Visualizing Climate Change: The Role of Construal Level, Emotional Valence, and Visual Literacy

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Research Article

Keywords: climate change, construal level theory, emotional valence, visual communication, experiment

Posted Date: April 26th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-373073/v1

Version of Record: A version of this preprint was published at Climatic Change on January 1st, 2022. See the published version at https://doi.org/10.1007/s10584-021-03291-x.

Abstract

This study examines how the level of concreteness and abstraction of climate change imagery influences people's responses via emotional valence, and how such effect is moderated by people's visual literacy. Findings show that concrete images promote negative feelings, which subsequently reduce people's perceived distance to climate change, encourage concern and behavioral intention. Less visually literate people are more influenced by the visuals' effect and are more motivated by concrete images. Our study integrates theoretical perspectives from construal level, emotional valence and visual literacy, while also offering practical advice regarding how to effectively visualize climate change to engage a wide audience.

Introduction

Visualizing climate change: The role of construal level, emotional valence, and visual literacy

Climate change has become one of the most serious threats facing humankind. In 2018, the report from the Intergovernmental Panel on Climate Change emphasized the importance of limiting warming to 1.5 degrees Celsius above pre-industrial levels, and it called for immediate mitigation and adaptation actions across the globe to tackle the issue (IPCC 2018). However, currently, there is still a lack of public engagement with climate change in the United States (Pew Research Center 2017; Leiserowitz et al. 2020). When assessing the overall behaviors, only 25% of U.S. adults reported they make an effort to live in ways that help protect the environment "all the time" (Pew Research Center 2019).

Presently, significant psychological barriers are existent preventing people from engaging with climate change. Researchers argue that one primary barrier is the perception that the issue is *psychologically distant*, meaning that its uncertain impacts will affect other people, will happen in other faraway countries or sometime in the future (Brügger et al 2015). According to construal level theory (CLT), an event perceived as distant leads to a higher level of construal, that is, a more abstract mental processing of the issue (Trope and Liberman 2010). The view of climate change as abstract and psychologically distant is a major challenge to effective communication of the issue, as it can imply little personal relevance and may lead to delayed actions (Brody et al. 2012; Leiserowitz 2006). However, recent research also found evidence that decreased psychological distance or abstraction levels of climate change did not always lead to increased willingness to act (Brügger et al. 2016; Schuldt et al. 2018). Considering the intangible, multifaceted nature of climate change, the effects of construal level or psychological distance on people's responses to the issue may be dependent also on a variety of *other* important factors (e.g., McDonald et al. 2015; Wang et al. 2019).

Nowadays, going beyond the cognitive "deficit model," scholars point out that on climate change, a polarized topic, emotions have become an important factor in shaping people's attitudes and behaviors (Nabi et al. 2018). Visuals, in particular, have the ability to arouse emotions to make the message effective. Recent climate change communication studies have started to explore emotions, visuals, and

CLT, such as climate visuals' effect on emotions (Hart and Feldman 2016), the interaction between emotion and information (Nabi et al. 2018), self-conscious emotions in relation to CLT (Ejelöv et al. 2018). However, the attention was devoted to discrete emotions, textual information. How construal levels interact with affective responses (i.e., emotional valence) in the context of visuals remains unexplored.

In this study, we empirically test 1) the role of emotional valence - the positive or negative character of an emotion - in influencing the relationship between image-induced construal level and climate change responses. In addition, 2) we examine how visual literacy influences the effect of abstract and concrete construals of climate change as well as the potential indirect effect of emotional valence in the process. Going beyond psychological-distance message framing (i.e., distant vs. proximal) studies and discrete emotion induction experiments, we theoretically demonstrate and empirically test the interacting effect of construal level and emotional valence in climate change visual communication. The findings also complement prior CLT, emotion and climate change visualization literature (e.g., Ejelöv et al. 2018; Schoenefeld and McCauley 2016) by considering audience characteristic - visual literacy. Practically, our findings could offer important advice to journalists and educators regarding how to effectively visualize climate change with appropriate levels of abstraction and emotional valence to mobilize climate change engagement.

Literature Review

Construal level theory and climate change communication

The concept *psychological distance* can be classified into four dimensions - temporal, spatial, social, and hypothetical distance, each referring to how far removed an object is from the present (Trope and Liberman, 2010). Temporal distance is defined as the perceived distance between current time point and the time when an issue will occur. Spatial distance refers to the geographical distance between an individual and the location of the issue. Social distance refers to the extent to which a person or group of people are different or similar to oneself, and hypothetical distance explains the level of certainty that the event is occurring. According to CLT, the four dimensions are interrelated, and they all positively relate to the level of construal (Bar-Anan et al. 2006). The more distant an issue is perceived to be, the more abstractly it will be mentally processed in people's minds (Trope and Liberman 2010, 2011), and such abstract mental construal further encourages people to perceive greater distance to the issue (Liberman et al. 2007).

Climate change is generally perceived as a psychologically distant issue (Brügger et al. 2015; Spence et al. 2012). It was found that reducing psychological distance has merit in promoting people's climate change-related concerns and willingness to act (Evans et al. 2014; Jones et al. 2016). However, studies also argued that other factors (e.g., individuals' cognitive style, Sacchi et al. 2016; Hart and Nisbet 2012) may affect or moderate such relationship - a reduction in psychological distance does not always lead to increased concern or behavioral intention (Brügger et al. 2016; Schuldt et al. 2018).

The effect of construal level

One possible explanation for these conflicting findings is that the perceived psychological distance is highly subjective (Trope and Liberman 2010) and is hard to manipulate. People may view climate change as psychologically near or distant based on many personal factors (e.g., personal experience with climate change, personal connections with climate victims, affected geographical areas), and they may consider the issue as temporally present but happening faraway (i.e., spatially distant). Overall, framing climate change as a distant or proximal issue, by nature, is ineffective in changing people's perception of the issue. We propose that one way to make a theoretically valid manipulation is to examine the role of construal level, that is, how abstractly or concretely people mentally process the issue (McDonald et al. 2015).

Construal level has been central to research in social psychology. It is found to be able to influence people's evaluation of information, their information recall, and behavioral outcome. For example, abstract construals make core, central values of an issue more salient, leading people to behave in ways that are more aligned with those values (Eyal et al. 2009). Under a high (abstract) construal level, people also rely more on intangible attributes in their evaluation and choice formation process (Ding and Tat Keh 2017).

In environmental communication, construal level might interact with many personal characteristics (e.g. pro-environmental values) to affect people's various responses to the environment (Ledgerwood et al. 2010). And as suggested by McDonald et al. (2015) and Brügger et al. (2016), abstract and concrete construals of climate change both have merits in encouraging climate friendly behavioral intentions. In spite of the discussion regarding the potential role that construal level plays in climate change communication (Geiger et al. 2017), few studies have empirically tested the possibly differential effects of abstract and concrete construals on people's perceptions. Due to the distant and abstract nature of climate change, understanding the role of abstraction in influencing one's perceived psychological distance, attitudinal, and behavioral responses to climate change, has great significance for the communication of the issue and mitigation efforts. Therefore, we explore the effect of abstract versus concrete construal level of climate change in this study.

Emotional valence

Another possible explanation for the conflicting results in CLT and climate change communication is that construal level may interact with other important factors to influence people's attitudes and behavioral intentions. One possible factor is emotion. The CLT framework, by itself, has provided a cognitive account for many behavior and decision-making processes (Nabi et al. 2018). However, climate change is a polarized topic, and communication research on it has moved beyond the cognitive factors underlying message effectiveness to investigate the role of emotions, such as guilt, fear, hope (e.g., Bilandzic et al. 2017; Feldman and Hart 2016; Feldman and Hart 2018). Emotions might influence the construal level cognitive processing of climate change messages to make an impact on people's responses to the issue, and we explore such mechanisms in this research.

In recent years, emotions have been examined in climate change communication studies and construal level psychological studies separately. In climate change communication, scholars explore the discrete emotions such as guilt, fear, anxiety and hope. It has been found that guilt and fear positively mediate the effect of loss frames (i.e., negative consequences of *not* engaging in climate change protection) on willingness to make climate change-related sacrifices (Bilandzic et al. 2017). However, fear and anxiety were found to not always increase mitigation intentions (Chadwick 2015). Persuasive messages that induce fear and anxiety can sometimes be threatening and counterproductive (O'Neill and Nicholson-Cole 2009). Specifically, when communicating climate change for encouraging behaviors (e.g., biking, walking) rather than avoiding behaviors (e.g., not driving), hope is likely to be more effective than fear (Chadwick 2015).

One possible reason for these inconsistencies is that although discrete negative emotions like anger, fear are evaluated as negative by most people, individuals might significantly differ in how negatively they feel about these discrete emotions. For example, some people might feel extremely negative toward "fear," whereas others might have more negative feelings toward "anger" and not such strong negative attitudes toward "fear" (Harmon-Jones, et al. 2011). In some complicated situations (e.g., climate change), instead of discrete emotions, emotions may be more easily addressed by general psychological states such as *emotional valence*, as suggested by Harmon-Jones, Harmon-Jones, and Summerell (2017). In this study, we specifically focus on overall affective responses – the emotional valence in climate change messages.

Emotional valence generally refers to the "positive" or "negative" character of an emotion, or to the character of some aspect of emotion (Colombetti 2005). As an essential component of affect, emotional valence characterizes the underlying complicated experience of feeling or mood (Barrett 2006; Frijda and Scherer 2009). According to the affect heuristic, emotional valence could skew people's judgments of a risk, bias the decision making (Keller et al. 2006), ultimately shaping judgments and risk perceptions (Slovic et al. 2005). In the communication of climate change related decisions, scholars relied on the experiential theories of risk information processing and suggested that affect and other experiential factors strongly influenced people's risk perceptions and policy support (Leiserowitz 2006). Generally, negatively valenced emotions are positively related to climate change engagement (Bilandzic et al. 2017; Hornsey and Fielding 2016), though there are debates noted earlier on the effective use of discrete emotions in various communication contexts.

While CLT does not hold an absolute relationship to emotional valence, emotions have been explored in the context of construal level psychological studies. Findings suggest that abstract construals tend to be more positively valenced compared to concrete construals. For instance, Herzog, Hansen, and Wänke (2007) found that people have a more difficult time generating cons for an action if the action pertains to the distant rather than near future. Abstract (vs. concrete) thinking elicits a focus on goals underlying one's behavior (Fujita et al. 2006) and these goals are largely perceived as positive (Carver and Scheier 1990; Custers and Aarts 2005). Building on the potential relationship between construal level and emotions, recent studies have found that affective responses to climate change may increase or

attenuate overall construal level effect on psychological distance perceptions, which may subsequently affect the formation of behavioral intentions (Leviston et al. 2014). Based on this literature, we propose an empirical study investigating the role of emotional valence as an additional mediator in applications of CLT to climate change.

The role of visuals and visual literacy

Visuals are used extensively in the communication of climate change. An increasing number of recent studies involving climate visuals have recognized the role of emotions and construal level (i.e., the level of abstraction the visuals entail) in the visuals. Images that contain negative valenced discrete emotions including fear, guilt, or vulnerability could symbolize helplessness, provoke low self-efficacy, or disengage the public with the issue (e.g. Nerlich and Jaspal 2013; O'Neill and Nicholson-Cole 2009). Images that present the "globalness" of climate change could help shape the abstractness of the issue (Rebich-Hespanha et al. 2015), whereas images that personalize climate change present more personal meanings to what otherwise might be a global, abstract, problem to the public (O'Neill and Nicholson-Cole 2009). Overall, different construal levels induced by the visuals might be associated with different levels of engagement with climate change, as suggested by O'Neill et al. (2013). As aforementioned, given that "affect heuristic" is strongly associated with climate change risk perceptions (Smith and Leiserowitz 2014), in addition to cognitive deliberation, people may perceive various emotional valence of the images, which influence their perceived risks, concern and behavioral intention. Therefore, we integrate the CLT and climate change emotions literature to explore how emotional valence might mediate the visuals' construal level effect on people's responses to climate change.

When examining visuals' effect, one factor that is worth considering is visual literacy - the set of abilities that enables people to effectively interpret, evaluate, use, and create visuals (Association of College and Research Libraries 2011). It is difficult to come up with a consensus definition of visual literacy, as the concept is by nature interdisciplinary, encompassing education, design, and media communication contexts (Avgerinous and Pettersson 2011). Our research builds on the review of the field (Brill and Branch 2007; Brumberger 2019), uses the communication perspectives (Messaris 1998; Trumbo 1999) to conceptualize visual literacy as the ability to think, learn and communicate visually.

Visual literacy has traditionally been explored in the educational context, with a special focus on student learning, the uses and effects of visual design (Brumberger 2019). In media communication, the public's increasing visual literacy has led to the growth of photographic advertising industry (Wilkinson 1997). As a result, with the proliferation of visually rich, screen-based materials, being visually literate has become a necessity for effective visual media communication (Riddle 2009). Media scholars also argue that visual literacy is a useful tool for comprehending visual news information, being critically aware of visual media manipulation, seeing how the camera angles are used for persuasive purposes, which all subsequently affect audience responses to the news content (Lazard et al. 2020).

In recent years, scholars have shifted to focus on the role of visual literacy in communicating scientific issues (Brumberger 2019). In particular, the attention has been devoted to how to train science

communicators in visual literacy (Rodríguez Estrada and Davis 2015), the role of visual literacy in influencing people's environmental science message processing (Lazard and Atkinson 2015). Overall, it is found that the images of science and the underlying scientific principles range from purely symbolic to highly representational, and they may not clearly enhance the understanding of science if there is a lack of visual literacy among the audience (Trumbo 1999, 2000). In terms of climate change, media scholars have called for maturing the education of literacy, including the literacy of understanding visual stories in the media, as the ability has been identified as a key strategy in improving public acceptance of climate science in today's age of digital information (Cooper 2011). Scholars believe that audiences have different levels of visual literacy, and more literate or sophisticated people tend to have heightened conscious awareness of how meaning is created visually (Edwards 2012) and elaborate the scientific information more deeply (Lazard and Atkinson 2015). Thus, when researching effective science visualization, it is important to consider the audience's visual literacy levels and design visuals accordingly. In this research, we attempt to examine how visual literacy interacts with the abstract versus concrete visualizing strategies to affect a variety of climate change responses.

Research questions and hypotheses

While previous literature recognized the value of psychological distance in climate change communication, there has been a lack of understanding of the effect of construal level - the level of abstraction at which climate change is mentally represented. In particular, researchers in psychology have called for the integration of construal level and emotional considerations (Dhar and Kim 2007), and an in-depth understanding of visuals' effect (Chapman et al. 2016; Wang et al. 2018), which together may help account for many climate change related attitudes and behavior intentions. Our study attempts to fill this gap by testing the effect of the climate change images' level of abstractions, as well as the mediating role of emotional valence. Considering that positive emotions are elicited by abstract construal (Williams et al. 2014) and are generally considered to decrease climate change advocacy (Nabi et al. 2018; Hornsey and Fielding 2016), we propose the following hypotheses:

H1 Abstract (vs. concrete) construal is associated with greater perceived psychological distance to climate change through positive emotion.

H2 Abstract (vs. concrete) construal is associated with lower concern for climate change through positive emotion.

H3 Negative emotion will mediate the relationship between construal level and willingness to act in that more concrete construal will lead to greater negative emotions, which will lead to greater willingness to act on climate change.

As previous studies have started to consider individuals' literacy levels when examining pro-environmental message effect (Lazard and Atkinson 2015), we also took visual literacy into consideration to contribute to the methodology and empirical evidence on climate change visual communication. We explore the following research questions.

RQ1 To what extent does individuals' visual literacy influence the relationship between images' abstraction level and their perceived psychological distance (RQ1a), abstraction and concern (RQ1b), abstraction and willingness to act on climate change (RQ1c)?

RQ2 To what extent is the indirect relationship via emotional valence between images'

abstraction level and perceived psychological distance (RQ2a), images' abstraction level and climate change concern (RQ2b), as well as between images' abstraction level and climate change willingness to act (RQ2c) conditional on individuals' visual literacy?

Method

Materials and procedure

Pretest procedure

Pretest served as a manipulation check. In it, we selected nine abstract and nine concrete climate change images and tested if they successfully encouraged people's abstract and concrete construal, respectively. First, participants were randomly assigned to either the abstract or concrete condition in an online experiment. Then, after viewing the nine images, participants were given the Behavioral Identification Form (BIF; Vallacher and Wegner 1987, 1989) which measured their difference in construal level.

Main study procedure

In the main study, participants were randomly assigned to one of two experimental conditions (abstract, concrete). In both conditions, participants firstly viewed nine climate change-related images and captions. Then, they were asked to complete a questionnaire asking about their emotional reactions, perceived psychological distance of climate change, concern for climate change, behavioral intention, visual literacy. Participants' demographic characteristics were also measured.

Experimental stimuli

We selected 18 climate change images for this study, including nine with abstract features and nine with concrete features. These abstract and concrete features have all been identified and verified in prior experimental psychology research (Burgoon et al. 2013) and in the previous content analysis research which clarified how levels of abstraction should be measured. For instance, according to Lee et al. (2014), colorful images are more concrete than their black-white image counterparts. Thus, we coded the presence of color as a concrete feature and the absence of color (i.e., black-white display) as an abstract feature. In general, images used in our abstract condition were *black-white non-photographs* with no people, focused primarily on the *causes* of climate change and portrayed climate change as a *gradual, relatively invariant*, and *stable* process (e.g. gradual temperature change, greenhouse gas emissions). Images in the concrete condition were *colorful photographs*, featuring *human victims* in the United States, detailed information about the present temporally and socially urgent situation*)* and emphasizing the

certain consequences as well as the *incidental* disastrous aspects of climate change (e.g. wildfires, hurricanes). All images were modified slightly to display in similar size and style.

Participants

Participants were adults recruited from around the United States via Amazon Mechanical Turk (MTurk). MTurk is an efficient crowdsourcing platform for recruiting online research participants, and the platform is especially reliable for experimental data collection (Paolacci et al. 2010). To ensure data quality, we concealed the research purpose, prescreened workers to include only those with excellent survey completion records and used attention-check questions to avoid inattentive responses.

Within the final sample (N = 448), 55.8% identified as female. White (81.9%) and Asian (6%) were each slightly overrepresented, while African American (9.2%) and Hispanic (6.7%) were slightly underrepresented. The average age of respondents was 42.5 years (*SD* = 12.19). Over half of participants had completed at least a bachelor's degree (53.9%). The sample leaned left slightly, consisting of 21.4% conservatives, 9.4% conservative-leaning respondents, 18.1% moderates, 12.7% liberal-leaning respondents, and 38.4% liberals. Respondents residing in the Midwest (20.8%) and South (38.4%) were proportionally represented while those in the Northeast (21%) were slightly overrepresented and those in the West (20.5%) were slightly underrepresented. The median total annual household income of respondents was between $10,000 and $50,000.

Measurements

Emotional valence

Overall perceived emotional valence was measured with the question "Overall, how would you rate your subjective feelings to the climate change images you just viewed?" Responses ranged on a Likert-type scale from 1 (*completely unhappy*) to 9 (*completely happy*) (*M* = 2.71, *SD* = 1.76). The question was adapted from a study by Marian and Kaushanskaya (2004).

Psychological distance of climate change

All four dimensions of psychological distance were included. Perceived spatial distance was measured by four questions such as "I feel the estimated distance between the geographical areas(s) that are being negatively affected by climate change and my location could be __ ." Perceived temporal distance was measured by three questions such as "climate change is an urgent threat or risk for my generation." Perceived social distance was measured by questions such as "People generally similar to me can feel/experience the negative impacts of climate change". Perceived hypothetical distance was measured by Likert scale questions such as "It is certain that climate change will have a negative impact on me." The responses ranged from 1 (*strongly disagree/extremely close*) to 7 (*strongly agree/extremely distant*). All four dimensions of distance were collapsed into one composite score of perceived psychological distance (*M* = 3.26, *SD* = 1.15, Cronbach's alpha = .869), with higher values indicating greater perceived distance.

Willingness to act

We divided 25 “willingness to act” questions into two types - mitigation intention and adaptation intention, each with five-point Likert-type responses ranging from 1 (*very unlikely*) to 5 (*very likely*). For each, questions were split between generic and specific intentions. Generic mitigation intention was measured with questions such as “I plan to take some actions to stop climate change.” Specific adaptation intention was measured with questions including “I intend to buy flood insurance or other climate-related disaster insurance for my (future) house.” Then we aggregated the overall mitigation intention and overall adaptation intention questions to form a scale on “willingness to act,” which was found to be internally consistent (M = 3.51, SD = .75, Cronbach’s alpha = .859). All questions were adapted from previous studies (Broomell et al. 2015; Brügger et al. 2016; Gifford and Comeau 2011; O'Connor et al. 1999).

Concern for climate change

We used three questions to measure participants’ concern for climate change. All questions utilized Likert-type responses ranging from 1 (*not at all concerned*) to 5 (*a great deal concerned*). For example, one question asked, “Considering any potential effects of climate change which might be on you personally, how concerned, if at all, are you about climate change?” (M = 3.39, SD = 1.27, Cronbach’s alpha = 0.91).

Visual literacy

Visual literacy was measured using four visual thinking and visual creation items such as “How often do you draft mind mapping, diagramming (see examples below) in your day-to-day thinking?” “Do you do PowerPoint slides presentations on a regular basis?” “How skillful are you with photo software such as Adobe Photoshop?” “How skillful are you with illustration software such as Adobe Illustrator?” Responses ranged from 1 (*entry-level amateur/Never)* to 5 (*Expert professional/Always*) (M = 2.03, SD = 0.77, Cronbach’s alpha = 0.78). All questions were adapted from previous study (Brumberger 2011). In this study, other demographic characteristics were measured as well, including age, gender, race, ethnicity, geographic region, political orientation, and education level.

Results

Pretest

Results from Pretest showed that respondents who were exposed to abstract images were more likely to prefer abstract behavioral descriptions (n = 93, M = 16.53) in the BIF test than those who viewed concrete images (n = 99, M = 14.35) (p = .024, Cohen’s d = .33). These results suggest images selected for this study successfully encouraged participants in the abstract group to have higher level of construal than those in the concrete condition. Thus, the stimuli manipulation was successful.

Main Study

A series of independent sample t tests were conducted to examine the main effect of construal level experimental manipulation. Participants who viewed abstract images were found to perceive significantly greater psychological distance to climate change than those who viewed concrete images ($M_{abstract}$ = 3.45, $SD_{abstract}$ = 1.13, $M_{concrete}$ = 3.08, $SD_{concrete}$ = 1.15, $t(446) = 3.35$, $p < .01$, Cohen's $d = .32$). Participants who viewed abstract (vs. concrete) images also had more positive emotions about the images ($M_{abstract}$ = 3.03, $SD_{abstract}$= 1.92, $M_{concrete}$ = 2.39, $SD_{concrete}$ = 1.51, $t(446) = 3.93$, $p < .001$, Cohen's $d = .37$). However, no significant between-condition difference was found on other outcome variables such as climate change concern, behavioral intention ($p > .05$).

The mediating role of emotion

To examine H1, we conducted a mediation analysis using the PROCESS Macro Model 4 for SPSS (Hayes, 2018), with 5,000 bootstrap resamples and 95% confidence intervals. We included images' abstraction-level conditions as independent variable, emotional valence as mediator, and perceived psychological distance as dependent variable. Social demographic variables were also entered into the model as covariates to control for their potential impacts. Findings on the indirect effects partially support H1, as emotional valence partially mediates the relationship between perceived psychological distance and images' abstraction level ($\beta = .14$, $SE = .04$, 95%CI [.07, .22]; Fig. 1). Table 1 reports the estimates of the mediation model.

Next, we performed the same analysis with climate change concern as dependent variable. Results showed that images' abstraction level did not have a direct impact on climate change concern. However, it had an indirect effect on the concern ($\beta = -.16$, $SE = .04$, 95%CI [-.24, −.07]; Fig. 2) via emotional valence: Abstract (vs. concrete) construal led to increased emotional valence, which then reduced the concern for climate change. Therefore, H2 was supported.

To test H3, we ran the same model with willingness to act as dependent variable. It was shown that emotional valence also negatively mediated the influence of images' abstraction level on willingness to act on climate change ($\beta = -.07$, $SE = .02$, 95%CI [-.11, −.03]; Fig. 3). Thus, H3 was supported.

Visual literacy

The first set of research questions (RQ1a-c) asked to what extent visual literacy could moderate the effects of images' abstraction level on people's responses to climate change. To address these questions, we conducted a moderated mediation analysis using PROCESS Macro Model 8 to test both the direct and indirect paths from images' abstraction level to the climate change response variables. Similar to the mediation model, we entered images' abstraction level (abstract = 1, concrete = 0) as independent variable, emotional valence as mediator, perceived psychological distance as dependent variable and social demographic variables as covariates. The remaining analyses were identical to the first except that concern, willingness to act were entered as dependent variables, respectively.

The analyses revealed that our image manipulation interacted with visual literacy to affect people's perceived distance to climate change ($\beta = -.26$, $p < .05$; Fig. 4), concern for the issue ($\beta = .31$, $p < .01$; Fig. 5), and their willingness to act ($\beta = .16$, $p < .05$; Fig. 6), after controlling for social demographic variables. Specifically, on the one hand, for people with low visual literacy (1 SD below the mean), abstract (vs. concrete) images increased their perceived psychological distance to climate change ($\beta = .40$, $SE = .13$, $p = .00$, 95%CI [.15, .65]). Such construal level manipulation did not affect the perceived distance among people with high visual literacy. On the other hand, for people with high visual literacy (1 SD above the mean), abstract (vs. concrete) images significantly increased their concern ($\beta = .34$, $SE = .12$, $p = .01$, 95%CI [.10, .57]) and willingness to act ($\beta = .19$, $SE = .09$, $p = .03$, 95%CI [.02, .37]).

Last, regarding RQ2a-c, we found the high and low visual literacy groups did not significantly differ with regard to the manipulation's conditional indirect effect on psychological distance (High visual literacy: $\beta = .16$, 95%CI [.00, .31]; Low visual literacy: $\beta = .12$, 95%CI [.01, .24]), concern (High visual literacy: $\beta = -.18$, 95%CI [-.35, −.00]; Low visual literacy: $\beta = -.14$, 95%CI [-.26, −.01]), and willingness to act (High visual literacy: $\beta = -.09$, 95%CI [-.18, −.00]; Low visual literacy: $\beta = -.07$, 95%CI [-.13, −.00]). We looked at the indices of moderated mediation, which test if there are indirect effects of images' abstraction level on the outcome climate change responses through emotional valence with respect to different levels of visual literacy. It was found that visual literacy conditions did not significantly differ in influencing the indirect relationships (Psychological distance: Index = .02, 95%CI [-.12, .16]; Concern: Index = −.02, 95%CI [-.18, .13]; intention to act: Index = −.01, 95%CI [-.09, .07]). Table 2 reports the conditional indirect effects.

Discussion

A surging number of climate change communication studies have investigated the psychological distance of climate change, the role of discrete emotions, and the impact of climate change visuals. Bridging these areas of study, we made an initial attempt to explore the mediating role of emotional valence and the moderating role of visual literacy in the relationship between (abstract, concrete) construal level and climate change engagement. We found evidence that concrete (vs. abstract) images brought people negative (vs. positive) feelings, which subsequently led people to perceive less psychological distance to climate change, generate greater concern and willingness to act. In addition, people with low (vs. high) visual literacy were more influenced by the construal level visual manipulation. And unlike highly visually literate people who were motivated by abstract images to engage with climate change, people with low level of visual literacy were positively influenced by concrete images. Overall, we demonstrate how abstract and concrete visual messaging strategies may be used more effectively with the consideration of emotional valence and individual's visual literacy. The theoretical integration and empirical tests respond to the recent calls for more nuanced understanding of emotional complexity, individual differences in preferences for local versus global climate change images (Wang et al. 2019; Chapman et al. 2017). The results also offer practical implications to communicators, advocates, and media workers regarding how to promote climate change engagement among different groups of audience with the effective use of visuals.

The analyses show that participants who viewed abstract images perceived greater distance between climate change and themselves. This is aligned with environmental communication literature which explained that local frames of climate change could encourage people's worry and concern about the issue (Bloodhart et al. 2015). It also confirms CLT which suggests that people's perceived psychological distance to an issue is positively influenced by the level of abstraction at which the issue is mentally represented (Trope and Liberman 2010). Future visual communication scholars and advocates could follow this line of thinking to explore how to use concretizing strategies to make climate change become psychologically close to the public.

Supporting the hypotheses, we found that abstract images led to increased perceived psychological distance, less concern and willingness to act via positive emotions. This finding is in close accord with past CLT literature which explains that compared to concrete construals, abstract construals encourage people to generate more pros (reasons in favor of a course of action) than cons (reasons against a course of action), consequently having more positive perceptions of an issue (Eyal et al. 2004; Williams et al. 2014). Also, the negativity elicited by concrete thinking of climate change could further encourage climate change engagement. It is likely that when portraying climate change negatively, a low level, concrete construal could help motivate people with urgency and action-oriented thinking. Whereas under a high level, abstract construal, the negativity might become vague, involve less intense emotions, and thus raise less concern or behavioral intentions (Van Lent et al. 2017). Although fear was sometimes overwhelming and discouraging (O'Neill and Nicholson-Cole 2009), future scholars could build on our finding and continue to explore whether or not concretizing certain negative emotions (e.g., using anger instead of sadness) might be able to effectively promote climate change engagement.

Despite concrete thinking encouraging concern and willingness to act via negative emotions, we found that construal level mindsets did not directly influence people's concern for climate change, nor did they have a direct impact on willingness to act. These findings are aligned with CLT which originally explains only the positive relationship between construal level of and psychological distance of an issue, not how such construal level cognitive style is related to environmentally friendly attitudinal and behavioral outcomes (Trope and Liberman 2010). The findings are also consistent with the CLT assumption in climate change context explained by McDonald et al. (2015) and Brügger et al. (2016), confirming that abstract and concrete construals of climate change both have merits in encouraging pro-environmental behavioral intentions. In light of this, future studies should be more cautious when using construal level messaging strategies to influence the public. Instead, more investigations are needed to unveil under what emotional valence or other informational and personal conditions may construal level be effective in mobilizing climate friendly attitudes and behaviors.

Furthermore, findings from our analysis show that individuals' visual literacy played an important moderating role between construal level and climate change outcomes, though it did not influence the indirect effect of emotional valence on the relationship. This is consistent with previous work by McDonald et al. (2015), which claimed that the effect of abstract versus concrete messages on people's climate change decision-making is dependent upon various individual-level factors. Specifically, we found

that less visually literate people were more influenced by the construal level visual manipulation, and concrete images made them perceive significantly less psychological distance to climate change. On the contrary, the perceived psychological distance among people with higher visual literacy was not influenced by the construal level visual effect. One possible explanation is that highly visually literate people were able to critically consume visual information. As a result, they were less subject to visual abstraction or concreteness persuasion tactics. This confirms the study by Messaris (1994), Messaris and Moriarty (2005), unveiling that audience critical visual thinking and design skills can greatly impact the effectiveness of visual communication.

Additionally, we found that abstract images drove highly visually literate people to engage with climate change. Whereas less visually literate people were more motivated to engage by concrete images. We speculate that in abstract images, there is a lack of detailed information, and meanings are symbolic, indirect, and are constructed via black-white, data-intensive graphs, cartoons. All of these features require higher visual thinking and design ability. This way, people with high visual literacy are able to understand the abstract images more deeply, process them more effectively, and thus being able to get motivated by them. For less visually literate audiences, concrete images communicate the direct, representational rather than symbolic meanings to them with detailed information, human elements, colorful design, and these facilitate better, easier visual message processing and thus more favorability among them. This result also explains one of our earlier findings that abstract and concrete construals did not directly influence people. We speculate that abstract and concrete visual portrayals of climate change activate not only different construal levels but also people's visual skills. And for viewers with different visual literacy levels, the processing style and the level of understanding of the visual information might be different. Future research should continue to explore visual literacy as an influential personal factor and take other audience characteristics (e.g., cognitive style, visual preference) into account when examining visual communication effectiveness. These findings shed light on the importance of incorporating visual literacy into visual communication efforts.

Overall, our study is a first step toward an integration of construal level and emotions in climate change visual communication. We demonstrate that concrete visuals of climate change elicit negative emotions toward the issue, which further leads to greater concern, willingness to act. There are also individual differences in terms of visual information processing. For people with high visual literacy, visual construal level effect on perceived distance to the risk is minimal, and abstract images are more effective in encouraging climate change engagement. However, for less visually literate people, we found the opposite patterns.

This study is not without limitations. First, this study measured visual literacy by self-reported questions that focused on visual creation skills, visual use and thinking habits. The questions on how well people interpret visuals did not reach internal consistency and were thus eliminated from further analyses. Second, in this study, we did not differentiate between low-level (concrete) and high-level (abstract) behaviors, or near future (short-term) and distant future (long-term) behaviors, which were found in prior research to possibly associate with different concrete and abstract construals, respectively. Last,

emotional valence in our study captured only the overall affective responses people had towards the images, and it is unknown how intense people felt towards the images and what exact discrete emotion contributed to the attitudinal or behavioral change. Future research should continue to investigate the interactions between construal level and emotions, with more variables being considered such as emotional intensity, the abstraction and concreteness of the emotion.

It is expected that this study will encourage future research on the intersections among construal level of climate change, emotions, and climate change visual communication. On the one hand, future research should build on our findings to link people's construal level with psychological distance and other attitudinal or behavioral outcomes to further assess construal level visualizing strategies. On the other hand, the results from this study show construal level effect becomes salient and gets intensified by positive and negative emotions, and among less visually literate audience. Future studies should further explore under what other cognitive or affective conditions or in what audience groups abstract and concrete construals can be particularly effective in influencing people's ecological attitudes.

Declarations

Funding

The authors received financial support for the research from the Center for Advanced Media Studies at the University of Nevada Reno.

Conflicts of interest/Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and material

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

Code availability

Not applicable

Ethics approval and consent to participate

This project has been approved by University of Nevada Reno Institutional Review Board under Exemption Category # 2. Approved Project ID #: 1585997-1. Consents were obtained from participants before they took part in the study.

Consent for publication

Not applicable

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Tables

Table 1 Results of the moderated mediation analysis (PROCESS Model 8)

	β (SE)		
	Mediator: Emotional valence		
Constant	3.69 (.60)***		
Abstract images (X)[a]	.38 (.45)		
Visual literacy (W)	.21 (.15)		
Interaction: Abstract images* visual literacy	.09 (.21)		
R^2	.12		
F	6.02***		
df1, df2	10, 437		
	Dependent variables		
	Perceived psychological distance	Climate change concern	Willingness to act
Constant	3.12 (.35)***	2.97 (.33)***	3.13 (.24)***
Abstract images (X)[a]	.72 (.25)**	-.54 (.24)*	-.26 (.17)
Emotional valence (M)	.25 (.03)***	-.28 (.03)***	-.14 (.02)***
Visual literacy (W)	-.02 (.09)	.07 (.08)	.27 (.06)***
Interaction: Abstract images* visual literacy	-.26 (.12)*	.31 (.11)**	.16 (.08)*
R^2	.36	.43	.30
F	22.35***	30.22***	17.10***
df1, df2	11, 436	11, 436	11, 436

Note: a. Abstract=1, Concrete=0; N = 448; Adjusted for age, gender, race, region, political orientation, education, and income. Bootstrap confidence intervals were constructed using 5000 resamples and 95% bias-corrected confidence intervals; *p < .05, **p < .01, *** p < .001 (two-tailed); β: unstandardized coefficient, SE= Standard error.

Table 2 Results of conditional indirect effect

Moderator: Visual literacy (W)	Conditional indirect effect	Bootstrap SE	Bootstrap LLCI	Bootstrap ULCI
Dependent variable: Perceived psychological distance				
Mean-1SD	.12	.06	.01	.24
Mean	.14	.04	.06	.22
Mean+1SD	.16	.08	.00	.31
Dependent variable: Climate change concern				
Mean-1SD	-.15	.12	-.38	.08
Mean	.09	.08	-.07	.26
Mean+1SD	.34	.12	.10	.57
Dependent variable: Willingness to act				
Mean-1SD	-.06	.09	-.22	.11
Mean	.07	.06	-.05	.19
Mean+1SD	.19	.09	.02	.37

Note: LLCI = Lower level confidence interval; ULCI= Upper level confidence interval; Level of Confidence = 95%; Number of bootstrap samples = 5000; SE= Standard error.

Figures

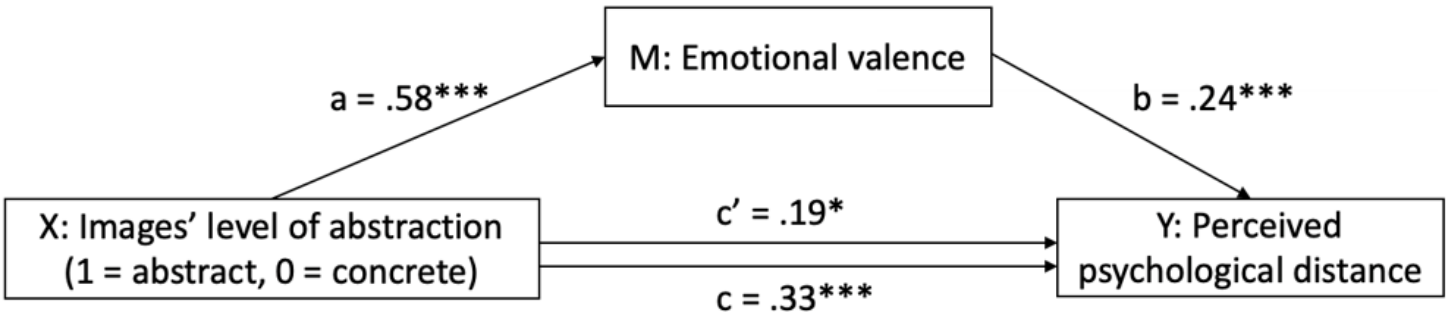

Figure 1

Mediation model linking images' level of abstraction, emotional valence of the images, and perceived psychological distance to climate change Note: Social demographic variables of age, gender, race, political orientation, region, education, and income were included as covariates within the analysis. Values provided are unstandardized beta coefficients; c = total effect, c'= the direct effect of X on Y controlling for M; *p<.05, *** p <.001; the indirect effect was significant at 95% CI [.07, .22].

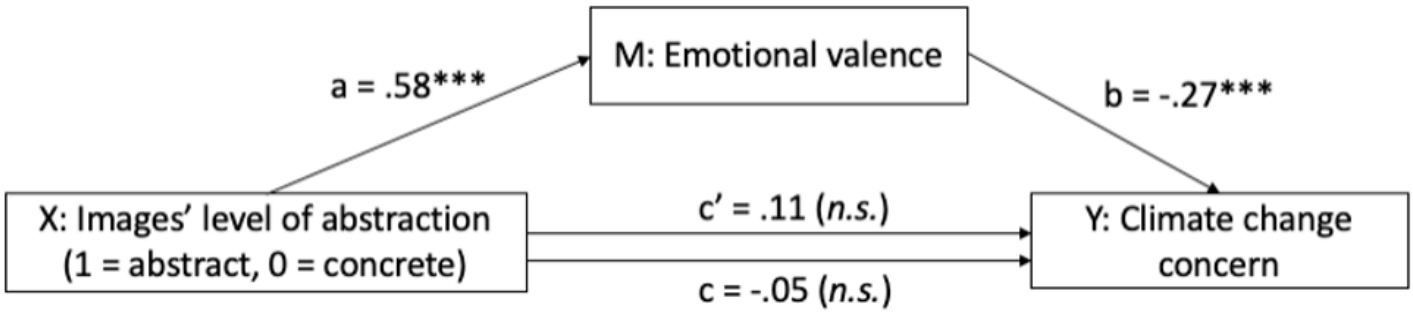

Figure 2

we performed the same analysis with climate change concern as dependent variable. Results showed that images' abstraction level did not have a direct impact on climate change concern. Note: Social demographic variables of age, gender, race, political orientation, region, education, and income were included as covariates within the analysis. Values provided are unstandardized beta coefficients; c = total effect, c'= direct effect; *** p <.001; the indirect effect was significant at 95% CI [-.24, -.07].

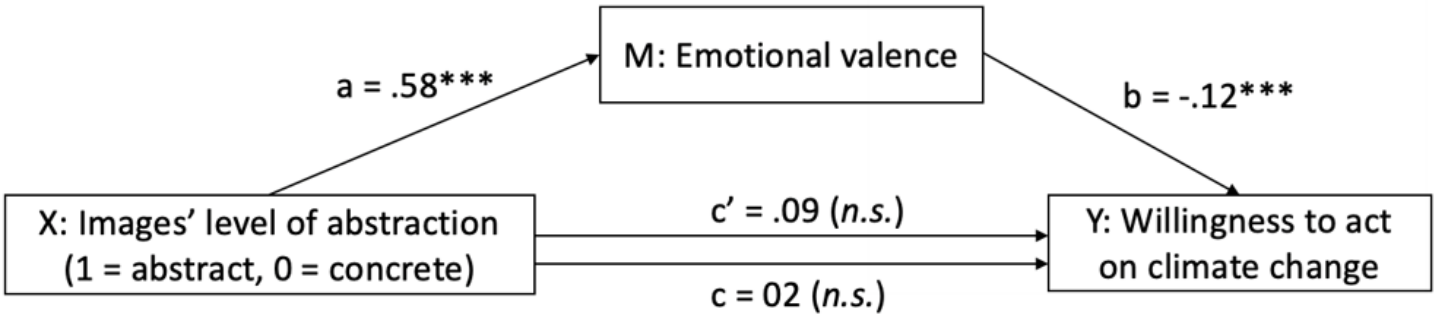

Figure 3

we ran the same model with willingness to act as dependent variable. It was shown that emotional valence also negatively mediated the influence of images' abstraction level on willingness to act on climate change Note: Social demographic variables of age, gender, race, political orientation, region, education, and income were included as covariates within the analysis. Values provided are unstandardized beta coefficients; c = total effect, c'= direct effect; *** p <.001; the indirect effect was significant at 95% CI [-.11, -.03].

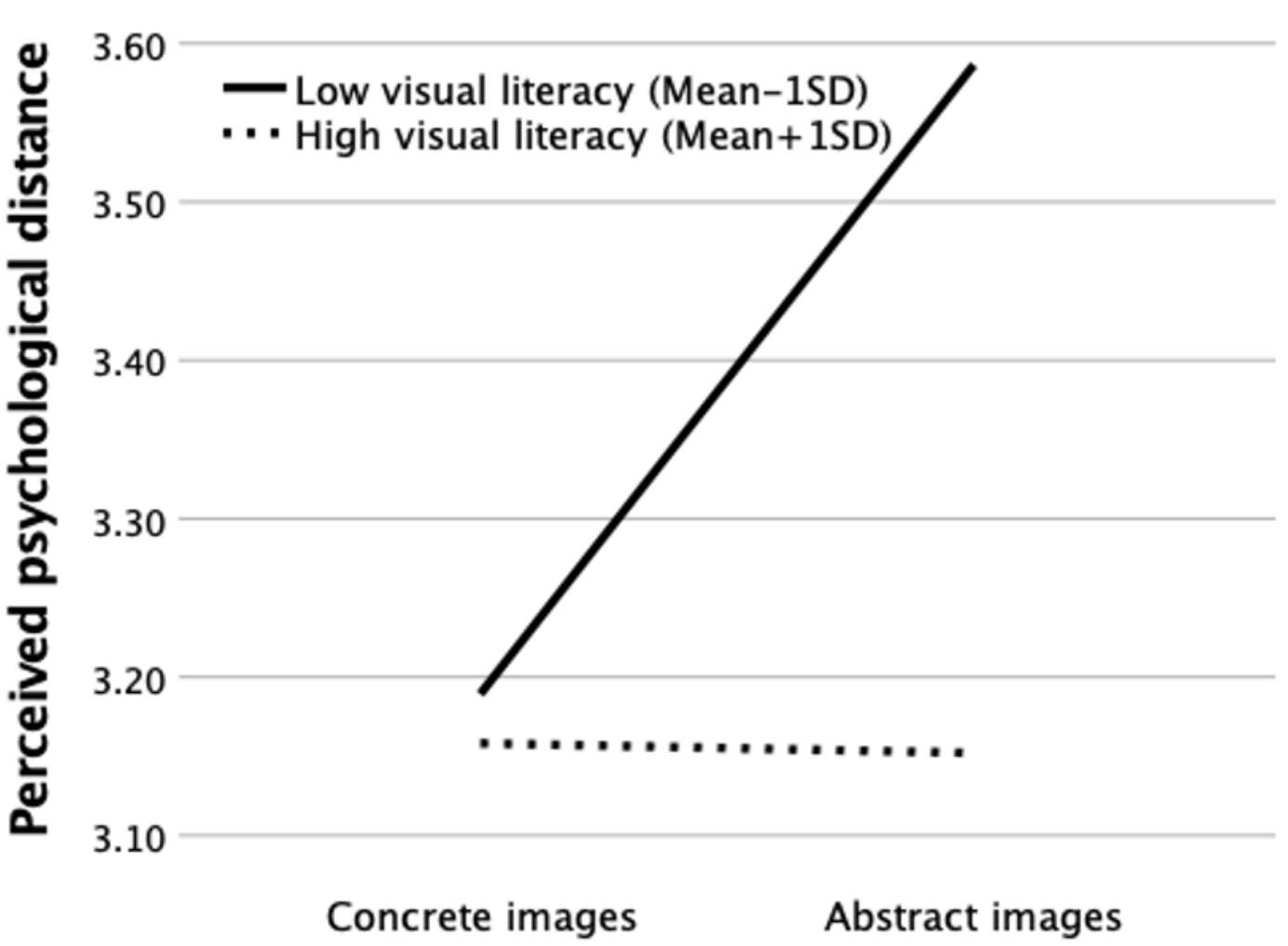

Figure 4

The analyses revealed that our image manipulation interacted with visual literacy to affect people's perceived distance to climate change

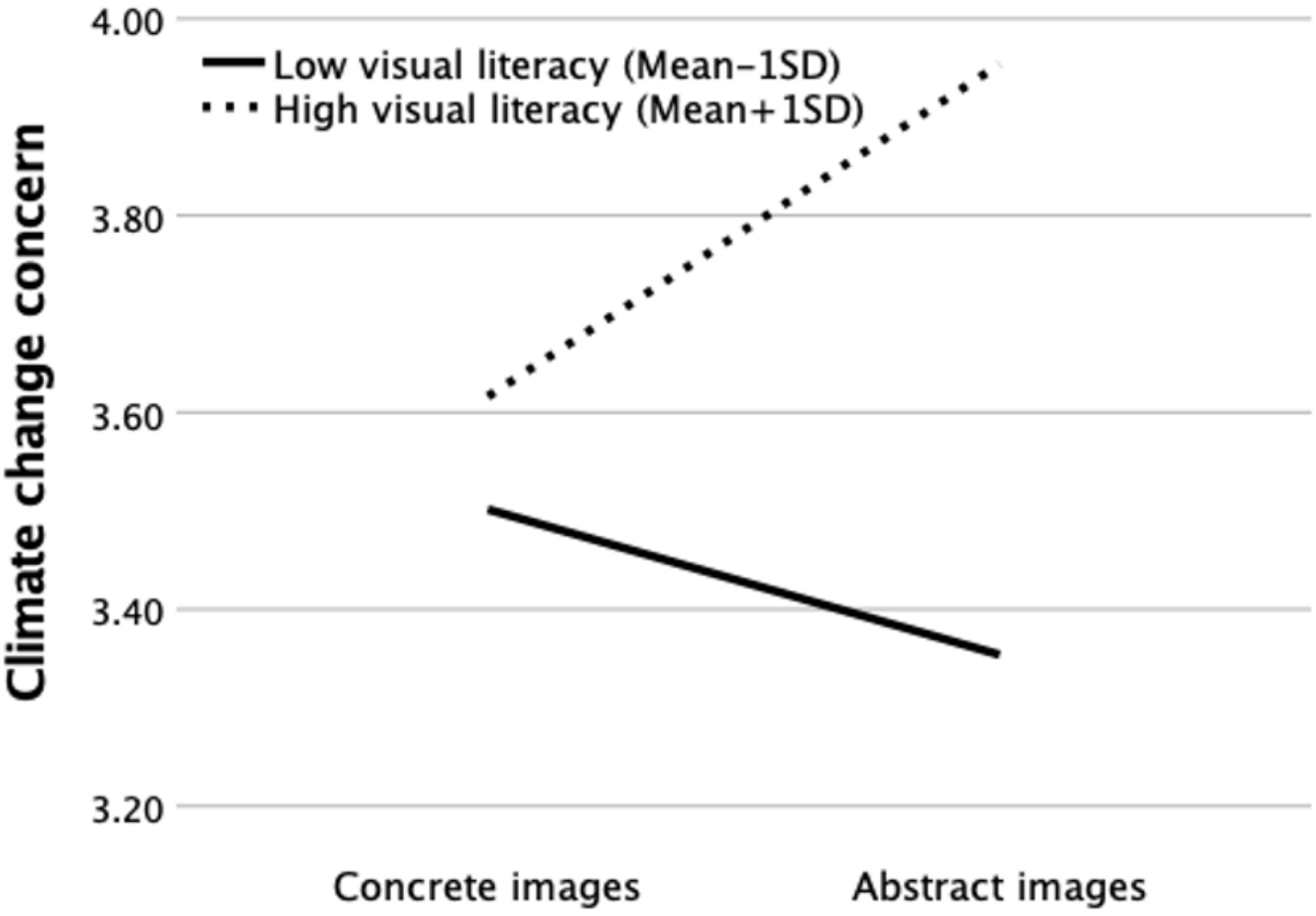

Figure 5

The analyses revealed that our image manipulation interacted with visual literacy to affect people's perceived distance to concern for the issue.

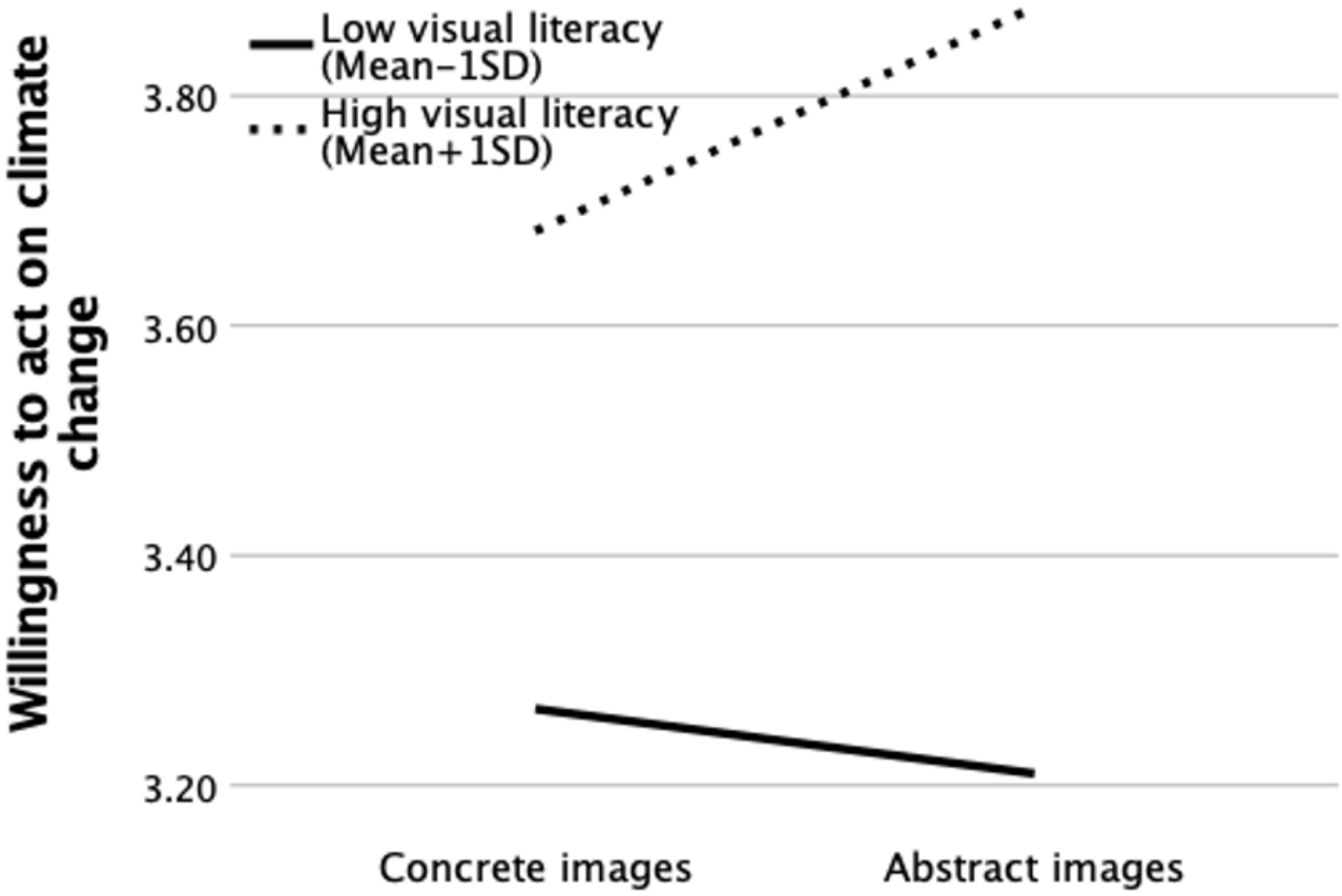

Figure 6

The analyses revealed that our image manipulation interacted with visual literacy to affect people's perceived distance to their willingness to act