Can Multiple Texts Prompt Causal Thinking?
The Role of Epistemic Emotions

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Abstract

When individuals seek to learn about scientific information, they likely turn to the Internet. There, they will find multiple documents with conflicting points of view and varying degrees of accuracy. Integrating this information is challenging and may evoke epistemic emotions which may, in turn, influence how this information is integrated. Additionally, understanding complex scientific topics such as climate change requires causal reasoning. The current study investigated the role of emotions and prior knowledge in learning about the causes and effects of climate change from multiple texts. One hundred and twelve university students read either a congruent argument (two texts affirming the same point of view) or an incongruent argument (two texts with competing points of view). Text presentations were counterbalanced. Those who read congruent texts showed greater knowledge gains and were more likely to think causally than those in the incongruent group. Across all conditions, emotions tended to decrease in salience as participants read the second text, suggesting that individuals may become desensitized to the challenges of climate change with increased exposure to information. This suggests that caution must be taken to avoid promoting disengagement and inaction of individuals around controversial issues.

Keywords: Climate change, Multiple texts, epistemic emotions, causal reasoning

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Learning about issues of personal and global significance means contending with conflicting documents (Rapp & Braasch, 2014). This is often the case for topics seen as "controversial" such as stem cell research, genetically modified foods, or the causes of climate change. These topics that "encompass social dilemmas with conceptual or technological links to science" (p.1, Sadler, 2004) are also known as "socio-scientific" topics. For example, if individuals want to know if vaccines are safe, or when they wonder whether fracking can cause earthquakes, they will likely turn to the Internet. There, they will find multiple documents, with conflicting points of view, and varying degrees of accuracy. This gluttony of information creates challenges for the publics' understanding of science as many students struggle with discerning the accuracy and value of these sources (Sinatra & Hofer, 2016; Sinatra, et al., 2014; Sinatra & Lombardi, 2020).

Integrating information across multiple sources is itself a challenge. Creating a coherent mental model from information scattered across multiple documents increases the search time and cognitive resources required to process this information. This increase in resource expenditure can strain available resources, causing learning to break down (Mayer & Moreno, 2003). In addition, learning from multiple texts often involves resolving conflicting points of view from different sources of knowledge (Bråten, et al., 2011; List & Alexander, 2017). Thus, regardless of the accuracy of their prior knowledge, learners may encounter information that is in direct conflict with previous sources – both online and derived from personal experience.

These discrepant sources may trigger strong emotional reactions that affect how individuals process the information (Thacker, et al., 2019; Trevors, et al., 2017). Positive

emotions (like enjoyment or curiosity) may cause the reader to engage more deeply with the text, whereas negative emotions (like frustration or anger) may cause the reader to disengage. These emotions can play a significant role in mediating individuals' views of controversial topics with some emotions facilitating and other constraining understanding of the issues. In some cases, these emotions may be sufficiently strong so as to have an individual either engage or disengage with the topic before they begin to process the information presented (Sinatra & Broughton, 2011).

Finally, thinking deeply about complex scientific topics such as climate change requires causal reasoning (see Perkins & Grotzer, 2005). Climate change is an especially salient topic as the debate often focuses on whether or not *humans* are causing this phenomenon, or if, as others argue, this phenomenon is real but not caused by humans. When people perceive there is a cause-and-effect relationship between events or phenomena, then they believe that there is a mechanism responsible for that relationship (Ahn & Kalish, 2000). The greenhouse effect, the major causal mechanism underling global warming, is not well understood by the public (Ranney & Clark, 2016). To understand the causes of climate change, one must examine possible mechanisms for linking event A with outcome B. But first, before anyone can examine mechanisms of causation, possible causal actors or events must be attended to and identified.

The current study explores how epistemic emotions and causal thinking influence how students learn about global climate change from multiple texts. In the next sections, we review relevant literatures supporting the key constructs investigated: multiple document comprehension, epistemic emotions, and causal thinking.

Comprehending Multiple Documents

The comprehension of multiple documents can at once be seen as an extension of a single document text approach (with many of the underlying assumptions of reading comprehension) but at the same time significantly more difficult as multiple texts may present multiple, conflicting viewpoints that need to be categorized and potentially integrated. It incorporates all of the assumptions from learning with a single document – that students possess limited cognitive resources that they must apply to read, decode, monitor, draw inferences, and ultimately create a mental model of text content. This model also adds a few other components that one could expect when adding additional texts. One additional component deals directly with the situation model of the individual text content and can be thought of as analogous to the meta-information (or metadata) that accompanies a computer file. This information includes the source information, the rhetorical goals, and the content of the text (Perfetti et al., 1999). This could include, for example, information about the authors (titles or credentials) or the type of document (journal article vs blog post), the intended audience (colleagues, general public) and the intent of the author (explain, persuade).

Often referred to as a "situational" model or "gist" model (Ainsworth & Burcham, 2007; Kintsch, 1988, 1992; McNamara, et al., 1996), this model of understanding can be thought of as a mental representation of the actors, actions, events, and settings mentioned, where gaps (connections not made explicit by the text) are filled with inferences and prior knowledge from the learner. For example, reading the phrase "the plate fell off the table. There were pieces everywhere," the learner might infer from their prior knowledge of plates that the plate fell off the table *onto the floor*, and *this fall was sufficient to break the plate*, which resulted in *the plate fracturing into multiple pieces* and those pieced *scattered across the floor*. Glenberg and

Langston (1992) expand on this idea, suggesting a mental model of text content is a representation of the situation described by the text, not specifically a representation of the text itself. In the passage above, for example, the representation of the plate as fragile was inferred by the learner. Wiley et al. (2005) point out that "the critical component in all these theories is that the reader establishes causal, logical or explanatory relations between the propositions given in the text" (p. 3). Thus, if the text is about the complex series of events that contribute to the alteration of the Earth's climate, a student with a good situational model will be able to recreate and explain the process through which these events shape, and are shaped by, multiple causal and explanatory relations (or not).

Britt and colleagues (Perfetti, Rouet, & Britt, 1999) refer to this model as the inter-text model, an interwoven, global understanding of the content conveyed by all the texts. This is the most desirable outcome, but, given the constraints mentioned, and the increased resources required to combine multiple texts, a number of other, less desirable outcomes are possible. Two common models include the "separate representations" model and the "mush" model.

As the name suggests, the separate representations model is comprised of multiple situation models of each specific text, but these models fail to be integrated (Perfetti et al., 1999). One reason for this outcome is that the texts are simply unrelated, although a more likely reason would be that learners lack the available cognitive resources to relate these two sources, and simply encode them side-by-side. Another plausible reason concerns the timing of reading – too much time between documents and learners may fail to make the connection between prior knowledge (as learned from the first document) and incoming information (as learned from the second document).

Another outcome is that students read both texts and create a mush model (Perfetti, et al., 1999). In the mush model, the documents have been completely integrated, including the meta-information. The learner cannot recall from which document arguments originated or connect the form of the document (journal article vs. opinion blog) to the arguments made. This can be especially problematic when learners are comparing legitimate sources (the World Health Organization) to less legitimate sources (blogs found on social media). This model can arise from too much conceptual overlap between documents, or, too little time passing between readings. While this model may promote a better situational model of text content, it precludes the learner from articulating the origin of the information, making the verification and evaluation of information more difficult.

The final and most optimal model is the fully integrated documents model (Perfetti et al., 1999). The document model is comprised to two inter-related models – the situational model for each text (including the source, goals, and content) and the inter-text model, which relates these (multiple) situational models to one another. The major difference between this model and the others is the inter-text model is comprised of a highly integrated model of *most* of the text content. The document model allows the learner to create a coherent mental model of both the arguments and counter arguments, source those arguments, and use those argument to answer questions like "explain to your friend the process of human-induced climate change and how it will effect diverse communities around the world."

When reading multiple and conflicting texts, the conflict will often center around causes, rather than basic facts. Many individuals accept that the climate is changing. The real debate centers on the causes of the change: is the change due to natural fluctuations or human impact on the environment? In reading about genetically modified foods (GMF's), the central debate is

whether GMF's cause adverse health effects. The debate around vaccinations is also a causal one: concerned parents wonder if vaccines cause autism. Thus, identifying causes and linking them to outcomes is a key aspect of any explanation (Keil & Wilson, 2000), particularly a scientific explanation (Lombardi et al., 2016). When learning from texts, learners construct mental models about the information as well as about causation (Johnson-Laird, 2005). According to this view, individuals "deduce the consequences of causal claims from what holds in their mental models of the premises" (Goldvarg & Johnson-Laird, 2001, p. 606). In other words, when reading conflicting accounts, identification of possible premises of causation is paramount to reasoning about causes.

Ferguson et al. (2012) argued that students often struggle to make judgments about relevance and reliability when confronted with vast amounts of information. This is particularly true when there are multiple sources that present conflicting information. When students face multiple sources, they must evaluate the veracity of the information, the evidence to justify knowledge claims, and determine if the claims count as knowledge. An integrated model can become especially problematic when finding information online, where knowledge is not curated, and misinformation is presented as scientifically reviewed information (Sinatra & Lombardi, 2020). In the present investigation, we use three texts with varying viewpoints on the causes and outcomes of climate change. Two of these texts presented congruent ideas – that human actions were causing climate change and the consequences would be severe. The third text presented an incongruent idea – that natural causes (solar radiation, magnetism) outside of human control were causing the climate to change. We expect that not only will the topic of climate change induce strong emotional reactions, but the whether or not the texts are themselves congruent with one another could influence these emotional reactions.

Emotions

Emotions that students experience permeate academic achievement settings (Pekrun, 2006). According to Pekrun and Stephens (2012), emotions are intense, complex processes, which contain, "affective, cognitive, physiological, motivational, and expressive components" (p.2). Briefly, emotions (like anxiety or boredom) are multifaceted phenomenon that are comprised of affective components (feelings of dread), cognitive components (anticipation), physiological components (increased heart rate), motivational components (impulses to quit to maintain engagement), and expressive components (nervous leg twitching, fidgeting) (Pekrun & Stephens, 2012). Barrett et al., (2007) similarly describes the complex experience of emotions as "a continuously changing stream of consciousness in which core affect continuously evolves, interacts with, and mutually constrains construals of the psychological situation" (Barrett et al., p. 385) Emotions can be classified in terms of their valence (positive vs. negative), their level of activation (activating vs. deactivating), and their focus (epistemic and/or topic), rather than simply the conceptual or prototypical category ("anger" or "sadness" for example).

These emotions can complicate the process of learning from multiple texts. In some cases, emotions can direct attention towards a task, contribute to engagement, encourage deep processing strategies and promote learning (Pekrun & Stephens, 2012). For example, enjoyment while reading a text can generate increased engagement, which can promote greater learning of the content (Broughton, et al., 2013; Heddy & Sinatra, 2013). In other cases, emotions can direct attention away from a task, lead to a lack of engagement, facilitate shallow processing strategies, and hinder the learning process. For example, feeling hopeless that the ideas in a text can be understood can cause disengagement and have a negative influence on learning (Pekrun & Linnenbrink-Garcia, 2012; Sinatra, et al., 2015). Some emotions, like confusion, have a more

complicated relationship with learning. On the one hand, experiencing confusion can cause distraction and thus hinder learning. On the other hand, experiencing confusion may cause learners to feel motivated to reduce their confusion, and thus lead to deep processing strategies to learn the content (D'Mello & Graesser, 2012).

The type of emotions that are experienced when reading texts can influence the extent of learning in complicated and nuanced ways. Pekrun and colleagues (Pekrun & Linnenbrink-Garcia, 2012; Pekrun & Stephens, 2012) define epistemic emotions as emotions that arise as a result of the cognitive qualities of task information and the processing of that information. If the information in this text or news broadcast conflicts with the individual's current epistemic beliefs (e.g., a belief that knowledge about climate change is certain, but conflicting information is presented which indicates uncertainty), cognitive incongruity can occur. Cognitive incongruity can result in surprise (Kang et al., 2009), confusion, anxiety, and frustration (Bendixen, 2002; Craig et al., 2008; D'Mello et al., 2014).

A number of recent studies (Broughton et al., 2013; Heddy et al., 2016; Sinatra and colleagues, 2014; 2015, Thacker et al., 2019) have illustrated that emotions and affect are bound to, and clearly influence, both how learners approach learning and teachers and professors approach teaching "controversial" socio-scientific topics including climate change and genetically modified foods. In the present study, we predict that when cognitive congruity occurs, an increase in positive emotions (such as enjoyment and curiosity) and a decrease in negative emotions (such as frustration and boredom) would also occur.

Current Study

We asked learners to read multiple text documents and assessed their knowledge before and after reading. We experimentally manipulated these documents to present a congruent

argument (two texts affirming the same point of view) or an incongruent argument (two texts with competing points of view). Based on theoretical and empirical considerations from Bråten et al. (2011), Pekrun (2006), and Bohn-Gettler and Rapp (2011), we asked the following research questions:

1. Would learners exposed to congruent texts outperform learners presented with incongruent texts on a knowledge assessment?
2. Would congruent or incongruent text be more likely to prompt causal thinking?
3. What emotions would learners exposed to congruent texts express, compared with learners exposed to incongruent texts?

we expect that congruent text would promote greater knowledge than incongruent text as congruent text would provide a more coherent causal explanation (RQ1). For this reason, we also expect the congruent text to be more likely to prompt causal thinking (RQ2). Finally, we expect that emotions would differ with text conditions.

Method

Participants

Participants were 150 university students from North America with 75% self-reporting as female, 40% White/Caucasian, 40% Asian/Pacific Islander, 8% Hispanic, 4% Chicano, 3% Black/African American, and 5% "other." The mean age was reported as 20.25 (*SD* = 1.4) and mean university GPA (out of 4.0) reported as 3.38 (*SD* = .38). While these demographics are reported to contextualize this specific participant group, we did not analyze them for differences on reading materials. Additionally, while students were sampled form undergraduate psychology courses, academic majors included psychology as well as accounting, business, biology, political

science, and many were undecided. Some participants did not have complete data sets and thus the number of participants for those analyses was 112.

Design

This study follows a 2 (Text Condition: Congruent vs Incongruent) by 2 (Text Order: T1 first position v T1 second position) by 2 (Time: Pretest v Posttest) design.

Materials

Experimental texts. Three texts on the causes and effects of climate change were adopted from Strømsø and colleagues (Bråten et al., 2008; Strømsø et al., 2010). Participants were presented two of the three texts depending on their experimental condition, with all participants seeing the Human Causes Text.

Human Causes Text. Text 1 (314 words) presented information on the human causes of climate change. The text attributed the greenhouse effect to human production of climate gases that radically upsets the sensitive and complex balance of the climate system. Source information at the top of the text showed that it was published by the Center for International Climate and Environmental Research at the University of Oslo. Readability statistics indicate a reading ease score of 37.2 and a F/K grade level of 14.8.

Natural Causes Text. Text 2 (325 words) explained historical variations in the climate as due to a host of astronomical causes like solar radiation and magnetism outside of human control and concluded on a note of uncertainty of the causes of climate change. Source information indicated that it was written by a professor of astrophysics and published in a research magazine. Readability statistics indicate a reading ease score of 54.0 and a F/K grade level of 10.1.

Negative Consequences Text. Text 3 (356 words) detailed several negative consequences of a changing climate, from tumultuous weather, impacts on farming and forestry, and rising

ocean levels endangering coastal communities. Source information showed that it was a journalistic news article. Readability statistics indicate a reading ease score of 49.3 and a F/K grade level of 11.1.

Conditions. All participants were assigned to read Text 1 (*Humans Causes*). This was chosen so that all participants would be exposed to the scientifically accurate account of global climate change. Participants then read either Text 2 (*Natural Causes*) and were thus presented with two different accounts of the causes of climate change (incongruent condition); or, Text 3 (*Negative Consequences*) and were thus presented a relatively more congruent scenario that aligned human causes with negative consequences (congruent condition). The order of the texts within condition (incongruent – T1 & T3, or congruent – T1 & T2) was counterbalanced, creating a total of four possible combinations (T1=>T3 / T3 =>T1 as incongruent, and T1=>T2 / T2=>T1 as congruent). Comparing across the two conditions (T1 & T2 vs T1 & T3) we find the incongruent condition read 637 words with a readability ease of 46.6 and F/K grade level of 12.0 and the congruent condition read 668 words with a readability ease of 44.3 and F/K grade level of 12.5

Epistemic Emotions Scales. The emotions participants experienced while reading were measured using the Epistemic Emotions Scales (EES) (Pekrun, Vogl, Muis, & Sinatra, 2017), a 21-item self-report questionnaire each consisting of a single adjective (e.g., “curious”) designed to measure emotions. Immediately after reading each text, participants were instructed to respond to the following prompt: “How did you feel while reading this text?” Responses were rated along a 5-point Likert scale that assessed how strongly they felt each of the emotions while reading. Responses ranged from 1 (“not at all”) to 5 (“very strong”). We created two sub-sets of emotions – “positive” (surprise, interest, inquisitive, amazed, happy, excited, astonished, joyful, alpha =

.775) and "negative" (bored, confused, anxious, frustrated, worried, muddled, irritated, monotonous, dissatisfied, nervous, and puzzled, alpha = .835). We also explore discreet emotions later in the manuscript.

Knowledge measures. Three knowledge assessments were used – one assessment of students' prior knowledge (administered to all participants) and two assessments of post-reading knowledge (one test per group – congruent vs. incongruent). The prior knowledge measure consisted of 15 multiple choice questions regarding natural and environmental issues relating to climate change (for example, "The Kyoto Protocol deals with… correct answer: the reduction in the discharge of climate gases). Prior knowledge was rather low (M = 49%, SD = 16.5%) and the alpha reflected this knowledge was not consistent between individuals (alpha = .56). The post-reading knowledge assessments consisted of 13 (congruent, alpha = .92) or 10 (incongruent, alpha = .86) inference questions adopted from Bråten and Strømsø (2006). These questions asked participants to determine (true or false) if the following statement could be reasonably inferred from combining the two texts they had read (for example, "Global warming can be due to the fact that the sun's magnetic fields draw the each and other planets closer to the sun" – false). For the purpose of this study, the percentage of correct answers (out of the total possible) was used for all analyses. The scores for all three knowledge measures were normally distributed, with average scores of 65% (*SD* = 12.4%) for the congruent condition and 53% (*SD* = 18.7%) for the incongruent condition.

Post-test essay. To derive additional measures of learning from multiple texts, particularly causal reasoning, participants were asked to write a short summary of the texts. Specifically, participants were instructed to "Type a short essay (minimum 2-3 paragraphs in length) summarizing the texts you read on climate change." Essays were coded in two unique but

complementary analyses. First, essays underwent text-mining in Microsoft Excel to ascertain their inclusion of causal words (e.g., “caused,” “because”), causal actors, whether anthropogenic (e.g., “humans”) or natural (e.g., “nature”), and outcomes and consequences of climate change (e.g., “flooding”). Then, essays were coded on their inclusion of emotionally charged language (“catastrophic”, “terrible”, “disastrous”) and what, if any, epistemic statements learners made about the texts they read (“there is strong evidence to support…”, “other possible data should have been provided for their (authors’) extraordinary claims”). These statements were categorized as either epistemic in general (dealing with sources and justification, as cited above) or specific to the disagreement around anthropogenic causes (“some researchers say…Earth’s climate is cyclical… Meanwhile, other researchers say… people are the causes of global warming…”). Frequencies of each category were tallied for analysis (see Table 1).

Second, essays were qualitatively coded for support for the conclusion of anthropogenic cause of climate change. Since all participants read the Human Causes text (Text 1), we assume that differences would be due to the second text read (Text 2 or Text 3). Thus, essays were given a score of 0 if it did not overall conclude an anthropogenic cause; a score of 1 if it concluded equivocal support for an anthropogenic cause; and a score of 2 if it concluded unequivocal support for an anthropogenic cause of climate change. Two coders examined 20% of all essays together, after which the first author coded the rest. Interrater reliability was high, ICC = .9, and all disputes were resolved via discussion and agreement.

Procedure

All materials were presented via Qualtrics (an online survey tool) in an on-campus computer lab. After agreeing to participate, students completed the prior knowledge questionnaire. Then, students were randomly assigned to either the congruent or conflicting text

group. After reading the first text, students were asked to complete the Epistemic Emotions Scales. Then, students read the second text and completed the Epistemic Emotions Scales again. Finally, students completed the appropriate knowledge assessment and wrote a post-test essay.

Results

To answer Research Question #1, *Would learners exposed to congruent texts outperform learners presented with incongruent texts on a knowledge assessment?* we conducted a repeated measures ANOVA. As mentioned previously, we counter-balanced the order of the texts to counteract any possible order effects, rendering four possible experimental conditions (Human Causes-Natural Causes; Natural Causes-Human Causes; Human Causes-Negative Consequences; Negative Consequences-Human Causes). Preliminary analyses revealed that prior knowledge did not differ between groups ($p > .05$), so for the initial analysis these four conditions were collapsed into congruent (Human Causes-Negative Consequences and Negative Consequences-Human Causes) and incongruent (Human Causes-Natural Causes and Natural Causes-Human Causes). Results revealed a significant interaction between the time of testing and the text condition (congruent vs incongruent), $F (1, 153) = 17.8$, MSerror = 0.02, $p < .05$, $\eta^2 = .104$, indicating a moderate effect size. Specifically, while both groups preformed equally well on the pretest, the congruent text group (pretest M = 46%, SD = 18.2%, post test M = 64%, SD = 12.7%) significantly outperformed the incongruent text group (pretest M = 49%, SD = 14.1%, post test M = 53%, SD = 16.8%) on the post test (see Figure 1).

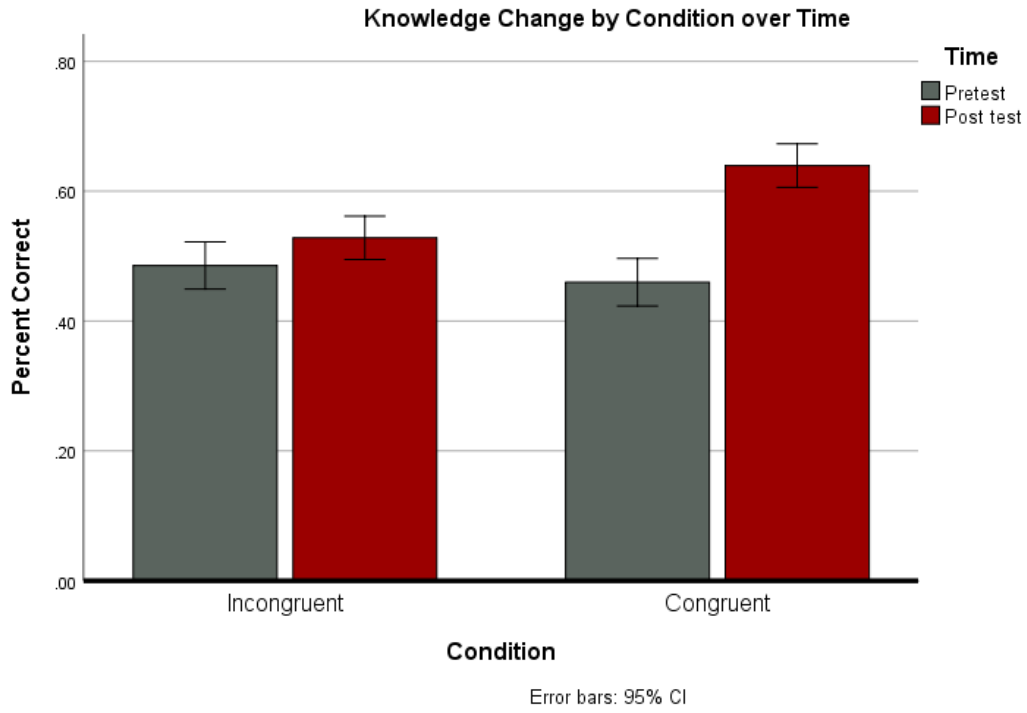

Figure 1: Knowledge Change by Condition

To answer Research Question #2 *Would congruent or incongruent text be more likely to prompt causal thinking?* we again began with our conditions collapsed into *congruent* and *incongruent.* An initial analysis of frequency counts of causal words and actors, as well as consequences and outcomes, found that participants exposed to the congruent texts were more likely to suggest that humans were causing climate change, $F (1, 109) = 7.60$, $p < .05$. Students in the congruent text group focused more on both causal actors ($F (1, 105) = 4.293$, MSerror = 4.139, $p < .05$) and outcomes of climate change ($F (1, 105) = 60.525$, MSerror = 203.98, $p < .001$). This latter difference is especially large, with those in the congruent text group discussing outcomes of climate change (sea level rise, extinctions, flooding, migrations, etc.) nearly four times as frequently as those in the incongruent text group. Looking at the distribution of scores across support for anthropogenic climate change, a Chi-square test for independence indicated a significant difference in distributions ($\chi^2 (2) = 20.31$, $p < .05$), with more students presented with

incongruent texts failing to support anthropogenic climate change [12 students in the conflicting condition (22%) vs. 4 students in the congruent condition (8%)], whereas more students in the congruent condition supported anthropogenic climate change [34 students in the congruent condition (65%) vs. 12 in the conflicting condition (22%)].

To answer research Question #3, *What emotions would learners exposed to the congruent texts express compared with learners exposed to incongruent texts?* we conducted a MANCOVA with condition (congruent vs. incongruent) as the between-subjects factor and positive/negative emotions entered as dependent variables. Results indicated that there were no differences between groups on the emotions elicited by the text condition, $p > .05$. Interestingly, both groups displayed rather low emotional scores (averages of approximately 2.2 for positive and 2.0 for negative emotions out of 5), corresponding, on average, to feeling "very little" of both positive and negative emotions. Thus, while the measure had adequate reliability, it could be that the topic of climate change elicits strong negative emotions and participants may be either numb or desensitized to reading another article about the negative consequences of climate change.

Significant differences were observed in the amount of both negatively charged emotional statements and statements of an epistemic nature. Specifically, students in the congruent essay group expressed more negatively charged statements ("devastating," "terrible," catastrophic") than those presented with incongruent texts ($F (1, 105) = 10.56$, MSerror = 16.56, $p < .05$). These students also made significantly more appeals to epistemic claims ("many studies over the last several decades have provided sufficient scientific evidence"), $F (1, 105) = 4.54$, MSerror = 1.02, $p < .05$, and significantly less epistemic statements about disagreement or discord ("the argument is difficult to conclude because there is evidence on both sides"), $F (1, 105) = 23.44$, MSerror = 2.63, $p < .001$.

Additionally, these variables were entered into a correlation matrix to determine whether they were interrelated. Results revealed that, regardless of condition, students who displayed more negative emotions in their essays were also more likely to endorse anthropogenic climate change ($r(106) = .354$), $p < .05$), discuss causal actors ($r(106) = .459$, $p < .05$), outcomes ($r(106) = .317$, $p < .05$), and make more epistemic statements ($r(106) = .229$, $p < .05$). They were also less likely to discuss disagreement or discord in the scientific community or confusion about whether or not climate change is happening ($r(106) = -.238$, $p < .05$).

Finally, we sought to further explore the self-reported emotions data by examining discrete emotions (e.g., curiosity) after reading specific texts. As mentioned previously, we counter-balanced the order of the texts to counteract any possible order effects, rendering four possible experimental conditions (*Human Causes-Natural Causes; Natural Causes-Human Causes; Human Causes-Negative Consequences; Negative Consequences-Human Causes*) and after each text, we asked participants to rate their emotional responses to the texts. One effect that we did not expect was a "numbing" of emotional responses. While the averages have been reported here, it should be noted that, generally speaking, participants reported *lower* levels of *nearly all* emotions on the second text (on average, a decline from $M = 2.2$ to $M = 2.05$). Since each emotion is discrete (seven in total), and we had four conditions, we only report some of these findings here. Specifically, when examining how each of the four conditions experienced Surprise, Enjoyment, Curious, Confusion, Anxious, Frustration, and Boredom, paired sample t-tests (of which there were 28; 7 paired emotions x 4 text orders), indicated significant differences on seven tests, with three additional tests approaching significance (P=.054 twice, .068 once). Of these ten results, nine indicated a reduction in emotions (for example, in surprise from text 1 to text 2). Of the additional 18 non-significant results, 15 descriptively indicated a reduction in

emotions. Said another way, of the 28 possible emotion / text order pairs we tested, only 4 (15%) indicated an increase in emotional salience, whereas the other 24 (85%) indicated a decrease in emotional salience. This reduction in emotions was an unintended and important finding, which we describe in more detail below.

Discussion

Overall, these findings illustrate that when individuals read multiple documents on a controversial topic it matters whether those documents converge on a coherent story or present conflicting information, and the order in which those documents are read. Addressing our first research question, these results indicate that when individuals read a coherent and scientifically accurate set of documents, they showed greater understanding of the issues than those who read two competing narratives. Moreover, we found preliminary evidence that may suggest that the order in which they read conflicting information may be a key factor. When individuals read the scientifically inaccurate *Natural Causes* text first, before the more scientifically accurate *Human Causes* text, performance showed a marked decline. This finding is particularly disturbing because the order in which individuals find information on scientific issues online may be at best random, or at worst, may be biased towards more popularized skeptic or non-scientific sites over scientific ones due to search engine algorithms that prioritize click frequency over veracity. Indeed, the public relations strategy of "getting ahead of the story" could include "flooding the zone" – increasing the media exposure of one view (over another) so as to increase the odds that an individual hears the preferred message first. We can see evidence of this strategy on local political news coverage, when stories lead with the controversial or alternative position first, which might be an attention grabber ("Volcano Off Oregon Coast Predicted To Erupt Between 2020 And 2024", Tomlinson, 2019) only to add context which softens or contradicts the initial

headline (the volcano is underwater, 300 miles off the coast, and has previously recorded eruptions in 1998, 2011, and 2015). Or similarly, how "click bait" headlines might state the contrary or surprising information only to grab readers ("Bet You Can't Guess What a 1,700-Year-Old Rotten Egg Smells Like", Hernandez, 2019), while the more scientific or accurate information is only presented later (they smell bad and sulfuric, like a rotten egg).

In regard to our second research question on causal language, in addition to increased knowledge, those who read the two congruent passages on climate change were more likely to agree that humans were causing climate change and to focus more on both the causes and the consequences of climate change. The conflict between causal explanations depicted in the incongruent condition (i.e., natural vs. human) was reflected in participants' self-generated essay responses, which showed more equivocation around the anthropogenic account of climate change. Creating conflict, confusion, and doubt on socio-scientific issues is in fact a well-worn strategy to undermine the influence of scientific consensuses in shaping policymaking (Oreskes & Conway, 2011).

In regard to our final research question on the emotions experienced while reading the text, the reduction in negative emotions that has been observed in prior research on controversial topics (like evolution and GMFs) did not occur in this case. Perhaps, the more individuals understand the causes and consequences of climate change, in consideration with current geopolitical trends, tamping down negative emotions may be increasingly challenging. Lombardi and Sinatra (2013) found that teachers who accepted that humans were contributing to climate change reported greater feelings of hopelessness than skeptics. It may be the case that the more individuals learn about the consequences of climate change, the more despair they may feel. In support of this conjecture, participants in the congruent condition used significantly more

negative language in their written essays, indicating that quantitative emotions survey results were muted, individuals who received a "double dose" of scientifically accurate information on human causes of climate change were experiencing more negative emotions as indicated by their discourse. In contrast, when presented with two misaligned texts, individuals were significantly more likely to focus on the conflict, reducing the causal claims and outcomes, and the negative emotions surrounding these factors. They were also less likely to fully endorse the scientific consensus (that climate change is real and currently caused by humans).

Implications

One interesting, although disconcerting, finding is that reading multiple texts on climate change (in any combination and any order) lead to a "numbing" of emotions – individuals reported feeling less emotions overall after the second text. Perhaps this signals that individuals become desensitized to the challenges of climate change as the amount of information they read increases. This is a cause for alarm for those who want to shed increased light on the public's understanding of climate change or other misunderstood scientific issues by providing more information. Conversely, this could be a form of "outrage fatigue" with controversial scientific issues as has been seen in the current climate of political discord. This is especially troubling given the recent revelations of "bots" spreading information online via social media, where the explicit goal could be to deaden the emotional response to specific events or outcomes. One possible approach to combat this "fatigue" is for educators to lean into discussions around climate change and other socio-scientific topics. Acknowledging that students may feel discomfort, frustration, confusion, and a whole host of other emotions in a non-judgemental way may allow for students to process these emotions as well as the incoming information rather than attempting to mute these emotions by disengaging with the information itself. There are some

that may want to use this strategy (of pushing emotional fatigue to induce disengagement) as a strategy to further their own agendas. As educators, we can prepare our students to reflect critically not only on the information, but how and why the information induces emotional responses. Likewise, science communicators can do more than just present coherent and congruent arguments. Recognizing and anticipating the counter-scientific claims made online can help arm students with the tools required to understand logical fallacies, appeals to emotions, and other attempts to mislead.

When individuals focus on the disagreement and opaqueness of climate change, the argument that the science is still being debated may function as a reinforcement to justify inaction. In a related study Authors (in preparation) interviewed college students who accepted that humans are contributing to climate change and asked them about their lack of action to take mitigative steps. Students tended to justify their inaction by expressing a sense of powerlessness with statements such as ". . . as an individual, you can't do much about it." Others diverted responsibility to individuals with ostensibly more knowledge or direct responsibility, "I'm a college student so how much do I really interact with [the topic]," and "it's not my job." Perhaps focusing on the perceived lack of consensus resulting from reading conflicting texts gives individuals yet another motivation for disengagement and inaction. One approach that has been fruitful in working through these conflicts is the work from Lombardi and colleagues (Governor et al., 2021; Lombardi, 2016; Sinatra & Lombardi, 2020;) and others utilizing Model-Evidence-Link diagrams where students can critically engage with conflicting evidence and determine, on an evidence by evidence basis, how multiple arguments are supported, refuted, or have nothing to do with these pieces of evidence.

Our results lend support to others who have argued that in their attempts to motivate citizens to action, scientists and science communicators may frighten individuals towards inaction (Doherty & Clayton, 2011). Based on our data, we agree with those who suggest the focus should be on activities that people can engage in, small differences in their communities, and scientific endeavors (such as research on alternative energy sources) that would be preferable even if the climate were not changing (Bain et al., 2012).

Limitations and Future Directions

As with all research, the present study had limitations that should be addressed and taken into consideration when conducting future research. Some major limitations of our study include the limited sample used, the topic of climate change, and the possibility that some results were due to survey fatigue. To begin, our sample was limited in several ways including the size and demographic characteristics. While 112 participants are certainly not inappropriate to make the assertions that we interpreted based on the findings, ideally the sampler size would be larger, which would allow for even more sophisticated statistical analyses. In addition, our sample was comprised of college students and thus may not necessarily represent a more general population. Therefore, our results may lack ecological validity and caution is warranted when generalizing to other contexts and populations. Future research would benefit from replicating this research with larger and more diverse samples.

A second limitation is that we used the topic of climate change to explore causal thinking with multiple texts and epistemic emotions. Climate change has been shown to influence student emotions and thus was purposely selected as the target topic (Broughton et al., 2013). However, other perceived controversial topics such as evolution, genetically modified organisms (GMO's), and water fluoridation, may influence causal thinking and epistemic emotions differently. For

example, evolution has been shown to promote anxiety at high levels as compared to other topics (Brem et al., 2003). This high level of anxiety may lead to a differential influence on causal thinking and epistemic emotions when reading multiple texts. Therefore, we recommend that future researchers explore the consistency of these results with topics other than climate change.

A third limitation that could influence our results is that what we interpret as the "numbing" effect could actually be caused by survey exhaustion. That is, the participants read a text and completed survey items and then repeated the process again. This repetition and resulting exhaustion could possibly be the cause of the "numbing" of emotions. While we doubt that this is the case (since many studies employ this procedure and have not reported on these results), we nevertheless recognize it as a possibility. Future researchers can investigate participant exhaustion through open ended response items or other techniques to rule out this possibility as an interpretation of these findings.

Conclusions

Individuals learn about scientific information from many possible sources including scholarly research or informally on the internet. These sources likely produce conflicting information and integrating this information can be an arduous task that influences causal thinking, emotions, and overall conceptual understanding of those ideas. Our research suggests that multiple conflicting texts can influence causal thinking and emotions, which in turn influence understanding. Science communicators and researchers should explore methods to reduce this conflict and help individuals to integrate conflicting information in a more effective manner. More research is necessary to investigate this phenomenon and interventions that can promote scientific understanding and resistance to misinformation.

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Table 1
Descriptive statistics for essay outcome variables by experimental condition

	Incongruent		Congruent		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Positive emotions [a]	0	0	0.02	0.14	0.01	0.10
Negative emotions [a]	0.56	1.06	1.35	1.43	0.94	1.31
Causes [a]	2.74	2.20	2.23	1.78	2.49	2.01
Causal actors [a]	1.28	0.81	1.67	1.13	1.47	1.00
Outcomes [a]	1.15	1.25	3.92	2.29	2.51	2.30
Anthropogenic score (qualitative) [b]	1.00	0.67	1.58	0.64	1.28	0.71
Epistemic [a]	0.09	0.29	0.29	0.61	0.19	0.48
Dispute [a]	0.31	0.47	0.00	0.00	0.16	0.37
Misconception [a]	0.09	0.29	0.13	0.34	0.11	0.32

[a] Raw frequency counts of words appearing in post-reading essays.
[b] Qualitative scoring of essays: 0 = no overall anthropogenic cause; 1 = equivocal support for anthropogenic cause; 2 = unequivocal support for anthropogenic cause.