

Violations of residual normality are suspected to influence the detectability of effects for the following variables: *fear*, *hostility*, and *CC_Fear*. *CC_Fear* has a clear celling effect in which most responses are concentrated at the maximum response (see Figure 2.7); therefore,

[25] See Tables Folder

group differences may be difficult to detect. QQ-plots for both *fear* (see Figure 3.1) and *hostility* (see Figure 3.2) show a spike of identical values around the center. These deviations of residual normality should detract from the respective models' power to find effects. Conclusions from models with these outcomes should be treated with caution.

Table 7.
Normality for Confirmatory Outcomes Across Groups

Outcome	Shapiro-Wilk (*W*)	*p*-value	Skew	Kurtosis	QQ_Judgement
Fear	0.94	< .001	1.08	2.11	heavy-tailed
Hostility	0.89	< .001	1.23	2.63	heavy-tailed
Guilt	0.95	< .001	0.67	2.49	light-tailed
Sadness	0.93	< .001	-0.10	3.40	light-tailed
Joviality	0.98	= .049	-0.41	0.46	normal
Serenity	0.98	= .035	-0.41	0.25	normal
CCFear	0.80	< .001	-1.69	3.17	left-skew heavy; ceiling
CCRisk	0.97	= .003	-0.55	0.30	normal; ceiling
NEP	0.99	= .165	-0.37	0.25	normal

Note. N = 139
Emotions refer to change scores

4.3.3 Baseline equivalency between groups

The use of change scores as an outcome variable does not account for differences in baseline scores, and interpretation of group differences in change scores may be confounded by differential baseline levels between groups. In such cases, scores from the second occasion of measurement can be predicted from group membership while using scores from the first occasion of measurement as a covariate in ANCOVA. Because this was not considered during hypothesis formulation, such analyses will be considered exploratory if conducted.

Nonetheless, baseline equivalency between groups was considered for emotional outcomes. To test for group differences, separate regression analyses were conducted with emotional outcome scores at the first occasion of measurement as the dependent variable, and the condition groups as dummy coded predictors. Boxplots for emotions at time one (see Figures 4.1-4.6) were also evaluated to identify any baseline group differences.

Inferentially, no group differences were found for *fear*, *sadness*, *joviality*, or *serenity* on the first occasion of measurement. The omnibus test for *hostility* at time one was significant—$F(4, 134) = 2.77$, $p = .030$—and the omnibus test for *guilt* at time one approached significance, $F(4,134) = 2.23$, $p = .069$. Because these analyses are investigating assumptions and not directly testing hypotheses of interest, the threshold for post-hoc group comparison was relaxed.

Visually, all groups reported similar levels of *fear* at time one. Group means for *sadness* were between 8 and 9 for time one, except for the benign group, which was slightly higher (M = 10.34). The between group means were very similar for both *joviality* and *serenity*.

For *hostility* at time one, the climate change local group started with an insignificantly higher level of *hostility* than the control group (*mean difference* = 1.40, $p = .323$) and the non-climate change group (*mean difference* = 1.28, $p = .447$). Considering the descriptive statistics (see Table 4 & 5) and how concentrated these scores were, baseline group differences should be noted even if insignificant. Although no significant differences were detected, some group comparisons are worth mentioning: The climate change global group featured higher *hostility* scores than the control group (*mean difference* = 1.76, $p = .101$) and the non-climate change group (*mean difference* = 1.64, $p = .173$). If the *hostility* happened to be provoked more strongly in the CC_Global group relative to the other groups, the effect might be more difficult to detect: If hostility for CC_Global was high by chance at the first occasion of measurement, the increase in hostility might be obfuscated within the change score. Also, the benign group featured higher *hostility* scores than the control group (*mean difference* = 1.62, $p = .156$).

Although the omnibus test was not significant, a boxplot group comparison (see Figure 4.3) shows that the control group reported a lower level of *guilt* at time one. One significant group difference was detected; a lower level of *guilt* was observed at time one for the control group compared to the benign group (*mean difference* = 2.87, *p* = .048). Although no other significant differences were detected, some are worth noting; the benign group featured higher *guilt* scores than the climate change local group (*mean difference* = 1.91, *p* = .395), and the control group featured lower *guilt* scores than the non-climate change group (*mean difference* = -1.83, *p* = .421) and the climate change global group (*mean difference* = -2.04, *p* = .283).

Overall, the control group may have started with artificially lower scores than the other groups, which can lead to an overstated change in *guilt* in two ways: (1) If *guilt* for the control group rises in tandem with other groups, the degree of change might be overstated. Also, (2) if the control group's *guilt* at the second occasion of measurement is similar to the baseline-level in other groups, an artificial increase in *guilt* could be detected for the control group.

4.3.4 Homogeneity of variance

Heterogeneity of sample variances should not heavily bias the *F*-statistic for omnibus tests, because sample sizes are close to equal between groups (25-30). Nonetheless, this assumption was assessed visually (see Figures 5.1-5.9) and inferentially. Levene's test was only significant for outcomes of *fear* and *hostility*. Variance in the *fear* outcome was much larger in the CC_Local condition, which has a smaller sample size than all other conditions. Therefore, the small effect that heterogeneity of variance may have would be underestimation of the *F*-statistic significance level (i.e., it would underpower the ability to detect a significant omnibus effect). Similarly, *hostility* shows smaller variances for most of the larger groups. Also, although the variance in the CC_Global condition is higher than that of the CC_Local, they are similar enough to eliminate concern of type-I error inflation. In sum, for both emotional and environmental attitude outcomes, violations of homogeneity of variance should be minimal, and any that are present should not inflate type-I error for this procedure.

Table 8.

Homogeneity of Variance Evaluation: Levene's Test and Outcome Variances by Group

Outcome	Levene's Test	*p*-value	CC_Local (*n* = 25)	Control (*n* = 30)	Benign (*n* = 29)	Non_CC (*n* = 26)	CC_Global (*n* = 29)
Fear	$F(4, 134) = 3.78$	< 0.01	*13.08*	3.84 (-)	4.21 (-)	7.44 (-)	12.61 (-)
Hostility	$F(4, 134) = 4.97$	< 0.01	*13.71*	4.32 (-)	6.36 (-)	5.16 (-)	14.97 (+)
Guilt	$F(4, 134) = 2.44$	= 0.05	*7.76*	3.94 (-)	12.18 (+)	11.88 (+)	14.64 (+)
Sadness	$F(4, 134) = 1.34$	= 0.26	*4.86*	2.46 (-)	3.85 (-)	6.99 (+)	9.79 (+)
Joviality	$F(4, 134) = 0.21$	= 0.93	*15.52*	14.45 (-)	21.44 (+)	15.36 (-)	21.6 (+)
Serenity	$F(4, 134) = 0.64$	= 0.63	*6.08*	3.06 (-)	5.62 (-)	3.95 (-)	4.28 (-)
CCFear	$F(4, 134) = 1.21$	= 0.31	*2.12*	3.41 (+)	2.33 (+)	1.42 (-)	2.93 (+)
CCRisk	$F(4, 134) = 1.09$	= 0.37	*12.66*	17.13 (+)	13.61 (+)	6.48 (-)	14.26 (+)
NEP	$F(4, 134) = 1.63$	= 0.17	*0.13*	0.29 (+)	0.12 (-)	0.17 (+)	0.18 (+)

Note. -/+ signs next to the group specific variances indicate whether that variance was greater or less than the variance of the reference group, which had the smallest sample size out of all groups. Reference group variances are italicized. Emotional outcomes refer to change scores.

Appendix K.3 Confirmatory outcomes: Results

Group specific means and standard deviations can be found in Table 6 for all outcome variables considered. Note, for the following analysis, only comparisons to the local climate change group are considered, and these are summarized in Table 9.

Table 9.

Group Comparisons for All Confirmatory Outcome Variables

Outcome	Group	Hedges' *g*	95% CI		*B*	*SE B*	*p*	FDR *p*
Fear	Control	0.34	0.87	-0.20	-0.97	0.77	0.2112	0.7604
CC_Local Intercept:	Benign	0.46	1.00	-0.09	-1.33	0.78	0.0884	0.6031
B = 1.40,	Non_CC	0.12	0.67	-0.43	-0.40	0.80	0.6161	0.9881
SE = 0.57	CC_Global	0.34	0.87	-0.20	1.22	0.78	0.1178	0.6031
Hostility	Control	0.31	0.84	-0.23	-0.91	0.80	0.2614	0.8553
CC_Local Intercept:	Benign	0.01	0.55	-0.52	-0.04	0.81	0.9607	0.9881
B = 1.04,	Non_CC	0.00	0.55	-0.55	0.00	0.83	0.9985	0.9985
SE = 0.59	CC_Global	0.38	0.92	-0.16	1.48	0.81	0.0704	0.6031
Guilt	Control	0.31	0.84	-0.23	-0.74	0.86	0.3906	0.9881
CC_Local Intercept:	Benign	0.27	0.81	-0.26	-0.89	0.87	0.3068	0.9182
B = 1.44,	Non_CC	0.15	0.70	-0.40	-0.48	0.89	0.5912	0.9881
SE = 0.63	CC_Global	0.16	0.70	-0.37	0.56	0.87	0.5189	0.9881
Sadness	Control	0.67	1.21	0.12	-1.28	0.64	0.0469	0.5633
CC_Local Intercept:	Benign	0.38	0.92	-0.16	-0.81	0.64	0.2096	0.7604
B = 0.88,	Non_CC	0.40	0.95	-0.15	-1.00	0.66	0.1340	0.6031
SE = 0.47	CC_Global	0.02	0.55	-0.52	-0.05	0.64	0.9352	0.9881
Joviality	Control	0.84	1.39	0.28	3.27	1.14	0.0048	0.0864
CC_Local Intercept:	Benign	0.02	0.55	-0.52	-0.07	1.15	0.9513	0.9881
B = -4.24,	Non_CC	0.03	0.58	-0.52	-0.11	1.18	0.9285	0.9881
SE = 0.84	CC_Global	0.03	0.57	-0.50	0.14	1.15	0.9057	0.9881

Table 9 cont.

Group Comparisons for All Confirmatory Outcome Variables

Outcome	Group	Hedges' *g*	95% CI		*B*	*SE B*	*p*	FDR *p*
Serenity	Control	1.12	1.69	0.55	2.40	0.58	0.0001	0.0021*
CC_Local Intercept: *B* = -2.20, *SE* = 0.43	Benign	0.39	0.93	-0.15	0.96	0.58	0.1022	0.6031
	Non_CC	0.04	0.59	-0.51	0.08	0.60	0.8877	0.9881
	CC_Global	0.03	0.57	-0.50	-0.08	0.58	0.8966	0.9881
CCFear	Control	0.19	0.72	-0.34	-0.33	0.43	0.4452	0.9881
CC_Local Intercept: *B* = 8.96, *SE* = 0.32	Benign	0.13	0.67	-0.40	-0.20	0.43	0.6403	0.9881
	Non_CC	0.14	0.69	-0.41	0.19	0.44	0.6612	0.9881
	CC_Global	0.02	0.56	-0.51	0.04	0.43	0.9260	0.9881
CCRisk	Control	0.14	0.67	-0.40	-0.54	0.98	0.5812	0.9881
CC_Local Intercept: *B* =24.64, *SE* = 0.72	Benign	0.11	0.64	-0.43	0.39	0.98	0.6892	0.9881
	Non_CC	0.12	0.66	-0.44	0.36	1.01	0.7221	0.9881
	CC_Global	0.05	0.59	-0.48	-0.19	0.98	0.8458	0.9881
NEP	Control	0.24	0.77	-0.30	-0.11	0.12	0.3316	0.9182
CC_Local Intercept: *B* = 4.05, *SE* = 0.09	Benign	0.15	0.69	-0.38	-0.05	0.12	0.6376	0.9881
	Non_CC	0.22	0.77	-0.33	-0.09	0.12	0.4701	0.9881
	CC_Global	0.14	0.68	-0.39	0.06	0.12	0.6203	0.9881

Notes. Group specific means, and SDs, can be found in Table 6. Intercepts for emotional change scores represent the mean change in the respective emotion for the CC_Local group. The difference from zero indicates the direction and unstandardized magnitude of change. Intercepts for the environmental attitude outcomes represent the mean scores for the CC_Local group. The difference from zero is nonsensical. Hedges' *g* and the respective CIs were calculated using Lakens's (2013) spread sheet. *B* is the unstandardized beta value in the respective regression model. It represents the raw mean difference on the outcome between the CC_Local group and the respective comparison group. *p* is the raw *p*-value from the independent variable's *t*-test. FDR *p* is the *p*-value adjusted for the false discovery rate.

4.4.1 Negative emotions

With the dummy coded prime as the only predictor, significant omnibus tests were detected for the *fear* model—$F(4, 134) = 3.52$, $p = 0.009$, $\eta_p2 = .095$—and the *hostility* model—

$F(4, 134) = 2.45$, $p = 0.049$, $\eta_p 2 = .068$. Omnibus tests for *guilt* and *sadness* were insignificant. Nonetheless, *p*-values for all preregistered group comparisons were considered when applying the FDR correction.

Despite the significant omnibus test, those exposed to the local climate change prime did not significantly differ from any other group in *fear* or *hostility* changes. Notably, the measures of *fear* and *hostility* were perhaps the most problematic emotional measures in their ability to detect an effect. For both measures, this is evident when evaluating the normality of their residuals, and their heterogeneity between group variances (see Sections 4.3.2 & 4.3.)

The effects *fear* and *hostility* were not necessarily negligible, however, and their statistical significance may have been obscured by low power. Compared to the climate change local group, a smaller increase in *fear* was observed for the control group— Hedges' $g = -0.34$, 95% CI [-0.87, 0.20]—and the benign group— Hedges' $g = -0.46$, 95% CI [-0.99, 0.08], which is somewhat consistent with the hypotheses. A similar increase in *fear* was observed in the non-climate change group, Hedges' $g = -0.12$, 95% CI [-0.66, 0.41], and a greater increase in *fear* was observed in the climate change global group, Hedges' $g = 0.34$, 95% CI [-0.20, 0.87].

Compared to the climate change local group, a similar increase in *hostility* was observed in the benign group, Hedges' $g = -0.01$, 95% CI [-0.54, 0.52], and in the non-climate change group, Hedges' $g = 0.00$, 95% CI [-0.53, 0.53]. The control group demonstrated a slight increase in *hostility* ($M = 0.13$, $SD = 2.08$). Compared to the climate change local group's increase in *hostility* ($M = 1.04$, $SD = 3.72$), the control group's increase was smaller— Hedges' $g = -0.31$, 95% CI [-0.84, 0.23]—and the climate change global group's increase in *hostility* ($M = 2.52$, $SD = 3.87$) was larger, Hedges' $g = 0.38$, 95% CI [-0.15, 0.92].

4.4.2 Positive emotions

With the dummy coded prime as the only predictor, significant omnibus tests were detected for the *joviality* model—$F(4, 134) = 3.58$, $p = 0.009$, $\eta_p 2 = .096$—and the *serenity* model—$F(4, 134) = 7.03$, $p < 0.001$, $\eta_p 2 = .173$.

Those exposed to the local climate change prime with deleterious effects demonstrated decreases in *joviality* ($M = -4.24$, $SD = 3.94$) and in *serenity* ($M = -2.20$, $SD = 2.47$); however, comparatively little emotional change was seen in the control condition for both emotions ($M = -0.97$, $SD = 3.80$; $M = 0.20$, $SD = 1.75$ respectively). Compared to the control condition, the group in the local climate change condition dropped significantly in *serenity* Hedges' $g = 1.12$, 95% CI [0.29, 1.69].

Compared to the climate change local condition, the benign, the non-climate change, and the climate change global conditions all demonstrated similar decreases in *joviality*. No *p*-values were below .05, even before adjusting for the false discovery rate. Also, the Hedges' *g* effect size differences ranged from -0.03 to 0.03. For *serenity*, the story is similar. The same group comparisons did not yield significant differences even before the FDR adjustment. However, the decrease in *serenity* for the climate change local group ($M = -2.20$, $SD = 2.47$) was not identical to decrease in *serenity* for the benign group ($M = -1.24$, $SD = 2.37$). Although the standardized mean difference was not significant, it was not necessarily negligible and the effect may have been obscured by a lack of statistical power, $n_{\text{CC\_local}} = 25$, $n_{\text{Benign}} = 29$, Hedges' $g = 0.39$, 95% CI [-0.14, 0.93].

Confirmatory hypotheses. Table 10. mirrors the hypotheses from Table 1. It shows the observed Hedges' *g* for the comparison and the FDR adjusted *p*-value from the confirmatory analyses. It also shows a judgement of whether the null hypothesis (i.e., equal means) was retained, rejected, or whether the design was too underpowered (i.e., .80 ≥ 1-β) to detect the comparison's hypothesized effect.

Table 10.
Hedges' g *and FDR Adjusted* p*-values for Planned Comparisons to CC_Local Condition*

	Control			Benign			Non_CC			CC_Global		
Emotion	*g*	*p*	HYP	*g*	*p*	HYP	*g*	*p*	HYP	*g*	*p*	HYP
Fear	0.34	0.76	Retain	0.46	0.60	Retain	0.12	0.99	UND*	0.34	0.60	UND
Hostility	0.31	0.86	UND	0.01	0.99	UND	0.00	1.00	UND	0.38	0.60	UND
Guilt	0.31	0.99	UND	0.28	0.92	UND	0.15	0.99	UND	0.16	0.99	UND
Sadness	0.67	0.56	UND	0.39	0.76	UND	0.40	0.60	UND	0.02	0.99	UND
Joviality	0.84	0.09	UND	0.02	0.99	UND	0.03	0.99	UND*	0.03	0.99	UND*
Serenity	1.12	0.00	Reject	0.39	0.60	Retain	0.04	0.99	UND*	0.03	0.99	UND*
CCFear	0.19	0.99	Retain	0.13	0.99	Retain	0.14	0.99	Retain	0.03	0.99	UND
CCRisk	0.14	0.99	Retain	0.11	0.99	Retain	0.12	0.99	Retain	0.05	0.99	UND
NEP	0.24	0.92	NA	0.15	0.99	NA	0.22	0.99	NA	0.14	0.99	NA

Note. HYP refers to the hypothesized effect, which can be found in Table 1. The HYP columns show rejection or retention of the null hypothesis of equal means for planned comparisons. Planned comparisons that were underpowered to observe the predicted effect size are denoted with UND. Comparisons that were not planned are denoted with NA. Specific hypotheses for the NEP were not registered; however, CC_Local comparisons to other groups for the NEP were included in the FDR adjustment. Therefore, their effect sizes and FDR adjusted *p*-values are included in this table.
*Predicted to be 0 and $g < .2$

4.4.3 Environmental attitudes

Omnibus tests for environmental attitudes were insignificant. Specifically, the following tests were executed: fear of climate change—$F(4, 134) = 0.48$, $p = .75$, $\eta_p 2 = .014$—climate change risk perception—$F(4, 134) = 0.34$, $p < .85$, $\eta_p 2 = .01$—and the NEP—$F(4, 134) = 0.74$, $p < 0.57$, $\eta_p 2 = .02$. As noted above, the celling effects that come with fear of climate change, and to a lesser extent climate change risk perception, could influence the groups comparisons. Figures 6.1-6.4 demonstrate histograms of these variables specific to the control group and the CC_Local group. However, a ceiling effect would not explain the lack of effect found in the

NEP, which demonstrate substantial variation and normality. Note, the mediation model in section 3.1.3 was not executed because no group differences were found in these variables.

Figure 6.1
Control group histogram of CCFear

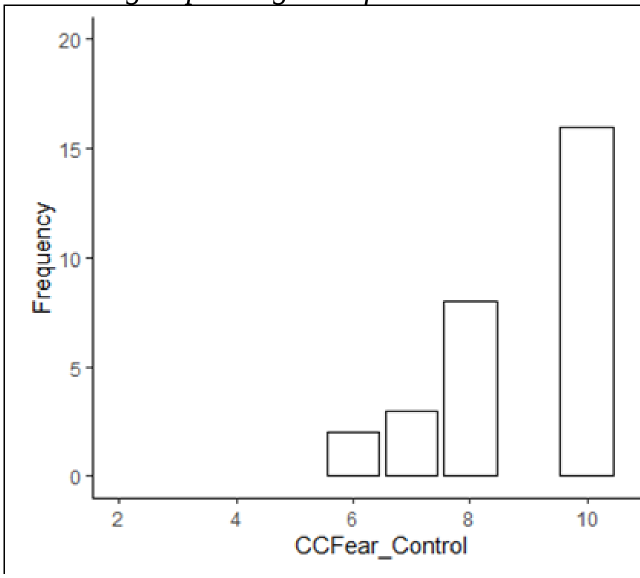


Figure 6.2
CC_Local group histogram of CCFear

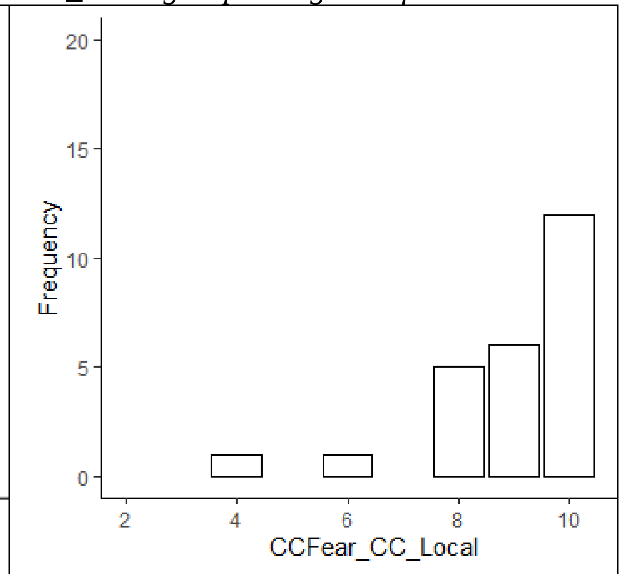


Figure 6.3
Control group histogram of CCRisk

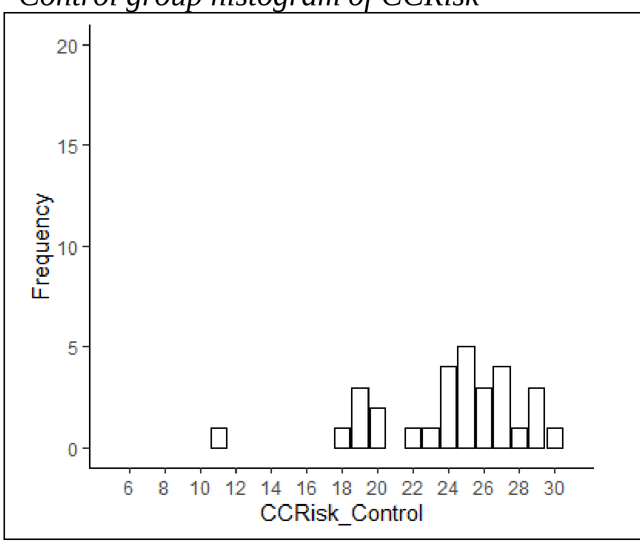
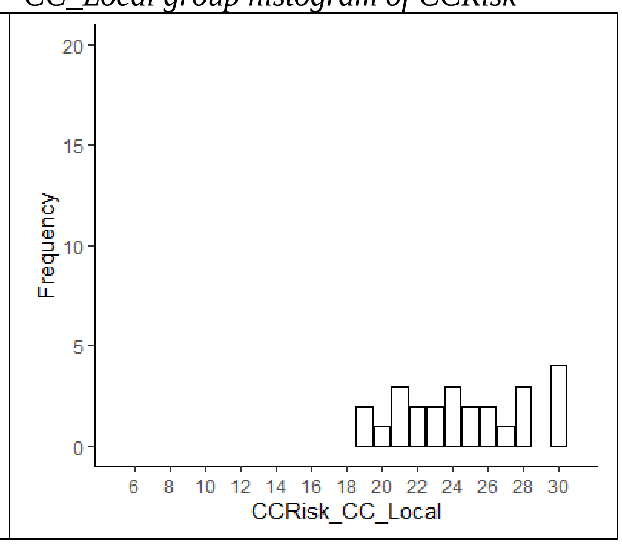


Figure 6.4
CC_Local group histogram of CCRisk



Note. The distributions of raw scores for *CCFear* and *CCRisk*, specific to the control and CC_Local conditions.

Appendix_K.4 Exploratory analyses: MANOVA

First, a MANOVA was considered for appropriately correlated outcome variables. Then, all comparisons were made between groups for the variables above and the FDR adjustment was applied. Finally, discriminant function analysis was employed to find specific combinations of outcome variables that best separated the groups. With these post-hoc analyses, one can consider whether groups varied in one emotional response (e.g., *serenity*) or some meaningful combination of them (e.g., *fear* and *hostility*). One can also consider the relative contribution of various outcomes to group differences (e.g., *serenity* explains group differences more than *fear*).

4.5.1 Variable selection

MANOVA can work differently depending on the intercorrelations that are considered (Tabachnick & Fidell, 2001), which is one reason why a lack of multicollinearity is such a crucial assumption to evaluate. Even if multicollinearity is absent, care should be taken in deciding which outcomes to assess in a single MANOVA. Unfortunately, absolute and widely accepted rules for choosing complementary outcomes are vague; Nonetheless, Tabachnick and Fidell (2001) provide some criteria for such choices.

An estimation of the Tabachnick and Fidell (2001) criteria can be found in the Table 11.1 key. Based on these correlation coefficient guidelines, intercorrelations between outcome variables were assessed for their compatibility within the MANOVA framework, which were described as either compatible, questionable, or incompatible. Blocks of compatibility were observed between the emotional outcomes and the environmental attitude outcomes. A theoretical selection of MANOVA outcomes would also point to these same blocks, which is encouraging. Therefore, two MANOVAs were executed: the first featured the emotional outcomes (i.e., *Fear*, *Hostility*, *Guilt*, *Sadness*, *Joviality*, and *Serenity*) and the second featured environmental attitude outcomes (*Fear of Climate Change*, *Climate Change Risk Perception*, and the *New Ecological Paradigm*). Statistical assumptions were assessed for each group of DVs separately.

Table 11.1.
MANOVA Outcome Compatibility Evaluation

	Fear	Hostility	Guilt	Sadness	Joviality	Serenity	CCFear	CCRisk	NEP
Fear	1.00	0.62	0.44	0.38	-0.20	-0.49	0.22	0.16	0.23
Hostility	0.62	1.00	0.52	0.34	-0.33	-0.49	0.22	0.05	0.29
Guilt	0.44	0.52	1.00	0.46	-0.44	-0.40	0.12	0.07	0.15
Sadness	0.38	0.34	0.46	1.00	-0.43	-0.23	0.09	0.16	0.24
Joviality	-0.20	-0.33	-0.44	-0.43	1.00	0.45	-0.04	-0.09	-0.03
Serenity	-0.49	-0.49	-0.40	-0.23	0.45	1.00	-0.15	-0.04	-0.10
CCFear	0.22	0.22	0.12	0.09	-0.04	-0.15	1.00	0.45	0.49
CCRisk	0.16	0.05	0.07	0.16	-0.09	-0.04	0.45	1.000	0.43
NEP	0.23	0.29	0.15	0.24	-0.03	-0.10	0.49	0.43	1.000

Table 11.2.
MANOVA Outcome Compatibility Guide

Assessment	Pearson Correlation Coefficient		
Compatible	-0.999	-0.350	
Questionable	-0.349	-0.300	-0.251
Incompatible	-0.250	0.000	0.250
Questionable	0.251	0.300	0.349
Compatible	0.350	0.650	
Questionable	0.651	7.000	0.849
Incompatible	0.850	0.999	

4.5.2 Multivariate normality

Within-group multivariate normality was assessed with the Mardia tests of skewness and kurtosis, which was calculated with the *MVN* package in R (Korkmaz, Goksuluk, & Zararsiz, 2014). In appendix X.2, see Table 7 and figures 3.1—3.9 for evaluations of univariate normality of residuals across groups. Tables 12.1—12.5[26] can be used to evaluate within-group univariate normality with outcome specific values for Shapiro-Wilk tests.

MANOVA is robust to moderate amounts of nonnormality; however, if outliers are driving it, severe problems can result (Tabachnick & Fidell, 2001, p. 329). If outliers are removed upon their evaluation, the multivariate normality assumption will be reevaluated; substantial attenuation of nonnormality could also support outlier removal decisions.

Emotional outcomes. The primary condition of interest—CC_Local—demonstrated multivariate normality, as did the non-climate change condition. The other conditions showed high and significant levels of multivariate skewness and kurtosis (see Table 13.1).

Table 13.1
Multivariate Normality for Emotional Outcomes

	Mardia Skewness	*p*-value	Mardia Kurtosis	*p*-value	Multivariate Normality
Climate Change Local (*n* = 25)	68.28	< .126	0.02	= .980	YES
Control (*n* = 30)	151.57	< .001	4.78	< .001	NO
Benign (*n* = 29)	99.31	< .001	2.99	= .003	NO
Non-Climate Change (*n* = 26)	68.55	= .121	0.44	= .660	YES
Climate Change Global (*n* = 29)	152.47	< .001	4.46	< .001	NO

Note.
$p < .05$ indicates a violation of multivariate normality

[26]see Tables folder

Table 13.2

Multivariate Normality for Environmental Outcomes

	Mardia Skewness	*p*-value	Mardia Kurtosis	*p*-value	Multivariate Normality
Climate Change Local (n = 25)	21.83	= .016	0.36	= .721	NO
Control (n = 30)	22.89	= .011	1.90	= .057	NO
Benign (n = 29)	13.90	= .177	-0.52	= .605	YES
Non-Climate Change (n = 26)	10.37	= .409	-0.90	= .370	YES
Climate Change Global (n = 29)	34.85	< .001	1.34	= .182	NO

Note.
$p < .05$ indicates a violation of multivariate normality

Environmental outcomes. When considering the environmental outcomes, the primary condition of interest—the local climate change condition—was significantly skewed, but did not demonstrate significant kurtosis. The global climate change condition demonstrated the same pattern. The control condition demonstrated significant skew and kurtosis. The benign and the non-climate change conditions demonstrated multivariate normality (see Table 13.2).

4.5.4 Homogeneity of variance-covariance matrices

Any heterogeneity of the variance-covariance matrices was predicted to have minimal influence on these analyses because of similarly sized groups, which ranged from 25 to 30. Also, violation of this assumption is sensitive to departures of normality (Tabachnick & Fidell, 2001, p. 330), which have been demonstrated above. Nonetheless, the assumption of equal covariance matrices across groups was tested for emotional outcomes, Box's M (84) = 138.79, p = .00016, and for the environmental outcomes, Box's M (24) = 29.45, p = .2036. Because Box's M is notoriously sensitive, a significant departure from matrix equality is indicated when the test's *p*-value < .001 (Tabachnick & Fidell, 2001, p. 330). Therefore, a significant departure was detected for the emotional outcomes, but not detected for the environmental outcomes. If the group sample sizes change because of outlier deletions, however, this assumption will have to be reevaluated. Evaluations of univariate homogeneity of variance can be found in the confirmatory results above (see Section 4.3.4).

4.5.5 Linearity

MANOVA assumes linearity between each pair of dependent variables within groups (Tabachnick & Fidell, 2001). Violation of this assumption will reduce the power to detect differences between groups. To evaluate linearity, each outcome was regressed onto each other outcome in separate multiple regressions, and this was repeated within each group. More specifically, Fox and Weisberg (2019) was used as a guide to generate visualizations of residuals by dependent variable raw scores, and to generate curvature tests. In the curvature tests, an outcome of interest was considered in isolation with each other outcome as a predictor, and the square of that predictor was then tested for additionally explained variance in the outcome of interest. Also, a linear combination of the other outcomes (e.g., all the other emotions in the first MANOVA) was tested for an effect, and the square of that linear combination was also tested for additionally explained variance.

For the emotional MANOVA, each of six emotional outcomes was predicted by six other variables (i.e., the other five emotional outcomes and their linear combination), within each group and for the combined sample: Testing for multivariate linearity within each cell resulted in 216 curvature tests for emotional outcomes. Table 14.1 provides a tally of curvature tests violated by both emotion and group. Forty-one emotional outcome curvature tests were violated.

Table 14.1
Frequency of Curvilinear Violations: Emotional Outcomes.

	Fear	*Hostility*	*Guilt*	*Sadness*	*Joviality*	*Serenity*	*Total for Group*
Control (n = 30)	1	2	2	1	0	0	6
Benign (n = 29)	2	1	3	2	1	0	9
Non_CC (n = 26)	6	1	0	0	3	0	10
CC_Local (n = 25)	0	1	0	3	0	2	6
CC_Global (n = 29)	0	1	1	1	0	0	3
Combined (n = 139)	4	1	0	0	2	0	7
Total for Emotion	13	7	6	7	6	2	41

Note. For a given cell, the value indicates the number of times variance in the respective emotion was additionally explained by either the square of one of the other emotions, or by the square of the linear combination of the other emotions, within the respective group. For example, the first cell indicates that one of the other emotions (or the linear combination of them) demonstrated one curvilinear relation with *fear*, in the control group. The threshold of significance for additionally explained variance was $p < .05$. Each cell that corresponds to both an emotion and a group has a ceiling of six possible violations. Each cell that corresponds to a *total for emotion*, or a *total for group*, has a ceiling of 36 possible violations. The last cell (i.e., bottom right) has a ceiling of 216 violations.

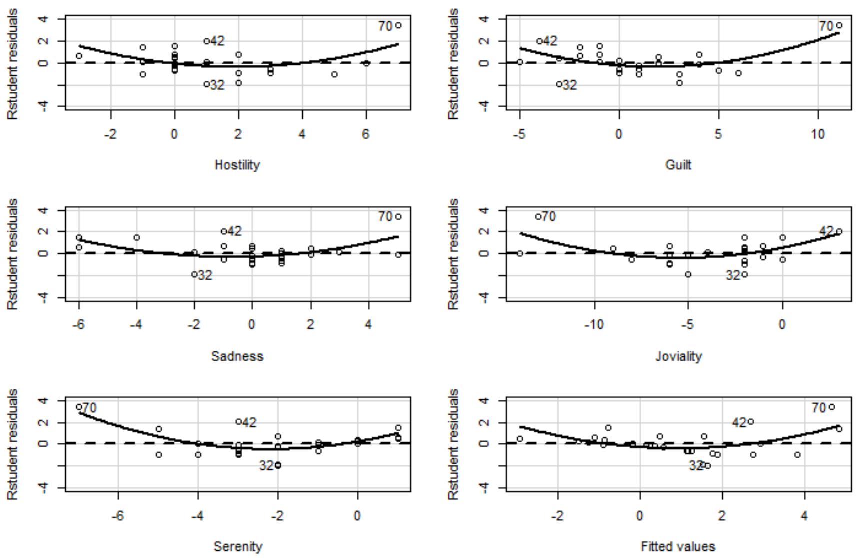
Additionally, the residuals for each outcome were plotted in relation to their predictor, which provided a visual evaluation of linearity for every corresponding curvature test. Cases of interest can be further evaluated with these visualizations (e.g., see Figure 7).

The most problematic emotion was *fear*, especially within the Non_CC group. Finding effects for *fear* might be somewhat difficult, and finding effects for *fear* when a specific group comparison that includes the Non_CC group could be extremely difficult. The least problematic emotion was *serenity*; however, it was somewhat problematic for the primary group of interest, CC_Local.

Only three curvilinear relations were observed in the CC_Global group, and these were distributed across the emotions; therefore, a lack of linearity between dependent variables should not undermine comparisons between the CC_Global group and other groups. Nine Curvilinear relations were detected in the Benign group, and these were distributed throughout the emotional outcomes. For group comparisons that include the Benign group, finding effects could be somewhat difficult across emotions. Ten curvilinear relations were detected in the Non_CC group, and these violations were concentrated on the outcome of *fear*: again, finding effects for *fear* when a specific group comparison includes the Non_CC group could be extremely difficult (see Figure 7).

Figure 7.

Curvilinear Relations Between Fear *and Other Outcomes Within the Non_CC Group*



Squared Predictor	*t*-value	*p*-value
Hostility	2.37	0.029
Guilt	2.77	0.012
Sadness	2.60	0.018
Joviality	3.68	0.002
Serenity	3.81	0.001
Combined	2.59	0.010

Note. The y-axis represents the Studentized residuals. The x-axis represents the raw scores of the predictor. For all cases within the group (i.e., Non_CC), this figure identifies how far the observed values are from their predicted values, in units of standard deviations, for specific values of the IV. If these are not consistent across values of the predictor, the assumption of linearity is violated. A significant *p*-value indicates that a curvilinear version of a given predictor explains significantly more variance in the outcome than the predictor alone; because the sample sizes are between 25 and 30 within each group, significant effects should be taken seriously and indicate a violation of the linearity assumption.

Table 14.2
Frequency of Curvilinear Violations: Environmental Attitude Outcomes.

	Climate Change Fear	*Climate Change Risk*	*New Ecological Paradigm*	*Total for Group*
Control (*n* = 30)	2	0	0	2
Benign (*n* = 29)	0	0	0	0
Non_CC (*n* = 26)	0	0	0	0
CC_Local (*n* = 25)	2	0	0	2
CC_Global (*n* = 29)	0	0	0	0
Combined (*n* = 139)	2	0	0	2
Total for Eniv. Att.	6	0	0	6

Note. For a given cell, the value indicates the number of times variance in the respective environmental attitude was additionally explained by either the square of one of the other attitude measures, or by the square of their linear combination, within the respective group. For example, the first cell indicates that two of the other variables (or the linear combination of them) demonstrated a curvilinear relation with *CC_Fear*, in the control group. The threshold of significance for additionally explained variance was $p < .05$. Each cell that corresponds to both an attitude and a group has a ceiling of three possible violations. Each cell that corresponds to a *Total for Eniv. Att.* has a ceiling of 18 possible violations. And each cell that corresponds to a *Total for Group,* has a ceiling of 9 violations. The last cell (i.e., bottom right) has a ceiling of 54 violations.

For the environmental attitudes MANOVA, each of three attitudinal outcomes was predicted by three other variables (i.e., the other two outcomes and their linear combination), within each group and for the combined sample, which resulted in 54 curvature tests, six of which were violated (see Table 14.2). The only problematic environmental attitude measure was CC_Fear. Specifically, CC_Fear had a curvilinear relation with CC_Risk in the control group and in the combined samples, a curvilinear relation with the NEP in the local climate change group, and a curvilinear relation with the linear combination of other variables in each of these groups. Finding effects for CC_fear when a specific group comparison includes either the control or the local group could be difficult.

4.5.6 Multicollinearity and singularity

For MANOVA, if variance in a dependent variable is substantially explained by the other dependent variables, or a near-linear combination of the other dependent variables, the original dependent variable may provide redundant information (Tabachnick & Fidell, 2001). To investigate further, the multiple regression models calculated from the linearity assumption were used to calculate the total variability explained in each dependent variable. In the context of multiple regression, in which each predictor is assessed for multicollinearity, the *B* coefficient's standard error will expand for a given predictor if that predictor is substantially explained by the other predictors: The corresponding effect will be less stable across samples (Navarro, 2012). Table 15.1 shows the squared multiple correlations (SMC) for each emotion: this is equal to the proportion of variance that is explained in that emotion by the other emotions and a linear combination of the other emotions.[27] No indications of unacceptable multicollinearity or singularity were found.

Table 15.1.
SMCs Between Emotions and Linear Combinations.

	Fear	Hostility	Guilt	Sadness	Joviality	Serenity
Control	0.494	0.418	0.366	0.375	0.358	0.265
Benign	0.477	0.296	0.245	0.217	0.386	0.533
Non_CC	0.497	0.477	0.497	0.439	0.407	0.572
CC_Local	0.590	0.678	0.424	0.587	0.433	0.513
CC_Global	0.691	0.720	0.673	0.676	0.771	0.613
Combined	0.489	0.483	0.406	0.332	0.379	0.410

Note. These values correspond to R^2 and indicate the extent to which variability in one variable is accounted for by all other variables and a linear combination of them.

[27] Variance inflation factors and tolerances can be calculated directly from these values.

Table 15.2.
SMCs Between Environmental Attitudes and Linear Combinations.

	CCFear	CCRisk	NEP
Control	0.616	0.431	0.542
Benign	0.265	0.326	0.432
Non_CC	0.226	0.192	0.047
CC_Local	0.386	0.246	0.363
CC_Global	0.127	0.216	0.199
Combined	0.314	0.260	0.293

Note. These values correspond to R^2 and indicate the extent to which variability in one variable is accounted for by all other variables and a linear combination of them.

An additional assessment of collinearity, which pertains to multivariate analyses, is the examination of condition indices and variance proportions, which were assessed with the *perturb* package in R (Hendrickx, 2019). For each outcome (e.g., *Fear*), several linear combinations of other dependent variables are calculated as alternative models to explain the outcome. This is analogous to the components generated in principle components analysis. Like the analyses above, each variable is considered an outcome (e.g., *Fear*) for the rest of the variables to predict (e.g., *Hostility*, *Guilt*, *Sadness*, etc.). Several orthogonal, linear combinations are constructed in accordance with the total number of predictor variables (i.e., five predictor variables for *Fear*, five linear combinations). Each linear combination gets an eigenvalue, which is a function of the residual variability around the given linear combination. The condition index indicates the "distance" from the respective eigenvalue to the eigenvalue of the best fitting linear combination.

If any condition index is very large (i.e., 30; Belsley et al., 2004), or rather, if one component explains a lot more variance in the outcome relative to the others, the overall model can be greatly influenced by small changes in the measured variables. Furthermore, the specific problematic predictors are indicated by whether they have large proportions of variance (i.e., > .50; Belsley et al., 2004) that correspond to a component with a high condition index.

Essentially, collinearity is detected when ***two or more*** predictors have large proportions of variance (i.e., > .50) that correspond to the same large condition index (i.e., > 30).

No condition indices above 30 were observed in the emotion model (MAX = 3.85), or in the environmental attitude model (MAX = 24.05). Collinearity should not be a problem for these data (see Tables 16.1 & 16.2).

Table 16.1

Variance Proportions and Condition Indices for Emotional Outcomes Across Groups

Condition Index	intercept	Fear	Hostility	Guilt	Sadness	Joviality	Serenity
1.00	0.02	NA	0.03	0.03	0.02	0.03	0.03
1.79	0.17	NA	0.01	0.05	0.33	0.01	0.03
2.27	0.09	NA	0.35	0.03	0.28	0.09	0.04
2.79	0.04	NA	0.09	0.79	0.17	0.00	0.20
2.98	0.38	NA	0.40	0.06	0.04	0.04	0.47
3.48	0.31	NA	0.11	0.04	0.17	0.83	0.24
1.00	0.02	0.03	NA	0.03	0.02	0.03	0.03
1.77	0.16	0.02	NA	0.05	0.30	0.02	0.02
2.19	0.03	0.42	NA	0.00	0.15	0.12	0.05
2.63	0.06	0.09	NA	0.81	0.30	0.00	0.00
2.90	0.49	0.09	NA	0.09	0.00	0.08	0.50
3.79	0.24	0.35	NA	0.03	0.24	0.76	0.40

Table 16.1 cont.

Variance Proportions and Condition Indices for Emotional Outcomes Across Groups

Condition Index	intercept	Fear	Hostility	Guilt	Sadness	Joviality	Serenity
1.00	0.02	0.03	0.03	NA	0.02	0.02	0.03
1.80	0.18	0.05	0.03	NA	0.28	0.03	0.01
2.07	0.01	0.12	0.09	NA	0.38	0.10	0.02
2.89	0.55	0.19	0.02	NA	0.04	0.10	0.33
3.03	0.01	0.19	0.74	NA	0.02	0.04	0.30
3.85	0.23	0.43	0.09	NA	0.28	0.72	0.32
1.00	0.02	0.02	0.02	0.03	NA	0.02	0.02
1.97	0.22	0.11	0.08	0.03	NA	0.09	0.00
2.50	0.08	0.17	0.01	0.57	NA	0.06	0.05
3.04	0.52	0.04	0.01	0.06	NA	0.07	0.55
3.25	0.01	0.24	0.81	0.20	NA	0.07	0.07
3.70	0.16	0.42	0.07	0.11	NA	0.69	0.31
1.00	0.02	0.03	0.03	0.03	0.02	NA	0.03
1.80	0.26	0.00	0.00	0.03	0.34	NA	0.05
2.29	0.37	0.15	0.15	0.03	0.29	NA	0.00
2.62	0.03	0.17	0.01	0.73	0.26	NA	0.01
2.96	0.32	0.04	0.17	0.00	0.00	NA	0.87
3.22	0.00	0.62	0.64	0.18	0.08	NA	0.04
1.00	0.02	0.03	0.03	0.03	0.02	0.03	NA
1.79	0.27	0.03	0.01	0.02	0.18	0.06	NA
2.06	0.00	0.17	0.13	0.01	0.34	0.09	NA
2.60	0.07	0.19	0.01	0.64	0.25	0.00	NA
3.06	0.14	0.22	0.58	0.30	0.00	0.19	NA
3.55	0.50	0.37	0.24	0.01	0.21	0.64	NA

Note. Six regression models were estimated with each outcome of interest regressed onto the other outcomes. The dependent variable for each model has a series of NAs in its respective column. Each row represents an orthogonal component used to predict the dependent variable. The first row for each model represents the component that explains the most variance in the dependent variable. The condition index represents the explanatory discrepancy between the respective row's component, and the best fitting component. Collinearity is detected when two or more predictors have large proportions of variance (i.e., > .50) that correspond to the same large condition index (i.e., > 30; Belsley et al., 2004).

Table 16.2

Variance Proportions and Condition Indices for Envi. Outcomes Across Groups

Condition Index	intercept	CCFear	CCRisk	NEP
1.00	0.00	NA	0.00	0.00
16.25	0.19	NA	0.98	0.09
23.35	0.80	NA	0.02	0.91
1.00	0.00	0.00	NA	0.00
13.55	0.19	0.90	NA	0.04
24.05	0.81	0.10	NA	0.96
1.00	0.00	0.00	0.00	NA
13.66	0.26	0.98	0.11	NA
17.07	0.74	0.02	0.89	NA

Note. Three regression models were estimated with each outcome of interest regressed onto the other outcomes. The dependent variable for each model has a series of NAs in its respective column. Each row represents an orthogonal component used to predict the dependent variable. The first row for each model represents the component that explains the most variance in the dependent variable. The condition index represents the explanatory discrepancy between the respective row's component, and the best fitting component. Collinearity is detected when two or more predictors have large proportions of variance (i.e., > .50) that correspond to the same large condition index (i.e., > 30; Belsley et al., 2004).

4.5.7 Multivariate outliers

Evaluation, selection, and elimination of Multivariate Outliers is by far the most confusing "assumption" to consider; also, it is the least consistently evaluated between texts. Initially, I was going to flag them with Mahlanobus Distance (MD) and then look for conceptual criteria for elimination, which included duration of the survey, English as the first language, and screening qualitative responses for "bizarre" answers. Additionally, I wanted to cross reference any cases found through that process with cases that may have driven previous assumption violations. This still seemed a bit subjective. Also, it seemed convenient; at some point, am I just eliminating cases to reform the structure of my data into something more powerful? Also, I don't know anything about variable transformations, which I would like to learn about, but I think that *would be a long process. Overall, I was very confused about how to proceed; so, I decided to run the analysis without eliminating outliers, especially since I already preregistered conceptual reasons for eliminating data and did eliminate them at the onset of the analysis. I'm happy to go over this again, eliminate flagged outliers, and compare the results to what I found below; I'm pretty sure the primary difference would be a more powerful omnibus test, but I could be totally wrong on that.*

4.5.8 MANOVA results

Omnibus results. A one-way multivariate analysis (MANOVA) was executed to test the hypothesis of no mean differences between groups in emotional change for six emotions: *Fear*, *Hostility*, *Guilt*, *Sadness*, *Joviality*, and *Serenity*. A statistically significant effect was detected, $F(4, 134) = 2.12$, $p = .002$, Wilks' $\Lambda = 0.689$, $\eta^2 = 0.089$. The MANOVA omnibus test for environmental outcomes—*CCFear*, *CCRisk*, and the *NEP*—was not significant, $F(4, 134) = 0.58$, $p = .858$, Wilks' $\Lambda = 0.949$.

Multiple comparisons. All multiple comparisons for emotional outcomes (i.e., 60) were tested for exploratory analyses. Six univariate ANOVA models were constructed, each of which corresponded to an emotional outcome. Each model was estimated using type III sum of squares to eliminate the influence of group order. A contrast scheme was constructed that specified every group comparison absent the combination of any groups (10 total comparisons). The intercept for each model was dropped and the coefficients for each group (i.e., group means for a given emotional outcome) were saved. Then, the means were compared via the contrast scheme for every emotion. Descriptive statistics, *t*-values, and raw *p*-values were saved, and the FDR correction was applied to every comparison. Finally, Hedges' *g* coefficients and confidence intervals were calculated for each comparison. Results for comparisons with an FDR adjusted *p*-

value below .05 can be found in Table 17.1: If the data were randomly generated from null distributions, one could expect three significant comparisons—out of 60—from chance alone. Results for all comparisons can be found in Table 17.2.[28]

Table 17.1
All Emotional Comparisons Retaining Statistical Significance After FDR Adjustment

Conditions		Emotion	*SE*	*t*	*p* (raw)	*p* (FDR)	Hedges' *g*	95% CI	
G1	*G2*							*LL*	*UL*
Control	CC_Global	Serenity	0.556	4.454	.000	.001	1.277	0.819	1.735
Control	CC_Local	Serenity	0.578	4.152	.000	.002	1.124	0.657	1.591
Control	Non_CC	Serenity	0.572	4.048	.000	.002	1.225	0.757	1.693
Control	Benign	Joviality	1.098	3.046	.003	.028	0.780	0.347	1.214
Control	Non_CC	Joviality	1.129	2.993	.003	.028	0.864	0.415	1.313
Control	CC_Local	Joviality	1.141	2.868	.005	.030	0.835	0.382	1.288
Control	CC_Global	Joviality	1.098	2.858	.005	.030	0.730	0.299	1.162
Control	CC_Global	Hostility	0.773	-3.084	.002	.028	0.761	0.328	1.193
Control	CC_Global	Fear	0.740	-2.956	.004	.028	0.756	0.324	1.189
Benign	CC_Global	Fear	0.746	-3.419	.001	.012	0.868	0.428	1.309

Note. Hedges'*g* calculated via Laken's (2013) spreadsheet. *p* (FDR) refers to the adjustment for all 60 comparisons, not just the ones in the table.

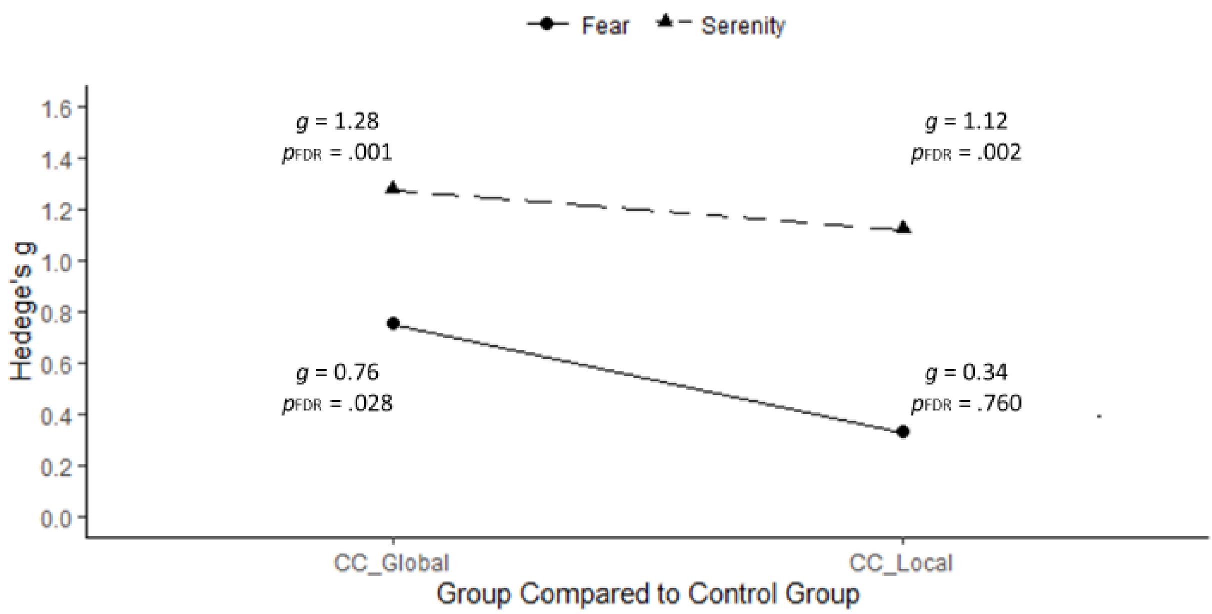
These comparisons can also help examine the possible distinction between *fear* and *serenity*. Figure 8 compares four effects: the Control vs. CC_Local effect on (1) *serenity* and (2) *fear*, and the Control vs. the CC_Global effect on (1) *serenity* and (2) *fear*. Temporarily, assume that *fear* and *serenity* fundamentally operate as a reciprocal function of one another (i.e., two sides of the same coin, or opposing ends on one continuum). Even if *serenity* was subject to less measurement error than *fear*, the difference between the groups in one emotion should mirror that of the other emotion (i.e., if *serenity* and *fear* are reciprocal forms of one another, the lines in Figure 8. should be parallel). Random variation and measurement error could interfere with a

[28] See Tables Folder

parallel relation. Nonetheless, a significant effect for *serenity* was found in both group comparisons, but a significant effect for *fear* was found in only one group comparison. Therefore, this serves as very tentative evidence that *fear* and *serenity* did not operate in the same way between the local and global conditions, at least from questionnaire measurement; perhaps they are not opposite ends of one continuum, or "two sides of the same coin".

Figure 8.

Hedge's g*s for Change in* Fear *and* Serenity *Compared to the Control Group*



Note. The CC_Local and CC_Global groups had higher *Fear* raw scores than the control group. The CC_Local and CC_Global groups had lower *Serenity* raw scores than the control group. For the CC_Local vs Control effect (i.e., bottom right), the raw *p*-value was insignificant ($p = 0.211$). All other effects were significant, even after the FDR adjustment.

Discriminant function analysis. A discriminant analysis was executed after the MANOVA. It used change scores from the same six emotions as predictors (i.e., *fear*, *hostility*, *sadness*, *guilt*, *joviality*, and *serenity*). The same five groups were also considered, but they were used as the *dependent* variables in this analysis. The same sample was used from the MANOVA analysis ($N = 139$). Also, the same statistical assumptions were addressed before evaluation of the MANOVA (see sections 4.5.2 to 4.5.7).

Four discriminant functions were calculated. The omnibus test, which corresponds to the omnibus MANOVA test above, generated the combined effect, $F(1, 451.24) = 2.12$, $p < .002$, $\eta^2 = .089$. About 9% of all the variability within the *predictors* can be explained by between group differences. For the first discriminant function, Canonical $R^2 = .20$; therefore, the first function accounted for about 20% of the variability across the predictors that can be explained by between group differences.

After removal of the first function, the association between groups and predictors wasn't significant, $F(15, 359.27)$, $p = .21$, Canonical $R^2 = .09$; although, the second function seemingly accounted for 9% of the shared variance between predictors and between groups that wasn't already explained, it was not significant. The third and fourth functions did not explain a significant amount association between predictors and between groups. Out of the variability between groups that can be explained by discriminant functions, the first function explains 63% and the second function explains 25%.

As shown in Figure 9, the first function maximally separates the control group from all other groups. Table 18.1 shows the structure (i.e., loadings) matrix between the predictors and the functions, or rather, the within-group pooled correlations between the functions and the predictors. When these loadings are squared, they indicate the proportion of variance in the function that is associated with the respective predictor. The first function was primarily composed of *serenity*, Canonical $r^2 = .79$; however, *joviality* also demonstrated a notable loading, Canonical $r^2 = .40$. Therefore, some combination of *serenity* and *joviality*—mostly *serenity*—maximally discriminate between the control group and the rest of the sample.

Table 18.1

Structure Matrix of Emotional Loadings onto Discriminant Functions

	Function			
Predictor	DF1	DF2	DF3	DF4
Fear	-0.32	0.87	0.23	-0.12
Hostility	-0.37	0.45	0.76	0.11
Sadness	-0.31	0.36	-0.05	0.84
Guilt	-0.18	0.46	0.07	0.11
Joviality	0.63	0.19	-0.22	-0.15
Serenity	0.89	-0.29	0.07	0.21

Note. Pooled within- groups correlations between discriminating variables and standardized canonical discriminant functions. DF stands for Discriminant Function. Values below .50 were ignored, in line with Tabachnick and Fidell's (2014) example.

Table 18.2

Standardized Canonical Discriminant Function Coefficients

	Function			
Predictor	DF1	DF2	DF3	DF4
Fear	0.10	0.84	0.05	-0.48
Hostility	-0.05	-0.11	-1.19	0.27
Sadness	-0.19	0.18	0.32	1.10
Guilt	0.41	0.33	0.32	-0.17
Joviality	0.39	0.53	0.35	0.17
Serenity	0.88	0.01	-0.55	0.17

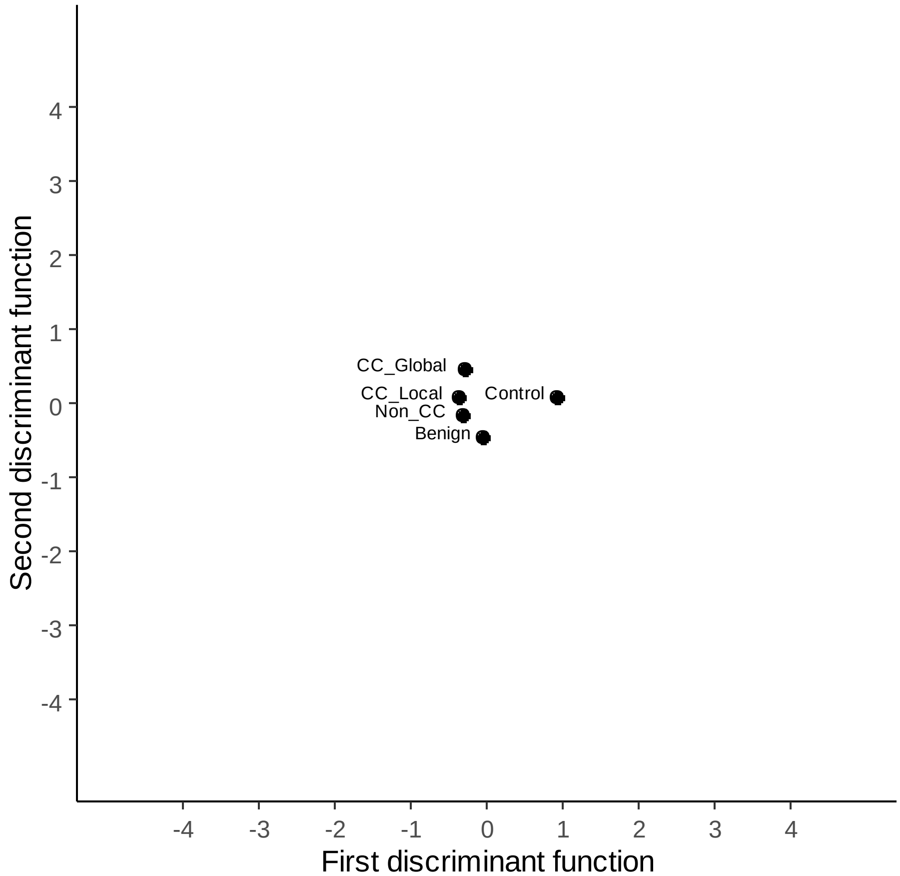
Note. Essentially, these are the standardized beta coefficients in the linear equation of predictors that composes the discriminant function. A discriminant score is attached to each observation for every function, and these are the standardized weights on the predictors that create that score.

The multiple comparisons computed after the MANOVA, show that the mean level of *serenity* in the control group differs significantly from means in the CC_Global group, the CC_Local group, and the Non_CC group, Hedges' *g*s ranged from 1.12 to 1.28., all FDR adjusted *p*-values were $\leq$ .002.[29] Additionally, the mean level of *joviality* in the control group differed from the mean level in every other group, but the effects were consistently smaller, Hedges' *g*s ranged from .73 to .86., all FDR adjusted *p*-values were $\leq$ .03.

[29] FDR *p*-value refers to an FDR adjustment for every group comparison, on the six emotions mentioned and three measures of environmental attitudes.

Figure 9.

Centroids of Five Experimental Groups on the First Two Discriminant Functions



Note. Plot of group centroids, or group specific means of the discriminant functions, for the first (i.e., x-axis) and second (i.e., y-axis) discriminant functions. Distance between groups along a given axis indicates the ability of the respective discriminant function to differentiate between the groups. For example, this figure indicates that the first discriminant function distinguishes the control group from the rest of the groups.

Despite its ability to distinguish the control group, the first function did not seem to discriminate between the other groups. Also, one should consider the degree to which the control group's task might elicit *serenity*. The act of reflecting on one's day might inherently increase emotions like *serenity* and *guilt*. The increase in *serenity* for the control group was small and insignificant (Cohen's d_x = .11, raw p-value = .54, see section 4.6), which indicates the decrease in *serenity* in the other groups was the primary driver in the first discriminant function's ability to distinguish the control group.

The second discriminant function did not significantly differentiate the groups; nonetheless, it is worth considering for several reasons. The treatment groups seemed to be furthest separated by the second discriminant function, which is composed of *fear* (Canonical R^2 = .76, see Table 18.1), and perhaps a bit of *hostility* and *guilt*. First, the only significant group comparison in the MANOVA follow-up that did not involve the control group was the mean level of *fear* observed in the benign group compared to the CC_Global group (Hedges' g = 0.87, FDR p = .012). Although the second function was not significant, one can see the difference between these two groups in Figure 9.

The second discriminant function could indicate that *serenity* and *fear* played different roles in distinguishing between the groups: perhaps *serenity* distinguishes the control group from the other groups, but a better measure of *fear* would distinguish the environmentally related groups, and further, it might indicate that the CC_Global condition elicits "the most" *fear*. Even if the exact role of *fear* remains uncertain, this analysis suggests that *fear's* role is distinct from *serenity's*. The orthogonal first and second functions indicate the distinction between their associated emotions: At least in how they were measured, *serenity* and *fear* do not seem to be two ends on one spectrum that differentiates groups in the same way, but two distinct predictors, which differentiate different sets of groups.

Appendix L: DK responses, missingness, and modeling

Krosnick and Presser (2010) consider the utility of "don't know" (DK) questionnaire options as filters that allow respondents to admit their lack of knowledge. They cite several studies that found answers to items were no more reliable with the inclusion of DK filters (e.g., Poe, Seeman, McLaughlin, Mehl, & Dietz, 1988). Overall, Krosnick and Presser (2010) argue that the quality of data does not improve with the inclusion of a DK response.

The validity of the DK response option is also questionable and item specific: What are researchers measuring with a "don't know" option? Respondents may choose DK responses for several reasons other than not having relevant information: such as ambiguity in the item scale, the item scale not having a neutral response, respondents feeling like they cannot defend their opinion, social desirability concerns, or perhaps respondents simply don't understand the question.

The meaning of a DK response may be elusive; nonetheless, many of these concerns can be addressed in the study design, and with pilot studies. Researchers in specific contexts may have good reasons to include a DK response, or some other response that does not neatly fit on an ordered scale. If such a circumstance arises, the primary problem is one of modeling: Assuming that we know the meaning of the DK response to those who provided it (e.g., "I don't have enough relevant information to make a judgement"), how can that response be modeled?

The simplest way to integrate the DK response option into an item is to treat every response option as an unordered category, and therefore, the variable as nominal. However, this can be undesirable for many reasons. First, the DK group might be very small; or rather, predicting the number of DK responses to a given item might be very difficult, and therefore estimating power requirements to assess such responses would be imprecise. This would increase power requirements, and therefore, it would greatly increase a study's expense. Such treatment would also change the nature of the relation between variables if the items contain ordered responses. Treating an ordered, or continuous variable as a categorial variable can misinform research questions and models, and it can result in a critical loss of information that comes with order and intervals (e.g., Irwin & McClelland, 2003).

Treating items with DK options as nominal will also distort the combination of items into composite variables. Although feasible, dichotomizing items that are usually ordered, and then including the DK response, and then developing some sort of counting system to create the composite variable would result in a loss of information. The effects on the statistical model from such a system would be difficult to discern, and relating results to other research would be very complicated.

Even if items for a composite variable remained ordinal, or interval, and the DK response was included, how would one create the composite variable with DK responses? One could simply take the mean of the composite items, and not include the DK response item. This is akin to treating the item as missing data, however. Essentially, for a given respondent, the mean of the other items in the composite variable would be imputed as the response to the DK item. Although theoretically problematic, Schafer and Graham (2002) say this practice may be practical when used for missing data if the items are conceptually related and have high reliability. However, they also describe more principled and newer methods.

For both single item variables, and composite variables, Schafer and Graham (2002) describe using procedures of maximum likelihood and multiple imputation for missing data. Importantly, these techniques use other collected data to estimate reasonable responses for missing data: In the case of a DK response, one would attempt to predict DK responses from the remaining data in the study instead of predicting missing values. And although substituting a numeric value may hold questionable validity, the imputed response will be based on the DK response, not the skipped question. Although they are sophisticated, such techniques are increasingly common between disciplines, have been tested with simulations, and they are replicable (Schafer & Graham, 2002). They often hold assumptions about the randomness of the “missingness” that may not be tenable, however.

Other treatments for missingness and DK responses have been proposed through latent variable modeling. For example, Liu and Wang (2016) use hierarchical item response theory models to integrate both, missing values and DK responses as distinct latent variables. Overall, one should consider critically whether a DK response will add to the quality of a given dataset, which can be done by considering studies that have used DK responses in the relevant literature. Next, the treatment of DK responses depends on whether they are random: If the item is a sensitive subject, for example drug usage, DK responses may systematically depend on the true value of the response. If this is the case, maximum likelihood and multiple imputation for the responses will be undermined. In this case, one is left in a complicated position: the need to model the DK response.

If a DK response needed to be modeled, and it was not missing at random, one could model it though latent variable analysis (e.g., Liu & Wang, 2016); but these procedures have not been widely implemented and are very advanced. In a widely administered questionnaire with a large sample size, such methods could be very beneficial. For a small sample, such as the one in this thesis, such methods would be unstable.