**Do Graphics Really Help? The Influence of Data Visualizations on Attitudes and Behaviours Towards Climate Change**

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**Background**

**Climate Change Communication**

Climate change is a “critical global issue” (Newell et al., 2016, p. 19) and poses a significant risk to the earth and humanity as a whole (Clayton et al., 2015; Ogunbode et al., 2022). Research often focuses on the impact that institutions have on climate change (Clayton et al., 2015). However, mitigating the detrimental effects of climate change necessitates intervening at the individual level (Herring et al., 2017; O’Neill & Nicholson-Cole, 2009). Identifying attitudes and behaviours related to climate change are vital to reducing climate-associated risks (Herring et al., 2017; O’Neill & Nicholson-Cole, 2009). It is crucial to examine the influence that individuals have on climate change in order to understand why and how analyzing and altering individual attitudes and behaviours can help combat climate change (Clayton et al., 2015; Newell et al., 2016).

Mitigating the effects of climate change relies on science communication (Clayton et al., 2015). Therefore, it is important to ask: How do we effectively communicate the climate crisis to the general population, and can we do so in a way that changes individual affect about climate change, and increases engagement in pro-environmental behaviours? The way in which individuals understand the impact of climate change relies heavily on how such information is communicated (Peters et al., 2022). Research has indicated that it is not necessarily *what* we learn about the risks associated with climate change that influences psychological and behavioural responses, but rather *how* we learn about it and the way in which we evaluate and comprehend such information (Clayton et al., 2015; Swim et al., 2009). Climate data must be communicated effectively and in a way that motivates individual change. However, climate change has been described as “…a notoriously hard topic to communicate” (Herring et al., 2017, p. 90). A couple factors that enhance the likelihood of one attending to and understanding climate information is the attractiveness and clarity of the content being communicated (Clayton et al., 2015; Petty & Cacioppo, 1986). Accordingly, data visualizations have been found to be an effective means of communicating climate change information and impacts (Daron et al., 2015; Harold et al., 2016; Hegarty, 2011; Nocke et al., 2008). Climate graphics can portray data in an attractive, intriguing, and comprehensible manner (Daron et al., 2015; Harold et al., 2016; Hegarty, 2011). Data visualizations of climate change help individuals gain a detailed understanding of the data being presented (Newell et al., 2016) and encourage individuals to identify and process climate patterns (Harold et al., 2016). The way climate data is presented significantly impacts one’s interpretation of such data (Daron et al., 2015).

Data visualizations have been found as being more effective at communicating information (including climate change data), than verbal or written information to the general population (Keim et al., 2008; McDonald, 2009). This finding is widely supported in the literature (Tufte, 1990 as cited in Sheppard, 2005). Graphics have the advantage of being able to communicate climate change information through multiple senses, which can reduce the cognitive load required for understanding information (Keim et al., 2008; McDonald, 2009; Sheppard, 2005). Data visualizations are also effective at increasing the memorability and recall of information (Merlini, 2020). Merlini (2020) stated that visualizations and infographics “…can be perceived to convey more clear and effective information than text alone” (p. 8), and such findings have been supported in other studies (Bobek & Tversky, 2016). In addition, Lazard and Atkinson (2014) found that infographics about climate change are more engaging than text-based messages. However, there is a difference between data visualizations, which are conceptualized as graphical representations of data in order to understand trends and patterns, and infographics, which tend to include images, text, and/or data visualizations (StatSilk, n.d.). Notably, verbal language is still beneficial for understanding climate change data as it “…uses precise syntactic devises to make propositions or connections…” (p. 73) and visualizations are not as effective at that (O’Neill & Smith, 2014). Therefore, it makes sense that research has found that a combination of visual and written information is most effective at communicating climate data compared to written information alone (Andres & Petersen, 2002).

**Climate Change and Psychological Distress and Anxiety**

Data visualizations have been found to be effective at altering one’s attitudes about various topics, including climate change (Merlini, 2020; Pandey et al., 2014). Therefore, it makes sense that research shows a strong association between exacerbated climate change and increased psychological distress and discomfort (Ogunbode et al., 2022; Ojala et al., 2021). Both abrupt and direct, as well as and gradual and indirect impacts of climate change contribute to negative psychological impacts and outcomes (Clayton et al., 2015). Abrupt impacts of climate change include distressing environmental events or disasters that are a result of climate change, such as wildfires, heatwaves, droughts, and floods (Clayton et al., 2015; Intergovernmental Panel On Climate Change (IPCC), 2023). Such events could lead to financial instability, displacement, food insecurity, or death (Clayton et al., 2015). Gradual impacts of climate change refer to the gradual changes in the environment and include the slow and steady rises in temperature and water levels (Clayton et al., 2015). Gradual impacts can also include anticipation about impending environmental changes and risks associated with climate change trajectories (Ballew et al., 2024; Crimmins et al., 2016). Both abrupt and gradual impacts of climate change have been found to negatively impact one’s psychological well-being and quality of life, including increasing anxiety, depression, grief, loss, and post-traumatic stress, and decreasing social networks and support (Clayton et al., 2015; Galea et al., 2005; Intergovernmental Panel On Climate Change (IPPC), 2023; Norris et al., 2002; Speller & Speri, 2003). Individuals can often become emotional after viewing data visualizations of climate issues, such as those depicting plastic consumption (Fratczak, 2022; TP-Europe, n.d.). Research has found that the certainty of climate change occurring and concern about climate change increased after viewing interactive data visualizations and graphs depicting worsening climate change (Herring et al., 2017). However, some research found that data visualizations did not significantly increase individuals concerns about climate change (Spott, 2023).

**Climate Change and Pro-Environmental Behavioural Engagement**

It would be remiss to discuss these psychological outcomes without exploring the impact of both climate change and psychological distress on pro-environmental behavioural change, engagement, and action. A large proponent contributing to climate change is harmful human activity (Merlini, 2020). Therefore, one way to aid with climate change is to influence a change in human behaviour (Merlini, 2020). Behavioural action is a pivotal component to reducing the negative impacts of climate change (Whitmarsh et al., 2021). Notably, “awareness of climate change can be considered the first precondition for behaviour change” (Merlini, 2020, p. 5). Worries and anxieties about climate change have been found to be positively associated with increases in pro-environmental behavioural engagement (Ballew et al., 2024; Kovács et al., 2024; Merlini, 2020; Ogunbode et al., 2022). Therefore, alternations in attitudes and worries about climate change often contribute to positive alterations in human behaviour related to climate change (Merlini, 2020). Data visualizations depicting climate change also increased public engagement in pro-environmental behaviours and action, and encourage the development of appropriate solutions (DeCock-Caspell & Vasseur, 2021; Fratczak, 2022; TP-Europe, n.d.)

Notably, research has shown that lacking knowledge about the impact of climate change decreases the extent to which psychological distress about climate change influences one’s pro-environmental behaviour change (Vieira et al., 2023). Therefore, it is important to ensure that the population is receiving accurate, clear, and easily interpretable information about the detrimental changes in climate over time and associated impending risks. That is why using data visualizations to communicate climate information and risks is vital, especially given their effectiveness at communicating information to the general public (Keim et al., 2008; McDonald, 2009). Data visualizations are especially implicated given that, as mentioned, research has examined changes in attitudes and behaviours about climate change after one views graphics and visualizations of climate change (Herring et al., 2017).

**Climate Change and Emerging Adults**

Emerging adults are defined as individuals who are between the ages of 18 to 25, and often up to 29 years old (Arnett, 2000; Arnett et al., 2014). Emerging adults are more likely to be impacted by climate change than older generations (Thiery et al., 2021; Zimmermann et al., 2024). This is because they are more likely to live longer and therefore be exposed to unfavourable and harmful changes in the climate, including heatwaves, wildfires, flooding, and droughts (Thiery et al., 2021). Therefore, emerging adults is a developmental age group that is particularly worried about climate change, and their anxiety about this global phenomenon continues to increase as climate conditions worsen (Hickman et al., 2021).

**Gaps in Research and Present Study**

The current study aims to fill multiple gaps in the literature. First, research shows a positive association between climate change and both psychological distress (Ogunbode et al., 2022; Ojala et al., 2021) and behavioural changes (DeCock-Caspell & Vasseur, 2021; Fratczak, 2022; TP-Europe, n.d.). Research also shows that psychological distress about climate change is positively associated with pro-environmental behaviour (Ballew et al., 2024; Kovács et al., 2024; Merlini, 2020; Ogunbode et al., 2022). Although there are some studies on the ways in which data visualization directly impacts both climate change distress (Herring et al., 2017) and pro-environmental behaviours (DeCock-Caspell & Vasseur, 2021), such research appears to be limited and findings are mixed (Spott, 2023). Therefore, the current study will aim to add to the current literature and attempt to reconcile previous mixed findings by analyzing how data visualizations impact climate change distress and pro-environmental behaviour. Second, there is limited research comparing data visualizations versus verbal or written information on altering climate change distress and behavioural outcomes. Therefore, the current study aims at examining the direct comparison between how different modes of communicating climate change data impacts psychological and behavioural climate outcomes. Third, much of the research that does examine the impact of data visualizations about climate change on psychological and behavioural outcomes are conducted among university students (Herring et al., 2017; Newell et al., 2016). In the literature, university students have been conceptualized as being more educated and technologically able than the broader population (Herring et al., 2017). Therefore, it is important to analyze these associations among a general population of emerging adults.

The proposed study will aim to address certain gaps in research by examining two main research questions. The first research question is: Does one’s anxiety about climate change differ after being shown data about worsening climate change, and does that change differ depending on the format such information is presented in? The first hypothesis is that anxiety about climate change will increase after participants are shown data about how climate change has escalated, and this increase in distress will be even larger among those who view such data in the form of data visualizations with accompanying written explanations compared to those who receive such data in written form only. The second research question is: Does one’s engagement in pro-environmental behaviours in an effort to reduce the effects of climate change differ after being shown data about worsening climate change, and does that change differ depending on the format such information is presented in? The second hypothesis is that pro-environmental behavioural engagement will increase after participants are shown data about how climate change has escalated, and this increase in behavioural engagement will be even larger among those who view such data in the form of data visualizations with accompanying written explanations compared to those who receive such data in written form only. Research has also found that worry about climate change is positively associated with pro-environmental behavioural engagement (Ogunbode et al., 2022). Therefore, the current study also aims to replicate that finding with the hypothesis that anxiety and worry about climate change will be positively associated with pro-environmental behavioural engagement.

**Methods**

**Participants**

The current study proposes collecting data from approximately 500 to 1,000 Canadians between the ages of 18 and 25.

**Measures**

***Demographic Information***

Participants will provide demographic information including their age, assigned sex at birth, self-identified gender, cultural background, education, and employment status.

***Climate Change Anxiety Scale (Clayton & Karazsia, 2020)***

The Climate Change Anxiety Scale measures anxiety, emotional distress, and responses to climate change (Emerge, n.d.). It consists of 22 items total with a response scale of 1 (Never) to 5 (Almost Always). The scale includes four subscales: cognitive-emotional impairment (items 1 to 8), functional impairment (items 9 to 13), experience of climate change (items 14 to 16), and behavioural engagement (items 17 to 22). Authors of this measure indicate that items 1 to 13 measure the construct of climate change anxiety (Clayton & Karazsia, 2020). Therefore, for the purposes of this study, items 1 through 13 will be utilized to measure climate change anxiety. Sample items include, “I have nightmares about climate change”, “I find myself crying because of climate change”, “My concerns about climate change make it hard for me to have fun with my family or friends”, and “My concerns about climate change interfere with my ability to get work or school assignments done”. Items 17 to 22 measure the construct of current behavioural engagement in pro-environmental activities. Sample items include, “I wish I behaved more sustainably”, “I recycle”, “I turn off lights”, and “I try to reduce my behaviours that contribute to climate change”. Therefore, for the purposes of the current study, items 17 to 22 from this scale will be used to measure pro-environmental behavioural engagement. Previous literature has shown all four scales on the Climate Change Anxiety Scale to have good internal consistently (α > 0.80).

***Conditions / Intervention***

Participants will be randomly assigned to one of two conditions: (1) a data visualization plus written information condition, and (2) a written information only condition. For the purposes of this paper, the words ‘condition’ and ‘intervention’ will be used interchangeably.

**Data Visualization**

Data visualizations that depict temporal references are one of the most popular ways to visualize climate data (Nocke et al., 2008). Therefore, the current study includes data visualizations of climate change that specifically include temporal changes in environmental factors, including rising global and ocean temperature, increased carbon dioxide distribution, and flooding patterns over time. Data visualizations are better understood when a brief written explanation is included (Andres & Petersen, 2002). Therefore, participants who are randomly assigned to the Data Visualization condition will view six interactive data visualizations and their accompanying written information (Figure 1-6). All data visualizations and written information are from the NASA website, which can be accessed through this link, <https://climate.nasa.gov/interactives/climate-time-machine?intent=021>, and are cited appropriately below (NASA, n.d.). I was unable to include the interactive aspects of the data visualizations in this word document and therefore, I only included a screenshot from the NASA website of the first year included on each interactive graph (NASA, n.d.) for the purposes of this paper. Please refer to the NASA link above to view the full data visualizations in their interaction format (NASA, n.d.). These interactive graphs on this website show the change in multiple environmental factors over the course of many years (NASA, n.d.). Individuals visiting the website can interact with the data visualization by sliding a bar across the screen to change and compare climate factors across many years (NASA, n.d.). Participants in this study would be viewing the data visualizations in the interaction format as they appear on the NASA website:

A view of the earth from space

AI-generated content may be incorrect.**Figure 1: Sea Ice**

“This visualization shows the annual Arctic sea ice minimum since 1979. At the end of each summer, the sea ice cover reaches its minimum extent, leaving what is called the perennial ice cover. The area of the perennial ice has been steadily decreasing since the satellite record began in 1979” (NASA, n.d.).

**Figure 2: Sea Level**

A map of the united states

AI-generated content may be incorrect.“Recent satellite observations have detected that the Greenland and Antarctic ice sheets are losing ice. Even a partial loss of these ice sheets would cause a 1-meter (3-foot) rise. If lost completely, both ice sheets contain enough water to raise sea level by 66 meters (217 feet). This visualization shows the effect on coastal regions for each meter of sea level rise, up to 6 meters (19.7 feet). Land that would be covered in water is shaded red” (NASA, n.d.).

A map of the world

AI-generated content may be incorrect.**Figure 3: Carbon Dioxide**

“This time series shows global changes in the concentration and distribution of carbon dioxide since 2002 at an altitude range of 1.9 to 8 miles. The yellow-to-red regions indicate higher concentrations of CO2, while blue-to-green areas indicate lower concentrations, measured in parts per million” (NASA, n.d.).

**Figure 4: Global Temperature**

A map of the world

AI-generated content may be incorrect.

“This color-coded map shows a progression of changing global surface temperatures since 1884. Dark blue indicates areas cooler than average. Dark red indicates areas warmer than average” (NASA, n.d.).

**Figure 5: Ice Sheets**

A map of the polar land

AI-generated content may be incorrect.“Satellite observations show that the polar ice sheets shed a combined 418 billion metric tons of ice per year between 2002 and 2023, contributing the most to global sea level rise. The leading cause of this melt is the human burning of fossil fuels. These images show those changes, with oranges and reds indicating ice losses, while light blues illustrate ice gains. Gray areas show ice flow lines as they lead to prominent valley glaciers, which are areas with the most declines” (NASA, n.d.).

**Figure 6: Ocean Warming**

***A map of the world

AI-generated content may be incorrect.***“The ocean has absorbed 90% of human-induced global warming since 1955, causing the water's internal heat to rise. As a result, this change is contributing to polar ice loss, global sea level rise, extreme weather, large-scale coral bleaching events, and other far-reaching consequences. This visualization shows warming (also called "ocean heat content") in the ocean's upper 2,000 meters, or about 6,600 feet, in five-year averages. Reds show gained heat compared to the long-term average, while blues indicate lost heat” (NASA, n.d.).

**Written Information**

Participants randomly assigned to the Written Information condition will view six written descriptions explaining detrimental changes in climate, and they will not be shown any graphs. The written information that will be provided will be the six written descriptions included above in Figures 1 through 6 (NASA, n.d.). However, the written information will be altered for the Written Information condition by removing the sentences that explain the actual data visualizations and including written explanations of the data that the graphics are depicting. As an example, the description from Figure 4 could be altered to say something along the lines of, “There has been a ‘progression of changing global surface temperatures since 1884’ to 2022. Temperatures ranged from -4 to 1 Fahrenheit on average in 1884, and ranged from 1 to 4 Fahrenheit in 2022, which is a substantial increase in global surface temperature” (NASA, n.d.). This written explanation has been altered from the NASA website (NASA, n.d.). Similar written changes would be made to the other five written descriptions included above.

**Procedure**

Participants will be recruited online through Prolific, which is an online platform that allows researchers to recruit participants for studies. Participants who enrol in the study will read and sign an online consent form. They will then be randomly assigned to either the Data Visualization condition or the Written Information condition. They will then complete items 1 to 13 from the Climate Change Anxiety Scale to examine their (1) climate change anxiety, and then complete items 17 to 22 from the Climate Change Anxiety Scale to examine their (2) engagement in pro-environmental behaviours. This first completion of these items will be labelled as Time 1. Then, participants assigned to the Data Visualization condition will view a series of six different data visualizations on the [NASA website](https://climate.nasa.gov/interactives/climate-time-machine?intent=021) (NASA, n.d.), with details shown and explained above, depicting changes, specifically deteriorations and exacerbations, in different aspects of climate change, along with written explanations of the visualizations, also included above. Participants assigned to the Written Information condition will read a serious of written explanations that have been edited from the Data Visualization condition but will not be shown any of the graphics. Attention checks will be included after two of the six data visualizations and two of the six written information descriptions, which will be a brief multiple-choice question asking what the data visualization or written information was depicting. This will be to ensure participants were paying attention to the climate change information being provided and were providing reliable data. Participants will then complete the same sets of items from the Climate Change Anxiety Scale asking about their (1) climate change anxiety (items 1-13) and (2) engagement in pro-environmental behaviours (items 17-22). This second completion of these items will be labelled as Time 2. Participants will then receive a brief debrief of the online questionnaire battery and will be asked to complete a brief questionnaire in 6 months. Participants will be asked to complete the two sets of items from the Climate Change Anxiety Scale measuring (1) climate change anxiety (items 1-13) and (2) engagement in pro-environmental behaviours (items 17-22) at a 6-month follow-up. This third completion of these items will be labelled as Time 3. Upon completion of the questionnaires the third time, participants will read and sign a full debriefing form with an explanation of the purposes and design of the study and battery and its use for research purposes. Participants will receive monetary compensation that is aligned with Prolific’s payment principles (Prolific, 2025).

**Proposed Statistical Analyses**

Three models will be run to examine the changes in anxiety and behaviour over time.

**Model 1**

To test the first hypothesis, the first model will be a random intercept and slope multilevel model analysis to examine the change in climate change anxiety over time. This model will include time as a level 1, within-subject variable, with participants being measured at three timepoints: Time 1 (prior to viewing data visualizations or written information), Time 2 (immediately after viewing data visualizations or written information), and Time 3 (6-month follow-up). It will also include climate change anxiety as the dependent, level 1, within-subject variable and the condition of either data visualization or written information as the level 2, between subject-variable. Time will be nested within participants. A cross-level interaction between condition and time will be included. The model will include a random slope for time to allow the effect of time on climate change anxiety to vary across participants, and a random intercept to allow the model predicted mean in climate change anxiety to vary across participants. We will then probe the interaction to understand the effect of time in both conditions to understand if there is a difference in the magnitude or direction of climate change anxiety depending on the condition. The R code could be anxiety ~ time + condition + (condition X time).

**Model 2**

To test the second hypothesis, the second model will be a random intercept and slope multilevel model analysis to examine the change in pro-environmental behaviour engagement over time. This model will be the exact same as Model 1, but will include pro-environmental behaviour as the dependent, level 1, within subject variable instead of climate change anxiety. The R code could be behaviour ~ time + condition + (condition X time).

**Model 3**

To test the third hypothesis, the third model will be a linear mixed regression model where climate change anxiety is included as the independent variable that is measured at Time 1, and pro-environmental behaviour engagement is included as the dependent variable that is measured at Time 1, 2 and 3. This model will allow us to examine whether Time 1 anxiety predicts changes in pro-environmental behaviour engagement from Time 1 to Time 2 to Time 3.

**Hypothesized Results**

Regarding the first hypothesis, based on the literature, it is expected that climate change anxiety will increase from Time 1 to Time 2, and from Time 1 to Time 3. The change between Time 2 and Time 3 may be more exploratory. Climate change anxiety may not change from Time 2 to Time 3, may decrease, or may increase, but this increase would be predicted to not be as substantial as the increase between Time 1 and 2 or between Time 1 and 3. The increase or decrease from Time 2 to Time 3 could be due to confounding variables, such as memory. We know that data visualizations are effective at increasing the memorability and recall of information (Merlini, 2020), which could explain a potential increase from Time 2 to Time 3. However, memory of such climate change information may decrease over time, even when presented as a data visualization, which could explain a potential decrease from Time 2 to Time 3. In addition, it is expected that participants in the Data Visualization condition will experience greater climate change anxiety from Time 1 to Time 2 and 3 than those in the Written Information condition. It is also expected that pro-environmental behavioural engagement will increase from Time 1 to Time 2, and from Time 1 to Time 3. The change from Time 2 to Time 3 will likely be more exploratory for the reasons mentioned above. In addition, it is expected that participants in the Data Visualization condition will experience greater pro-environmental behavioural engagement from Time 1 to Time 2 and 3 than those in the Written Information condition. Finally, it is expected that climate change anxiety at Time 1 will predict an increase in behavioural engagement from Time 1 to Time 2 and 3.

**Discussion**

**Significance and Implications**

This research is important because many people obtain their information about climate change from written information and graphical representations (Soroka, 2002 as cited in Weber & Stern, 2011). Therefore, it is necessary for us to understand which type of framing of climate change data has more of an impact on psychological and behavioural outcomes, so that we can capitalize on that and encourage and motivate individuals to be more involved in climate change behaviours. In addition, using data visualizations can be cost effective (Czuchry et al., 2009), and therefore a feasible way engage in knowledge translation and dissemination of climate change information to the broader population.

**Limitations and Future Directions**

It is crucial to recognize the limitations of the current study in light of the strengths and implications. Although the longitudinal nature of the current study allows for an examination of how variables change over time in the way they influence each other, collecting data from participants at a 6-month follow-up increases the risk of attrition. Attrition may lead to a smaller sample size, and therefore reduced power. However, the current study will plan to run attrition analyses to examine if those who dropped out of the study before completing the 6-month follow-up differ significantly on their climate change anxiety and pro-environmental behaviour engagement compared to those who do not drop out. Another limitation of a longitudinal study is it may be more expensive due to compensating participants at two different time points (at Time 1 and 2, which are the pre- and post-conditions, and at Time 3, which is the 6-month follow-up). In addition, there could be other confounding variables that result in changes in anxiety or behaviour between Time 1/Time 2 and Time 3 that are not being measured or accounted for in this study. This would make it difficult to determine if changes in anxiety and/or behaviour over time is attributed solely to the conditions and variables in this study.

Future research could include attention as an individual factor since data visualizations have been found to be helpful for individuals with attention difficulties (Dansereau et al., 1995; Dansereau & Simpson, 2009). For example, attention could be included as a between-subject independent variable or a moderator and could be measured continuously. This could allow future research to examine the effect that the condition of either receiving (1) data visualizations and written information compared to (2) written information only has on attention difficulties and subsequently, on impacting climate anxiety and pro-environmental behavioural engagement.

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