Fear Emotion Decelerates Outcomes of Climate Change Education

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Abstract

Emotion mediating educational outcomes has been recognized for decades. However, empirical experiments to test these predictions, particularly for climate change education, which is often mixed with various emotions, are rare. In this study, we conducted a two-week climate change education program with specific video clips designed to induce fear or hope in students to explore how emotions affect educational outcomes. The study involved 1,730 students from nine middle schools in three coastal cities (Xiamen, Shenzhen, and Ningbo) in China. The results demonstrated that emotional video clips are a successful stimulus for the target emotion. In the hope treatment group, emotion did not significantly affect the educational outcomes, as indicated by the limited change in students' climate change involvement, self-efficiency, and mitigation behavior. However, in the fear treatment group, emotion significantly decelerated students' change in mitigation behavior compared to the lecture-only group. These decelerated behaviors are mostly located at the behavior change of low carbon life. Based on the mediation analysis, both the hope group and lecture-only group had direct effects on climate change mitigation behavior, while the fear group only had an indirect effect on climate change behavior, mediated primarily by climate change involvement. The study thus highlighted that both negative and positive emotions should not indiscriminately used in climate change education programs to safeguard significant educational outcomes.

1 Introduction

As a conscious mental reaction and subjectively experienced feeling, emotion is often associated with behavior changes and has drawn attention from environmental educationists for decades (Nabi 2003; Chapman et al. 2017; Nabi et al. 2018). While much debate remains concerning the effects of positive and negative emotions, an early study by Iozzi (1989) suggested that an emotionally-oriented attitude is a key predictor of unconscious behavior. Negative stimuli are detected more easily at lower levels of input or exposure than positive stimuli (Dijksterhuis and Aarts 2003); thus, negative emotions may enhance participants' attention or concern (Schupp et al. 2007). On the other hand, fear arousal is defined as an unpleasant emotional state triggered by the perception of threatening stimuli (Rogers and Deckner 1975). This emotional state involves physiological arousal as well as cognitive, affective, and behavioral responses directed toward reduction or elimination of fear; people in fear condition may perform fear control due to criticize or denying the threat presented in a message (Witte et al. 2001). In this case, a negative or counterproductive impact on fear may exist, which has been supported by some studies (Ruiter et al. 2014). The emotion of hope, however, appears to be constantly recommended for inclusion in environmental education (Ojala 2012; Stevenson et al. 2018). Hope may create goal congruence and enhance one's perceived control of a situation, leading to a more favorable attitude and increasing the intention to act (Lee et al. 2017). Positive emotions may also affect motivation and behavior for a long time (Fredrickson, 2001; Tannenbaum et al., 2015). Thus, bringing positive emotional perspectives into environmental educational practice has been increasingly adopted (Chadwick 2015; Jacobson et al. 2018; Greenaway and Fielding 2019).

Climate change education (CCE) aims to promote climate change mitigation behavior. Studies have highlighted the importance of emotions, beliefs, and perceptions in CCE (Pooley and o'Connor 2000; Kollmuss and Agyeman 2002). Some evidence suggested that discrete emotions alone were able to explain a large proportion of the variance (50%) in public global warming policy support, which is higher than several other variables (Smith and Leiserowitz 2014). Incorporating emotion into considerations for CCE is also ineluctable, as many communicators, governments, nongovernmental organizations, and individuals often deliver information related to climate change with strong emotions (Salama and Aboukoura 2018). Meanwhile, there is increasing debate on the effects of targeting specific emotions on motivating or inhibiting public engagement with climate change, especially for the emotions of fear and hope (Ojala 2012; Lemanski and Villegas 2019). For example, a limited series of studies investigating actual behavior in response to fear appeals showed that the results were mixed (Hine and Gifford, 1991; Bloodhart et al. 2018). Some researchers pointed out that instilling fear in people might cause avoidance and reductions in personal efficacy, whereas making people feel hopeful caused increased efficacy and engagement (O'Neill and Nicholson-Cole 2009). Others argued that messages designed to induce feelings of hope and optimism about climate change may lower motivation to engage in mitigation efforts (Hornsey and Fielding 2016). Arguments for these paradoxical results may be due to the research design, as often the emotion may also be associated with knowledge delivery or other psychological variables; it is not always easy to distinguish the effects of emotion on other variables (Chapman et al. 2017). Very little research on manipulating different emotions to determine the pure effect of emotion on CCE has been conducted.

Climate change affects mankind on a global scale, but the people most vulnerable to its impacts are children and youth in developing countries, where 85% of the world's children live (UNICEF 2014). Although climate action is undoubtedly imminent, the brunt of climate change impacts is projected to arrive just as younger generations reach adulthood (IPCC 2014). Hence, effective climate change education for teenagers is urgent in preparing them to tackle imminent environmental issues. Prior studies have shown that CCE may build concern and enhance knowledge among adolescents (Guy et al. 2014; Stevenson et al. 2014). More recent research suggests that fear can raise teenagers' risk perceptions and concerns about climate change and promote pro-environmental behavior (Skurka et al. 2018). Although the evidence is suggestive, it is not conclusive due to the limited experimental evidence and the incomprehensive understanding of the nature or direction of the relationship between different emotions of climate change engagement (Chapman et al. 2017). Therefore, the effectiveness of emotion in climate change education remains unclear, especially for today's youth.

In this study, we designed a curriculum focusing on the factual knowledge of climatic change, coupled with a video clip intended to instill emotions of fear or hope as treatments to determine how emotion affects curriculum-based CCE. Based on a review of the previous literature, we propose the following hypotheses.

H_1: The two emotional treatments significantly induce target emotions.

H_2: Students who receive lecture-only treatment show significant improvement in their knowledge of climate change, climate change mitigation behavior, and behavior intention.

H_3: Fear emotion treatment enhances educational outcomes via an increase in concern and involvement.

H_4: Hope emotion treatment enhances educational outcomes via an increase in self-efficiency.

2 Methods

2.1 Lectures for CCE and emotional stimuli

The lecture videos used in this study came from Stanford Middle School courseware, climate change lesson plans for years 7–11 from “Oxfam Education,” “China’s Perspective on Climate Change” in a massive open online course (MOOC), and other open-source educational videos on YouTube. The lectures were presented four times, including four aspects (see supplementary Table A1): concept of climate, facts of global climatic change, main causes for climate change, and climate mitigation action. Considering that the 7th-grade students might not have primary knowledge of climate change science, we simplified the concepts and used several animated videos to explain the scientific phenomenon (see Supplementary 1). Meanwhile, to decrease the emotional impact of lectures, we tried our best to apply a neutral image (line chart) and science language and finally recorded all four lectures as videos to avoid bias caused by the lecturers themselves. Each lecture video lasted 15 minutes to ensure that all procedures were completed in one lesson (40 minutes).

The emotional clips used in the experiment originated from two documentaries of climate change: “A Warming Earth” (Chinese) in 2008 and “An Inconvenient Sequel: Truth to Power” (English dialogue with Chinese subtitles) in 2019. The former film was awarded the title of Best Science Film from the 28st Golden Rooster Award in China, and the latter has been widely promoted and adopted as educational material worldwide (David 2006; Expatica 2007; Leask 2007). By adjusting the needs of the contents, time length, and target emotion, we edited four clips for each film (see Supplementary 2). In the “A Warming Earth,” we selected “The Super Typhoon Saomai” and “Sea Level Rising” as fear clips and “Carbon Sequestration Technology” and “New Clean Energy” as hope clips. In “An Inconvenient Sequel: Truth to Power,” we used “The Super Typhoon Haiyan” and “Extreme Weather” as fear clips and “Technical Leapfrog in Developing countries” and “The Pairs Agreement” as hope clips. The four fear clips were watched by the fear group students, and the hope clips were watched by the hope group students. They watched these clips before lecture videos in four classes. For example, fear group students in their first class watched “The Super Typhoon Saomai” first and then the lecture video “concept of climate”.

2.2 Pilot studies

To confirm that all emotional clips could induce the target emotion successfully, we conducted two pilot tests before the formal study. A total of 29 adults in Menglun, Xishuangbanna, Yunnan Province,

including five environmental education specialists and 24 college students, took part in the first pilot test. First, we asked each participant to extract the video sequence randomly. Then we played the eight emotional clips one by one, requesting that participants fill in the emotional questionnaire immediately after each of the eight videos. In this test, all the target emotions were salient, which proved that fear and hope can be induced by emotional clips in adults (see Supplementary 3). Considering that one fear clip ("Mosquito-borne virus") was difficult for children to understand, we replaced it with another familiar topic: "The Super Typhoon Haiyan." We also considered evaluate positive, negative, and neutral contents in these two emotions (see Supplementary Table A2).

The second pilot test was conducted at a junior school in Kunming, Yunnan Province with six first-grade classes (N = 285). This pilot study aimed to 1) retest the validity of emotional clips, 2) examine the difficulty and duration of lecture videos, and 3) test the reliability and validity of questionnaires in the target population. All six classes of students (N = 285) completed pre- and post-questionnaires, and four of them (N = 180) attended the education program. In this pilot study, target emotions were significantly higher than other emotions among junior students, which also supported the validation of the emotional clips. The reliability of the two items in the pre-test questionnaire did not meet the criteria (climate change concern, $\alpha = 0.57$; climate change involvement, $\alpha = 0.46$). However, after eliminating two items by confirmatory factor analysis, the reliability of all the variables was increased to an acceptable level ($\alpha > 0.60$).

2.3 Study sites and procedures

Previous research found that fatalities from natural hazards, vulnerability to sea level rise, and living within floodplains can largely predict the risk perception of climate change (Brody et al. 2008; Spence et al. 2011; Demski et al. 2017). Coastal cities might be more physically vulnerable to climate change due to being situated in low-lying areas within the immediate proximity of the coast. Thus, we selected coastal cities in three coastal provinces as the sites for studies: Shenzhen, Guangdong Province, Xiamen, Fujian Province, and Ningbo, Zhejiang Province. The formal study was conducted from September 2019 to December 2019 in nine junior schools. In each city, 2–4 junior schools were selected using convenience sampling.

Data collection in this study adapted pre- and post-intervention surveys and a control group design (Fig. 1). In each school, four classes of the same grade (grade 7, corresponding to ages 11–15) participated in the study. One class was randomly chosen as the control group for which we did not provide any intervention; the other three classes were conducted as three treatments: 1) lecture-only, 2) lecture with hope-based clips, and 3) lecture with fear-based clips. For the lecture-only treatment, we provided four lectures in a 2-week period; each lecture consisted of a 15-minute presentation video (total intervention time = (15 min × 4); see supplement 1). For the two emotion treatments, we provided a 2-minute emotional video prior to each lecture presentation (total intervention time = (2 min + 15 min) × 4).

2.4 Measures

Emotional responses were assessed after watching each video. Students in the emotion condition were asked to rate the strength of the 15 emotions they felt while watching the video on a scale of 1 (*not at all)* to 5 (*extremely)* (also see Nabi et al. 2018) (supplementary Table A2). Of these, three items related to fear (*anxious, afraid, worried*) (Cronbach's α = 0.90); three items related to hope (*hopeful, encouraged, optimistic*) (Cronbach's α = 0.88); three items related to sadness (*sad, upset, disappointed*) (Cronbach's α = 0.89), three items related to neutral emotions (*careless, calm, relaxed*) (Cronbach's α = 0.75); and three items related to happiness (*happiness, exciting, energetical*) (Cronbach's α = 0.91). Given the bland and descriptive nature of the control message, the 15 emotion items would have been incongruous and potentially counterproductive by unintentionally priming emotional responses unrelated to message content. Thus, participants in this condition were asked about general emotional intensity with four semantic differential items: This article seemed "*emotional/impressive/exciting*" (0 = *not at all* and 5 = *extremely*). To more closely match the time allotted to complete the threat message post-test, participants were asked several filler questions (e.g., "I learned a lot from this article," "The article seemed factual") that were not intended for analysis.

Perceptions The survey measured a range of perceptions associated with climate change, related behavior, behavioral intention, and key demographic variables. We used published scales to test these variables and prepared four to six items for each variable in the initial version. After the second pilot study, we deleted some items that had low reliability. The final questionnaire (Supplementary Table A3) includes seven variables using a 5-point scale ranging from "*strongly agree*" to "*strongly disagree*": four questions about climate change concern (Cronbach's α = 0.81), taken from previous research on climate change risk perception (Stevenson et al. 2015); five questions concerning climate change involvement (α = 0.78) according to environment involvement research (Schuhwerk and Lefkoff-Hagius 1995); five terms to test self-efficiency (α = 0.85) five questions evaluating mitigation behavior (α = 0.84), which came from climate change engagement research among young people (Mead et al. 2012; Ojala 2012); four questions testing mitigation behavior intention (α = 0.85), adapted from Hu and Chen (2016), who primarily conducted research on Chinese students; and 15 questions on climate science knowledge, divided into two aspects: single-item in subjective knowledge and objective knowledge (true or false, single choice; α = 0.76), selected these items from previous research about climate change knowledge on teenagers (Tobler et al. 2012). We used factor analysis to find that climate change mitigation behavior can also be divided into two subgroups (KMO = 0.82): learning and communication (α = 0.87) and low carbon life (α = 0.74).

Demographics The socio-demographic variables of gender, age, ethnicity and "Big Five Personality" (Rammstedt and John 2007) were included in the analysis (Supplementary Table A3). The "Big Five Personality" describes five discrete dimensions of personality: agreeableness, conscientiousness, extroversion, neuroticism, and openness. In this study, we only found four sections through principal component analysis: agreeableness, conscientiousness, extraversion, and openness (Supplementary Table A4). The post-test survey had the same content, although the order of the items differed from the pre-test.

2.5 Data analysis

To verify the effectiveness of emotional clips, univariate statistical models with one-way analysis of variance (ANOVA) were used.

The longitudinal analysis used 1,539 adolescents with matched pre- and post-test surveys, allowing changes for all climate-related outcomes to be calculated at the individual level. Univariate statistical models and pairwise comparisons with the Tukey HSD test were used to evaluate the effectiveness of the emotion on perceptions and mitigation intention. Type III sum of squares was used to determine statistical significance ($p < 0.05$).

To understand how changes in mitigation behavior were related to the changes in perceptions within the four groups, controlling site as a random factor, multiple regression using a mixed linear model in R (version 3.5.1) was programmed. Four regression models were used: all socio-demographic variables were included in Model 1, treatment variables were obtained in Model 2, all changes in perceptual variables were involved in Model 3, and all socio-demographic and perceptual variables were included in Model 4 (see Table 1). Further, multiple-mediation analysis was constructed in Mplus ($N_{fear} = 797$, $N_{hope} = 754$, $N_{lecture-only} = 789$) to understand the changes in mitigation behavior in the three treatments. Socio-demographic variables were included in the analysis as covariates. Bias-corrected bootstrap 95% confidence intervals (CIs) were based on 1,000 bootstrap samples for indirect effects.

3 Results

3.1 Emotion manipulation check

ANOVA revealed that emotion framing manipulation was successful in eliciting the intended emotional response (Supplementary Fig. A1). The threat video evoked a notably higher degree of fear ($M = 3.18$, $SD = 0.93$) than hope ($M = 2.10$, $SD = 0.87$), sadness ($M = 2.60$, $SD = 0.94$), neutral emotions ($M = 1.56$, $SD = 0.66$), and happiness ($M = 1.47$, $SD = 0.69$) ($F_{4, 2150} = 326.69$, $p < 0.001$). Similarly, the hope video triggered a higher degree of hope ($M = 3.32$, $SD = 0.99$) than fear ($M = 1.84$, $SD = 0.74$), sadness ($M = 1.57$, $SD = 0.66$), neutral emotions ($M = 1.90$, $SD = 0.71$), and happiness ($M = 2.77$, $SD = 1.10$) ($F_{4, 2175} = 317.94$, $p < 0.001$).

3.2 The effectiveness of emotion on climate science knowledge and mitigation behavior

Compared with the control group, the lecture-only group significantly improved climate change involvement, self-efficacy, climate science knowledge, and mitigation behavior, while there was no significant difference in climate change concern and total behavioral intention (Fig. 2a–f). The fear group had significantly increased self-efficiency and knowledge compared to the control group (Fig. 2c, d). The hope group showed significantly increased knowledge and total behavior compared to the control group

(Fig. 2d, e). Specifically, the lecture-only group had higher climate science knowledge than the hope group (Fig. 2d), while the lecture-only group showed improved mitigation behavior compared to the fear group (Fig. 2e).

Considering about the two subgroups (learning and communication, low carbon life) of mitigation behavior. All three treatments displayed higher communication behaviors than the control group (Fig. 2g). For the low carbon life subgroup, only the lecture-only group showed the greatest improvement compared to the control group. The hope group had no significant difference compared to the lecture-only group and the fear group, while the fear group was significantly lower than the lecture-only group (Fig. 2h).

3.3 The direct and indirect effect of treatments and mitigation behavior

The mixed linear model showed that all three treatments and changes in perceptions were positively correlated with changes in mitigation behavior, both for considering the factors together and separately (Table 1). Changes in concern, involvement, and self-efficiency were strong predictors of changes in mitigation behavior. Agreeableness and pre-test knowledge positively improved mitigation behavior. However, other personality traits and demographic variables failed to explain the changes in mitigation behavior.

Table 1
A linear mixed model analysis of Big Five personality, demographic variables, knowledge, four treatments, attitude change variables and mitigation behavior change variables

	Model 1	**Model 2**	**Model 3**	**Model 4**
Intercept	-0.51	0.13***	-0.03	-0.79*
Agreeableness	**0.11*** **			**0.07*** **
Conscientiousness	-0.01			-0.02
Extroversion	-0.01			-0.01
Age	0.05			0.05
Gender (male = 1)	-0.01			0.003
Ethnicity (Han = 1)	0.15			0.08
Extreme weather (yes = 1)	0.02			-0.002
Fear group		**0.12** **		0.05
Hope group		**0.16*** **		**0.12* **
Lecture-only group		**0.26*** **		**0.17*** **
Pre-test CC knowledge			**0.04*** **	**0.04** **
Δ CC knowledge			**0.02** **	0.01
Δ CC concern			**0.11*** **	**0.11*** **
Δ CC involvement			**0.24*** **	**0.23*** **
Δ Self-efficiency			**0.13*** **	**0.12*** **
R^2 **(fixed effect)**	0.03	0.02	0.15	0.17
R^2 **(total effect)**	0.04	0.04	0.16	0.18

"Δ" presents the changes between post-test and pre-test surveys, and numbers indicate unstandardized beta coefficients, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, N = 1549. The school is controlled as a random factor in the four models. The collinearity test results for the variance inflation factor (VIF) levels were acceptable.

The multiple-mediation model showed that the fear group indirectly affected mitigation behavior (Fig. 3). When the indirect effects of those mediators were included in the model, the positive relationship between fear group and mitigation behavior increased (standardized direct effect, c' = 0.061, $p = 0.082$; standardized total effect, c = 0.088, $p = 0.016$); change in involvement, with a small improvement through the fear group (B = 0.077, $p < 0.05$) and a large contribution to mitigation behavior (B = 0.24, $p < 0.001$), was the most important mediator of the relationship (95% CI: 0.01, 0.04).

The hope group could increase mitigation behavior directly (standardized direct effect, c' = 0.093, p = 0.006; standardized total effect, c = 0.116, p = 0.002). Moreover, the lecture-only group improved mitigation behavior both directly and indirectly in mediation analysis (standardized direct effect, c' = 0.136, $p < 0.001$; standardized total effect, c = 0.193, $p < 0.001$); change in involvement was the most important mediator of the relationship (95% CI: 0.01, 0.05), with a large improvement in the lecture-only group (B = 0.13, $p < 0.001$) and a large contribution to mitigation behavior (B = 0.23, $p < 0.001$). The change in concern was also a significant mediator (95% CI: 0.01, 0.03). The three mediation models explained 8%, 13%, and 13% of the variance in mitigation behavior, respectively.

4 Discussion

As emotions may mediate educational outcomes, a more comprehensive understanding of their effects is needed. This study showed that fear would indeed decelerate educational outcomes, as indicated by self-reported changes in climate change mitigation behavior, particularly on the change of low carbon life. Furthermore, hope did not have a significant impact on educational outcomes compared to the control, fear, and lecture-only groups. Thus, bringing emotion into EEC requires more prudential consideration.

A previous study suggested that messages with emotion improve pro-environmental behavior more than natural messages, especially negative emotions (Morris et al. 2019). Negative emotions often cause more attention or concern (Schupp et al., 2007), and thus may generate more action (Skurka et al. 2018). Consequently, science consultants advocated the use of fear and catastrophe narratives to represent the consequences of climate change (Doulton and Brown 2009; Hulme 2008). However, in this study, concern related climate change did not differ significantly among the treatments; there was no difference even with the control group, suggesting that students in the coastal cities in this study may already hold relatively high levels of concern for climate change. On the other hand, an increasing number of studies have suggested that the predominant negative information about climate change does not benefit the cultivation of mitigation actions (Hart and Feldman 2014; Morisson and Hatfield-Dodds 2011). A study in the environmental psychology field (Greitemeyer 2013) indicated that fear-framed, climate change–affirming films did not have a significant, positive impact on concern for the environment. It may be that fear does not trigger consideration, but rather apathy for the future consequences of climate change. A recent study that tested preferences for and impacts of three negative emotions (fear, sadness, and anger) in comparison to messages framed without emotion, found that people generally preferred messages framed without emotion (Bloodhart et al. 2018). Thus, an increasing recommendation found in academic research and literature is that participants prefer non-emotional messages to modified emotional messages about climate change (Bloodhart et al. 2018).

Our study has confirmed that fear has a negative impact on educational outcomes compared to the lecture-only group. Fredrickson (2001) noted that on occasions when survival is threatened, negative affect prompts action that brings immediate and direct adaptive benefits. There is also evidence that individuals with depression are more focused on the possible costs than the possible benefits of specific risks (Pietromonaco and Rook 1987; Yuen and Lee 2003). This suggests that individuals high in negative

affect will have a more limited understanding of the natural environment, and the adoption of mitigation behavior is costly. This may lead individuals with higher negative emotions to avoid them and engage instead in behaviors that yield immediate, rather than long-term benefits. This might explain why fear decelerates low carbon life in mitigation behavior in this study.

On the other hand, there is a call for promoting the development of hope among youth in climate change education (Stevenson et al. 2018), as hope may enhance people's self-efficiency (O'Neill and Nicholson-Cole 2009), thus leading to a more positive behavior change. However, hope emotion treatment did not contribute significantly to most of the psychological variables compared to the lecture-only group in this study. Notably, even the change in knowledge in the hope treatment group was lower than that of the lecture-only group. One possible reason is that hope may weaken people's motivation and cause them to become less engaged (Hornsey and Fielding 2016). These findings are consistent with one reading of fantasy realization theory (Oettingen 2012): If people focus entirely on a desired future and do not contrast that future with a negative current reality, the effect can be counterproductive in terms of working toward that future. Another study found that "constructive hope" (being hopeful because people—individually and collectively—can reduce climate change) is a predictor of increased policy support and political engagement, whereas "false hope" (being hopeful because something external other than people will fix the problem) predicts the opposite effect (Marlon et al. 2019). The complexity of the emotion of hope reminds us that hope-filled messages about climatic change need to be balanced with active reminders of the negative current reality. Educators also need to engage students taking personal responsibility for changing behaviors through cooperation, participation, and organization of social, political, and cultural efforts.

Our results provide not only an effective educational program for adolescents' behavior but also a theoretical model to understand the factors for changes in mitigation behavior. Hope group, lecture-only group, climate change concern, involvement, and self-efficiency were found to improve mitigation behavior directly. A prior study also found hope in youth's direct impact on mitigation behavior (Stevenson et al. 2018). Education can potentially build climate change hope by outlining strategies to mitigate climate change (Ojala 2016). The fear group influenced mitigation behavior was fully mediated by climate change involvement, and the lecture-only group influenced mitigation behavior was partially mediated by climate change concerns and involvement. Both fear and lecture-only groups translated involvement into a greater willingness for mitigation behavior. The elaboration likelihood model (ELM) model suggests that people increase involvement by consciously processing important information in detail and depth through the central process (Lazard and Atkinson 2015). Moreover, the appraisal-tendency framework (ATF) points out that different emotions have different cognitive processes (Tiedens and Linton 2001). Fear is characterized by low levels of certainty and negative valence. People tend to process fear information more elaborately, and fear is associated with central processing. Among all three mediation models, climate change involvement proved to be a more important variable than climate change concern and self-efficiency in influencing climate change mitigation behavior.

This study demonstrates the possibility of inducing fear and hope in adolescents through emotional videos. Prior research used film, music, pictures, and smells to induce emotion, while film presentations proved to be more effective in eliciting discrete emotions than music and smell (Lench et al. 2011). This research successfully induced fear and hope in adolescents through documentary clips related to climate change, showing that adolescents' emotions were indeed affected by mass media, such as news, the Internet, television, and films. Recently, an increasing number of educators around the world have adopted films or documentaries for use in their classrooms (Harness and Drossman 2011; Maier et al. 2014). No matter what kind of education method is utilized, emotions induced by pictures or videos exist in and out of the classroom. Therefore, educators need to be aware of the emotions that materials may evoke and their impact on education outcomes.

We note that our data are too limited to be generalized to other areas and other age groups. To increase personal involvement, people in different places need relevant stimuli (Moser, 2010). For instance, sea level rise can induce fear among teenagers residing in coastal areas, while its effectiveness on inland students is unclear. Further interventions and assessments are required for interior areas on engagement. Emotion stimuli in neutral materials should also be considered in future research. Although we carefully selected lecture materials, using science graphs instead of disaster photos, these may still arouse surprise and concern among teenagers. How to avoid the possible emotional interference of knowledge videos requires further exploration. Other objective assessment methods, such as skin conductance response (Ho and Lipp, 2014) or eye tracking (Lisa et al., 2017), can be adapted to improve the accuracy of emotion data.

Current information on climate change consists of many emotional messages (Salama and Aboukoura 2018). Many educational materials also contain striking emotional information, often invoking fear or sadness. Our study suggests that in order to achieve effective educational outcomes for climate change education, we should neither try to abuse negative emotion (as this can be counterproductive) nor to oversell positive emotion (because it can be overdone and needs to be balanced). Meanwhile, educators should work to boost students' involvement and level of concern to improve climate-change mitigation behavior in CCE. Particular storylines and visual materials based on local areas could increase teenagers' involvement and decrease the psychological distance of climate change (Mcdonald et al. 2015). Other educational tools to strengthen personal relevance, such as engaging in deliberative discussions and implementing school or community projects, have proven to be effective CCE strategies (Hu and Chen 2016, Monroe et al. 2017).

Declarations

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Conflicts of Interest

I declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of data and material

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Author Attribution

First author contributes to the conception and design of the study, acquisition of data, analysis data and writing manuscript.

Corresponding author contributes to design the study, manuscript revising, important intellectual content and final approval of the version to be submitted.

Compliance with Ethical Standards

This research involving human participants. All procedures performed in studies involving human were in accordance with the ethical standards of the institution at which the studies were conducted and ethical approval was obtained from Expert Committee on Biomedical Ethics, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Science. The reference number of ethical approval is XTBG2019-002.

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References

1. Bloodhart B, Swim JK, Dicicco E (2018) Be worried, be VERY worried: Preferences for and impacts of negative emotional climate change communication. Frontiers in Communication 3:63
2. Brody SD, Zahran S, Vedlitz A, Grover H (2008) Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. Environ Behav 40(1):72-95
3. Chadwick AE (2015) Toward a theory of persuasive hope: effects of cognitive appraisals, hope appeals, and hope in the context of climate change. Health Commun 30(6):598-611
4. Chapman DA, Lickel B, Markowitz EM (2017) Reassessing emotion in climate change communication. Nat Clim Chang 7(12):850-852

5. David L (2006) Science a la Joe Camel. Washingtonpost.com. http:// www.washingtonpost.com/wp-dyn/content/article/2006/11/24/AR2006112400789 _pf.html
6. Demski C, Capstick S, Pidgeon N, Sposato RG, Spence A (2017) Experience of extreme weather affects climate change mitigation and adaptation responses. Clim Chang 140(2):149-164
7. Dijksterhuis A, Aarts H (2003) On wildebeests and humans: The preferential detection of negative stimuli. Psychol Sci 14(1):14-18
8. Doulton H, Brown K (2009) Ten years to prevent catastrophe? Discourses of climate change and international development in the UK press. Glob Environ Chang 19:191-202
9. Expatica (2007) Gore climate documentary to be shown in schools. Expatica. http://expatica.com/actual/article.asp?subchannel_id=81&story_id36238
10. Fredrickson BL (2001) The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. Am Psychol 56(3):218-226
11. Greenaway T, Fielding KS (2019) Positive affective framing of information reduces risk perceptions and increases acceptance of recycled water. Environ Commun 1-12
12. Greitemeyer T (2013) Beware of climate change skeptic films. J Environ Psychol 35:105-109
13. Guy S, Kashima Y, Walker I, O'Neill S (2014) Investigating the Effects of Knowledge and Ideology on Climate Change Beliefs. Eur J Soc Psychol 44 (5):421-429
14. Harness H, Drossman H (2011) The environmental education through filmmaking project. Environ Educ Res 17(6):829-849
15. Hart PS, Feldman L (2014) Threat without efficacy? Climate change on U.S. network news. Sci Commun 36(2):1-27
16. Hine DW, Gifford R (1991) Fear appeals, individual differences, and environmental concern. J Environ Educ 23:36-41
17. Hornsey MJ, Fielding KS (2016) A cautionary note about messages of hope: focusing on progress in reducing carbon emissions weakens mitigation motivation. Glob Environ Chang 39:26-34
18. Ho Y, Lipp OV (2014) Faster acquisition of conditioned fear to fear-relevant than to non-fear-relevant conditional stimuli. Psychophysiology 51(8):810-813
19. Hu S, Chen J (2016) Place-based inter-generational communication on local climate improves adolescents' perceptions and willingness to mitigate climate change. Clim Chang 138(3-4):425-438
20. Hulme M (2008) The conquering of climate: Discourses of fear and their dissolution. The Geographical Journal 174(1):5-16
21. Iozzi LA (1989) What research says to the educator: Part one: Environmental education and the affective domain. J Environ Educ 20(3):3-9
22. IPCC (2014) IPCC Fifth Assessment Report: Impacts, Adaptation, and Vulnerability. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. http://www.ipcc.ch/report/ar5/wg2/

23. Jacobson SK, Morales NA, Chen B, Soodeen R, Moulton MP, Jain E (2018) Love or Loss: Effective message framing to promote environmental conservation. Applied Environmental Education & Communication 18(3):252-265
24. Kollmuss A, Agyeman J (2002) Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res 8(3):239-260
25. Leask D (2007) All secondary schools to see Gore climate film. The Herald. http://www.theherald.co.uk/misc/print.php?artid=1126957
26. Lazard A, Atkinson L (2015) Putting environmental infographics center stage: The role of visuals at the elaboration likelihood model's critical point of persuasion. Sci Commun 37(1):6-33.
27. Lee YK, Chang CT, Chen PC (2017) What sells better in green communications: Fear or hope? J Advert Res 57(4):379-396
28. Lemanski JL, Villegas J (2019) Affective Effects of Offering Options on Persuasiveness of Fear Appeals, Journal of Promotion Management 25(1):128-142
29. Lench HC, Flores SA, Bench SW (2011) Discrete emotions predict changes in cognition, judgment, experience, behavior, and physiology: A meta-analysis of experimental emotion elicitations. Psychol Bull 137(5):834
30. Lisa MS, Charlene PB, Parimal B (2017) How Emotional Arousal and Attitudes Influence Ad Response: Using Eye Tracking to Gauge Nonprofit Print Advertisement Effectiveness. J Market Manag 5(1):1-11
31. Marlon JR, Bloodhart B, Ballew MT, Rolfe-Redding J, Roser-Renouf C, Leiserowitz A and Maibach E (2019) How Hope and Doubt Affect Climate Change Mobilization. Front Commun 4:20
32. Maier M, Rothmund T, Retzbach A, Otto L, Besley JC (2014) Informal Learning Through Science Media Usage. Educ Psychol 49(2):86-103
33. Mead E, Roser-Renouf C, Rimal RN, Flora JA, Maibach EW, Leiserowitz A (2012) Information seeking about global climate change among adolescents: The role of risk perceptions, efficacy beliefs, and parental influences. Atlantic Journal of Communication 20(1):31-52
34. Morris BS, Chrysochou P, Christensen JD, Orquin JL, Barraza J, Zak PJ, Mitkidis P (2019) Stories vs. facts: Triggering emotion and action-taking on climate change. Clim Chang 154(1-2):19-36
35. Morisson M, Hatfield-Dodds S (2011) The success and failure of an inconvenient truth and the stern report in influencing Australian public support for greenhouse policy. The Economic Record 87(277):269-281
36. Moser SC (2010) Communicating climate change: history, challenges, process and future directions. Wiley Interdiscip Rev Clim Chang 1:31-53
37. Mcdonald RI, Chai HY, Newell BR (2015) Personal experience and the 'psychological distance' of climate change: An integrative review. J Environ Psychol 44:109-118
38. Monroe MC, Plate RR, Oxarart A, Bowers A, Chaves WA (2017) Identifying effective climate change education strategies: a systematic review of the research. Environ Educ Res 1-22

39. Nabi RL, Gustafson A, Jensen R (2018) Framing climate change exploring the role of emotion in generating advocacy behavior. Sci Commun 40(4):442-468
40. Nabi RL (2003) The framing effects of emotion: Can discrete emotions influence information recall and policy preference? Commun Res 30
41. Ojala M (2012) Hope and climate change: the importance of hope for environmental engagement among young people, Environ Educ Res 18(5):625-642
42. Ojala M (2016) Young people and global climate change: emotions, coping, and engagement in everyday life. Geographies of Global Issues: Change and Threat 8:329-346.
43. O'Neill S, Nicholson-Cole S (2009) Fear won't do it: Promoting positive engagement with climate change through visual and iconic representations. Sci Commun 30(3):355-379
44. Oettingen G (2012) Future thought and behaviour change. Eur Rev Soc Psychol 23:1-63
45. Pooley JA, o'Connor M (2000) Environmental education and attitudes: Emotions and beliefs are what is needed. Environ Behav 32(5):711-723.
46. Pietromonaco PR, Rook KS (1987) Decision style in depression: The contribution of perceived risks versus benefits. J Pers Soc Psychol 52(2):399-408
47. Rammstedt B, John OP (2007) Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. J Res Pers 41(1):203-212
48. Rogers RW, Deckner CW (1975) Effects of fear appeals and physiological arousal upon emotion, attitudes, and cigarette smoking. J Pers Soc Psychol 32:222-230
49. Ruiter RAC, Kessels LTE, Peters GY, Kok G (2014) Sixty years of fear appeal research: Current state of the evidence. Int J Psychol 49(2)
50. Schupp HT, Stockburger J, Codispoti M, Junghofer M, Weike AI, Hamm AO (2007) Selective visual attention to emotion. J Neurosci 27(5):1082-1089
51. Stevenson KT, Peterson MN, Bondell HD (2018) Developing a model of climate change behavior among adolescents. Clim Chang 151(3):589-603
52. Smith N, Leiserowitz A (2014) The role of emotion in global warming policy support and opposition. Risk Anal 34(5):937-948.
53. Salama S, Aboukoura K (2018) Role of emotions in climate change communication. Handbook of climate change communication, Springer International Publishing, Switzerland, pp 137-150
54. Stevenson KT, Peterson MN, Bondell HD, Moore SE, Carrier SJ (2014) Overcoming skepticism with education: Interacting influences of worldview and climate change knowledge on perceived climate change risk among adolescents. Clim Chang 126(3-4):293-304
55. Skurka C, Niederdeppe J, Romero-Canyas R, Acup D (2018) Pathways of influence in emotional appeals: Benefits and tradeoffs of using fear or humor to promote climate change-related intentions and risk perceptions. J Commun 68(1):169-193
56. Stevenson KT, Lashley MA, Chitwood MC, Peterson MN, Moorman CE (2015) How emotion trumps logic in climate change risk perception: Exploring the affective heuristic among wildlife science

students. Hum Dimens Wildl 20(6):501-513
57. Stevenson KT, Peterson MN, Bondell HD (2018) Developing a model of climate change behavior among adolescents. Clim Chang 151(3):589-603
58. Schuhwerk ME, Lefkoff-Hagius R (1995) Green or non-green? Does type of appeal matter when advertising a green product? J Advert 24(2):45-54
59. Tannenbaum MB, Hepler J, Zimmerman RS, Saul L, Jacobs S, Wilson K, Albarracín D (2015) Appealing to fear: A meta-analysis of fear appeal effectiveness and theories. Psychol Bull 141(6):1178-1204
60. Tiedens LZ, Linton S (2001) Judgment under emotional certainty and uncertainty: The effects of specific emotions on information processing. J Pers Soc Psychol 81(6):973
61. Tobler C, Visschers VHM, Siegrist M (2012) Consumers' knowledge about climate change. Clim Chang 114(2):189-209
62. UNICEF (2014) The challenges of climate change: Children on the front line. Innocenti insight. Florence: UNICEF Office of Research.
63. Witte K, Meyer G, Martell D (2001) Effective health risk messages: A step-by-step guide. Sage Publications, Thousand Oaks, CA
64. Yuen KSL, Lee TMC (2003) Could mood state affect risk-taking decisions? J Affect Disord 75(1):11-18

Figures

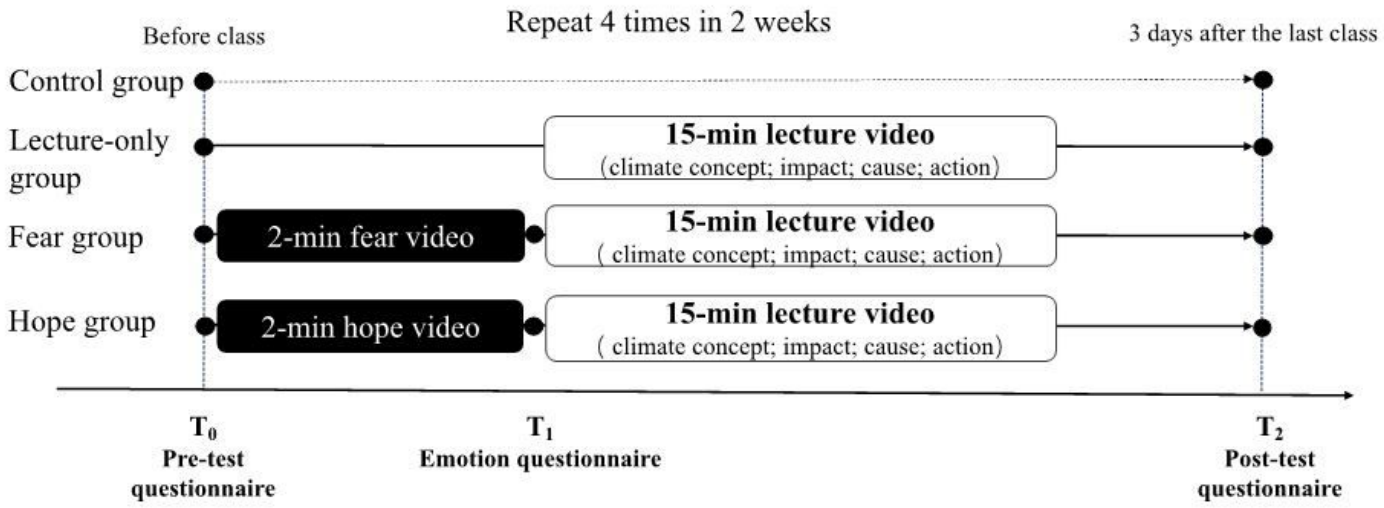

Figure 1

Design of climate change educational program process for grade 7 students, in Xiamen, Shenzhen, and Ningbo, China. The control group students only filled in the pre- and post-questionnaire without any intervention. The lecture-only group directly watched the lecture videos without emotional clips. Fear group students watched one of four fear clips before the lecture video, and hope group students watched one of four hope clips before the lecture video. The lecture frequency was two classes per week; thus, the course was finished in two weeks with a total of four lectures. T0 represents the time of pre-test before the program, T1 represents the time of answering the emotion questionnaire after the emotional video (only in emotional groups), and T2 represents the time of post-test, which was 3–5 days after the last class.

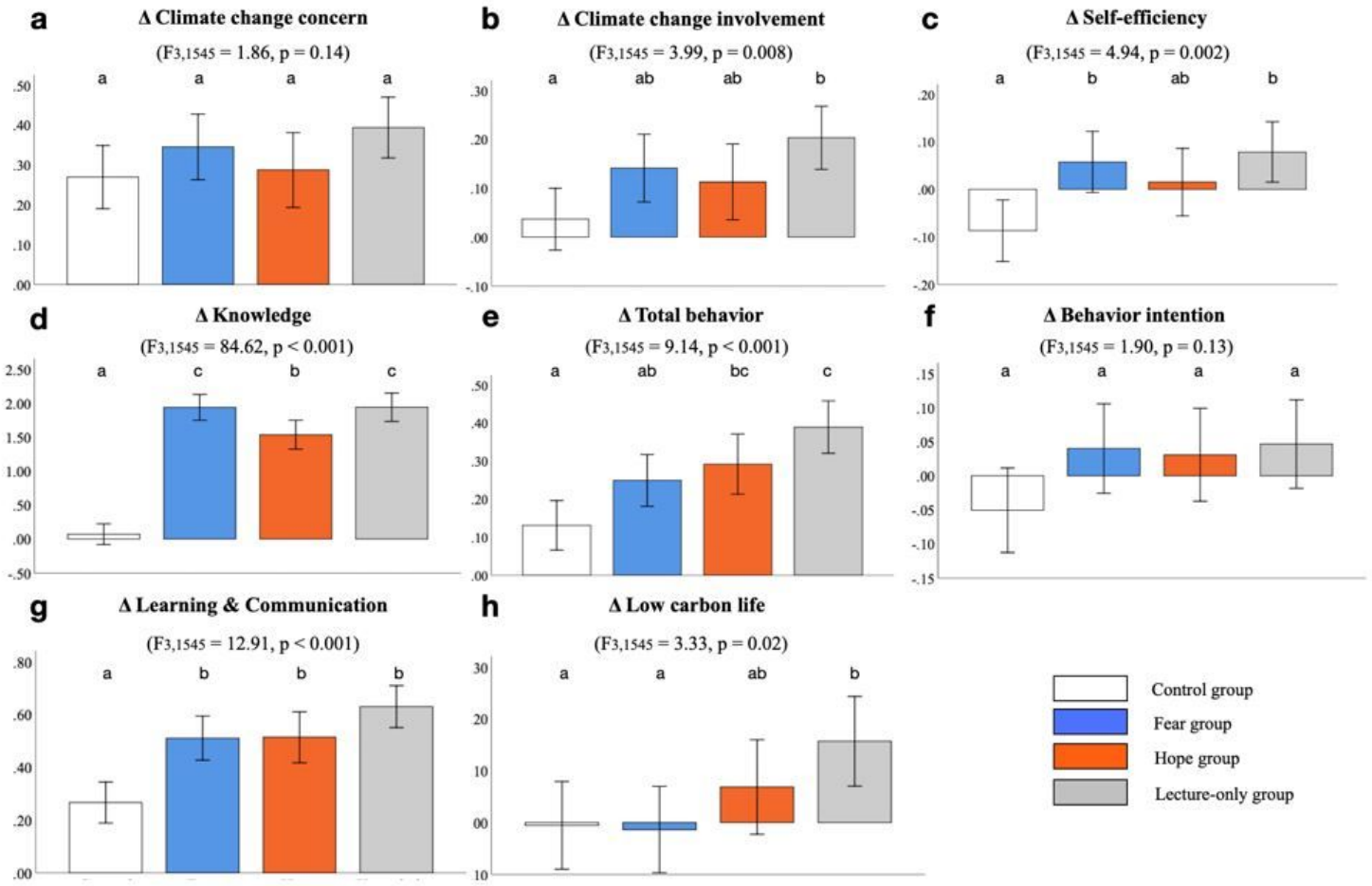

Figure 2

The effectiveness of the program on concern, involvement, self-efficiency, knowledge, mitigation behavior and behavior intention relating to climate change in four treatments. *"Δ" presents the changes between post-test and pre-test surveys. Error bar refers to the standard deviation. Figures g and h show two subdimensions of climate change mitigation behavior: learning and communication behavior and low-carbon life.

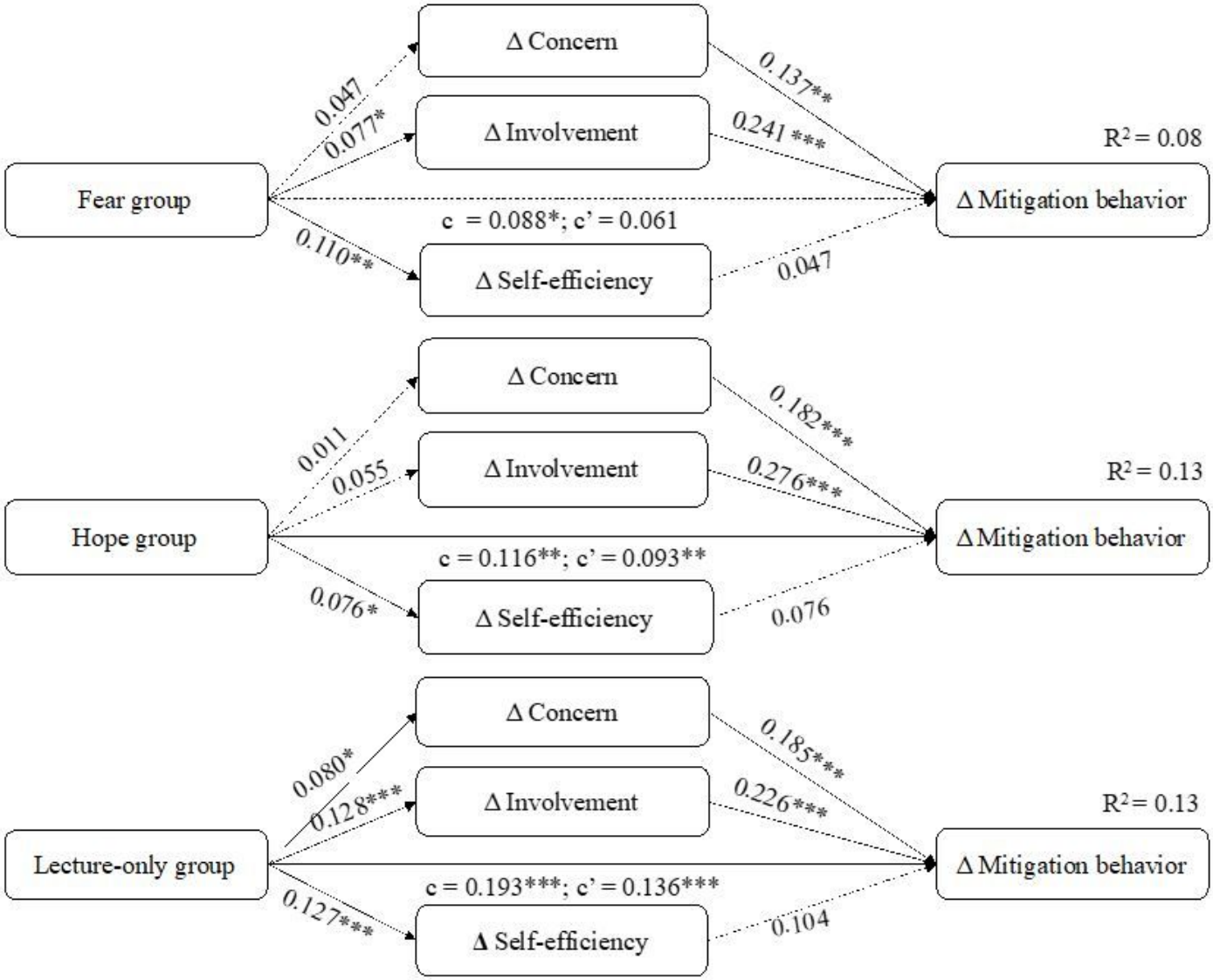

Figure 3

Mediation analysis between treatments, climate change related variables and behavior. "Δ" presents the changes between post-test and pre-test surveys. Coefficients are standardized, and the solid line shows the regression analysis between variables is significant. The dotted line shows the regression analysis between variables is not significant; c' represents the standard direct effects and c represents the standard total effects; Nfear = 797, Nhope = 754, Nlecture-only = 789, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Supplementary Files

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