BRIDGING THE VALUE-ACTION GAP

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ABSTRACT

Using an online charitable dictator game experiment (n=214), we explored how different, randomly assigned experimental treatments (social media posts) containing anti-climate-change sentiment (n=77, 36%), misinformation (n=74, 34.6%) and a control condition (n=63, 29.4%) impacted the real donation behaviour of pro-environmentalists to an environmental non-governmental organisation. Participants were recruited through social media (Facebook, Linked-In, and Reddit). We found that the treatments resulted in minimal differences to donation likelihood and amount. We used the same charitable dictator game experiment (n=56) to explore how these experimental treatments containing anti-climate-change sentiment (n=20, 35.7%), misinformation (n=26, 46.4%) and a control condition (n=10, 17.9%) impacted the social media response behaviour of pro-environments, as well as their real donation behaviour. We found that the treatments resulted in differences to reply frequency (p=0.02935) and minimal differences to reply tone (p=0.05698), while donation behaviour was unaffected. Donation behaviour did not stratify with demographic factors with the exception of geographic location (p=0.04825). These results suggest that the donation behaviour of pro-environmentalists is resistant to climate-change misinformation and anti-climate change opinions presented through social media, while these treatments may influence social media reply behaviour. Further research into the effect of this reply behaviour on other social media users and online spaces as well as whether these observations apply to the general population is necessary. These results also call into question the necessity of moderating misinformation and climate scepticism in online spaces, as there is some evidence that this content does not negatively affect prosocial behaviour, and instead may encourage cross-attitudinal discussion.

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

The value-action gap describes the difference between one's values, intentions, or beliefs, and action (Kollmuss and Agyeman, 2002). Numerous factors contribute to these gaps, including lack of knowledge, information, time, and money. The severity of a value-action gap is dependent on the subject area - notably, as of 2009, 72.3% of Canadians self-reported a gap between their intentions and their actions with respect to environmentalism (Kennedy et al., 2009). Understanding how to address these gaps is crucial to policymakers, who must bridge these gaps in order to achieve desired goals, such as the goal of increasing action to prevent or mitigate climate change.

Social media and social networks have been a focus of scientific research, as they have revolutionised interactions between and among individuals and organisations (Edosomwan et al., 2011). Social media can be defined as an outlet for broadcasting information with a broad audience, whereas social networks are tools for connecting with others; given that the two can be done simultaneously, these terms are occasionally mutually inclusive. Two main types of online communities exist on social media: open forums, where members have mixed attitudes or values, and echo-chambers, where members are all like-minded individuals, or those who share similar views or values (Williams et al., 2015). Authors assert that echo-chambers are much more common than open forums on social media.

Information, misinformation, and opinion are three descriptors of social media content. 'Information' describes data that is meaningful or valuable to a recipient (Davis and Olson, 1985), 'misinformation' is false or inaccurate information that is intentionally or unintentionally propagated (Wu et al., 2019), while 'opinion' describes a communicator's subjective value judgement of an object or idea. Social media has helped spread misinformation, as content is often not checked for veracity before being uploaded online (Eysenbach, 2020). Content on social media and other online spaces are a nexus for the opinion formation and behaviour of observers on a variety of issues, as social networks can heavily influence opinions and behaviour (Williams et al., 2015). Opinion formation can either be in support or against a subject; as an example of the latter, anti-climate change misinformation is asserted to cause scepticism, contrarianism, and denial, while pro-climate change misinformation may cause climate alarmism (Treen et al., 2020; Koonin, 2021).

Content moderation has been contemplated by social networks, states, academics, and policymakers as methods of addressing misinformation and other problematic online content (Mello, 2022; McCosker and Johns, 2014; Tai and Fu, 2020). Despite the prevalence of COVID-19 misinformation online leading up to 2022, social networks proved reluctant to intervene other than by labelling potentially false information as such (Gisondi et al., 2022). Moderation

reluctance may result from the additional costs of implementing content filters, as well as fears that filters may reduce user engagement. Whether or not misinformation is filtered, opinion is unlikely to be moderated unless it is disrespectful or disobeys the rules of a social network. This is particularly detrimental to efforts to educate and inform with respect to climate change, as misinformation and scepticism may promote further climate change scepticism, and hinder efforts to coordinate mitigation and adaptation efforts against the effects of climate change.

1.2 RESEARCH OBJECTIVES

The goal of this study was to measure whether exposure to climate change misinformation and anti-climate change opinions ("treatment posts") increase action taken by pro-environmental individuals, thus bridging the value-action gap. This action is measured by two behaviours: donation behaviour (Chapter 2) and reply behaviour (Chapter 3).

Both climate concern and climate action have been measured through statements of intent, often using surveys of willingness to pay (Streimikiene et al., 2019). Behaviour, rather than intent, may be more meaningful, particularly when measured experimentally, given that hypothetical stated values of intent can overstate real behaviour by up to a factor of three (List and Gallet, 2001). We aim to more accurately assess the effects of misinformation and opinion on observers by measuring their behaviour, through their replies to treatment posts, and the use of a charitable dictator game.

The charitable dictator game, a derivative of the ultimatum game, is an experimental design used to measure real behaviour, and is useful for measuring statements of intention with respect to environmentalism (Hoover et al., 2018; Kahneman et al., 1986). In the dictator game, one player (the "dictator") is allocated a sum of money (the "endowment"), and is given the option to split the sum with another player (the "recipient"). This game helps researchers explore questions related to altruism in economic decision-making. In the charitable dictator game, the recipient is represented by a non-governmental organisation such as a charitable fund. The charitable dictator game is a suitable analogy for charitable donations to an environmental charity, as the dictator has full control over their decision to give money and the amount given.

Given that social networks can heavily influence opinions and behaviour (Williams et al., 2015), this makes social media a prudent area of study with respect to bridging the value-action gap. Studies using the social media site formerly known as Twitter are overrepresented in information science in recent years (Pearce et al., 2018); as such, this study focussed on other social media: Facebook, Linked-In, and Reddit. Pearce et al. also stipulate that a focus of new research in social media should be qualitative, rather than purely data-driven (2018). For this reason, we offer some qualitative analysis of the participants' replies to the treatment posts.

1.3 CHAPTER OUTLINE

1.3.1 Summary

This thesis consists of four chapters. Chapter 1 provides an introduction to content presented throughout the manuscript, and contextualises the gaps in pre-existing research, which establishes the utility of this study. As well, this chapter outlines the contents of the following chapters. Chapters 2 and 3 are formatted as independent papers that seek to answer different, but closely related, research questions, while Chapter 4 summarises the results of those chapters, and discusses implications of their findings and associated recommendations for future research. Given their thematic similarities, there is significant overlap in some areas of Chapters 2 and 3; notably in the introductions (sections 2.1 and 3.1), methods (section 2.2 and 3.2), conclusions (2.5 and 3.5), and appendices (Appendix A and B of Chapter 2 are identical to those of Chapter 3, while some of the tables and figures in Chapter 3 Appendix C and D are presented in-text in Chapter 2). This overlap was necessary in order to fulsomely explore background literature related to both chapters, and to sufficiently articulate the study design and methodology, while the overlap in the conclusions pertain to similar recommendations for future avenues of study.

1.3.2 Chapter 2

In Chapter 2, we use the charitable dictator game to measure variation in donation amounts by participants with pro-environmental values to an environmental non-governmental organisation based on the treatment group that they were assigned to. As well, we stratified these data by demographic factors, to assess whether interaction effects exist. We present these findings as scatter plot graphs containing individual and average donation amounts, grouped by treatment, age, gender, and location. Finally, we discuss interpretation of the findings, and make suggestions for future research.

1.3.3 Chapter 3

Chapter 3 uses the participants' replies to the treatment posts they were shown to measure average reply rate based on treatment, to assess whether certain types of content are more likely to elicit a reply. Replies were then classified based on tone to assess whether the treatments influenced reply tone; this was measured by a manual classification of themes on the part of the principal researcher, as well as a machine learning model's (bag of words) classification. As in Chapter 2, we used the charitable dictator game to measure variation in donation amounts based on treatment type; this time, however, only of participants who replied to the treatment ("respondents"). We then stratified donation amounts by demographic factors of respondents, once again to assess whether interaction effects exist. We also compared the average donation amount of respondents to non-respondents. We present these findings as scatter plot graphs containing individual and average donation amounts, grouped by

treatment, age, gender, and location. In the analysis and conclusion, we discuss interpretation of the findings, and make suggestions for future research.

1.3.4 Chapter 4

The final chapter rearticulates the research objectives, and the findings of Chapters 2 and 3. It also discusses the implications of these findings on social media content moderation, and on interpretation of the value-action gap.

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CHAPTER TWO: EFFECT OF SOCIAL MEDIA INFORMATION ON DONATION BEHAVIOUR

2.1 INTRODUCTION

2.1.1 Background

While 'information' may be a staple of our vocabulary, its definition eludes even information scientists (McKinney Jr. and Yoos II, 2010). A minimalist definition of information is data that is meaningful or valuable to a recipient (Davis and Olson, 1985). The representation view of information expands on this definition, and argues that information must include a sign, object, and observer; for example, dark clouds (a sign) foretell a storm (object) to a hiker (observer) (McKinney Jr. and Yoos II, 2010). By this definition, information is a model of something to someone (Floridi, 2005). Information can have both internal and external representations; the former denoting unique interpretations specific to a single observer, and the latter are assumed to be common or similar among several observers (McKinney Jr. and Yoos II, 2010). Further confounding information is its communicator – the intent of a communicator can shape its representation, though ultimately its interpretation rests with the observer.

The format in which information is conveyed has varied over time. News stories spread online through social media disseminate much faster and to a wider network than other news stories (Al-Rawi, 2019). Over two-thirds of American adults have used social media to read the news at least once, with 20% doing so on a regular basis (Wu et al., 2019). While print media is regulated in part by the speed and cost of publishing and distribution, digital media faces no such challenges. This has led news outlets and governments to disseminate crucial information through social media platforms such as Twitter (Eysenbach, 2020).

Similar to information, misinformation also suffers from semantic challenges. Misinformation has been defined as false or inaccurate information that is deliberately created and intentionally or unintentionally propagated (Wu et al., 2019). Misinformation exists in many forms, including but not limited to disinformation (purposeful misinformation), fake news (false information often unknowingly shared), and rumour (unverified information). Social media has helped spread misinformation, as content is often not checked for veracity before being uploaded online (Eysenbach, 2020). This has led some to argue that misinformation on Twitter resulted in an 'infodemic', or crisis of unreliable information, shortly after the onset of the COVID-19 pandemic.

Misinformation can also have varying effects on a recipient. Primarily, the content of misinformation can mislead, misinform, and deceive (Treen et al., 2020). Acknowledging information as misinformation can be harmful as well; misinformation related to the COVID-19 pandemic led youth respondents to feel stress, confusion, frustration, annoyance, and anger, often due to the overwhelming presence of misinformation, rather than the content of the information itself (Borah et al., 2021). Aside from inducing negative emotions,

misinformation and normative statements can also influence action; for example, negative vaccine information may contribute to vaccine hesitancy (Yiannakoulias et al., 2022). These negative reactions to misinformation may exist in many subject areas.

Opinions can also impact their observer. While information and misinformation tend to be defined with respect to veracity (or the lack thereof), opinion is under no such constraints, instead only describing a communicator's subjective value judgement of an object or idea. Authors assert that social media and other online spaces are a nexus for the opinion formation of observers on a variety of issues, as social networks can heavily influence opinions and behaviour (Williams et al., 2015). Opinion formation can either be in support or against a subject; as an example of the latter, climate change misinformation is asserted to cause scepticism, contrarianism, and denial, while pro-climate change misinformation may cause climate alarmism (Treen et al., 2020; Koonin, 2021).

2.1.2 The Value-Action Gap in Environmentalism

The disparity between one's values, intentions, or beliefs and corresponding action is known as the value-action gap (Kollmuss and Agyeman, 2002). This gap is noteworthy to policymakers, who must identify methods of bridging these gaps in order to achieve desired goals, such as increased action to prevent or offset climate change. Both climate concern and climate action have been measured through statements of intent, often using surveys of willingness to pay (Streimikiene et al., 2019). Behaviour, rather than intent, may be more meaningful, particularly when measured experimentally, given that hypothetical stated values of intent can overstate real behaviour by up to a factor of three (List and Gallet, 2001). Notably, as of 2009, 72.3% of Canadians indicated a gap between their intentions and their actions with respect to environmentalism (Kennedy et al., 2009). Researchers have speculated that lack of knowledge, information, time, money, as well as systemic barriers are key reasons for this disparity (Kollmuss and Agyeman, 2002). Given that belief in climate change is correlated with climate action, understanding the effects of climate change information, misinformation, and opinions on pro-environmentalists is critically important.

The charitable dictator game, a derivative of the ultimatum game, is an experimental design used to measure real behaviour, and is useful for measuring statements of intention with respect to environmentalism (Hoover et al., 2018; Kahneman et al., 1986). In the dictator game, one player (the "dictator") is allocated a sum of money (the "endowment"), and is given the option to split the sum with another player (the "recipient"). This game helps researchers explore questions related to altruism in economic decision-making. In the charitable dictator game, the recipient is represented by a non-governmental organisation such as a charitable fund. The charitable dictator game is a suitable analogy for charitable donations to an environmental charity, as the dictator has full control over their decision to give money and the amount given.

Prior research involving dictator games has primarily focused on the influence of positive incidental emotions on decisions to share money. Incidental emotions are momentary, induced emotions unrelated to the task at hand that have an impact on decision making (Forgas 1995). Forgas explored the role of incidental emotions in impacting argument processing, finding that positive moods led to favourable argument evaluations, while negative moods led readers to be more critical. Fear, sadness, anger, and other negative emotions may drive specific donation behaviours, such as increasing or decreasing the likelihood of donating, as well as increasing or decreasing the donation amount (Kollmuss and Agyeman, 2002; Loewenstein, 2000).

A variety of studies involving dictator games have found changes to donation amount or donation probability based on incidental emotion. A 2016 charitable dictator game study found that some positive emotions such as awe increase the amount donated by the dictator, while a 2018 dictator game study found that induced negative moods increased the probability of giving money to a recipient (Ibanez et al., 2016; Perez-Dueñas et al., 2018). As well, stress was found to increase donation frequency in subjects without strong pro-environmental beliefs, while lowering the average amount donated by both pro and non-environmentalists in yet another dictator game study (Sollberger 2016). Anger is also thought to influence decision making (Andrade and Ariely, 2009), but there has been little research as to its impact in environmental contexts. In 2019, Shreedhar and Mourato used audio-visual media of endangered animal species to explore its causal effect on charitable giving to conservation-related charities. They found that donations correlated with the treatment to which respondents were exposed, insinuating that media content influences prosocial behaviour (Shreedhar and Mourato, 2019).

2.1.3 Social Media, Social Networks, and Polarisation

Social media can be defined as an outlet for broadcasting information with a broad audience, whereas social networks are tools for connecting with others (Edosomwan et al., 2011). Given these definitions, these terms are mutually inclusive, as users on social networks may broadcast information whilst simultaneously connecting with others, though this may not always be the reality. Network analysis of social media reveals two main types of online communities: open forums, where members have mixed attitudes or values, and echo-chambers, where members are all like-minded individuals, or those who share similar views or values (Williams et al., 2015). Authors assert that echo-chambers are much more common than open forums on social media. Prior research has shown that individuals tend to alter their social media connections with a preference for information and opinions they agree with (Tokita et al., 2021), thus creating echo-chambers within one's social network. Given that echo-chambers do not present users with a diversity of information or opinion (Moe et al., 2023), they tend to cement one's existing beliefs. This can have a polarising effect on the broader social media community, as it can further divide

groups with differing values (Cinelli, 2021). This is especially evident with respect to political polarisation (Tokita et al., 2021), as well as climate change belief and scepticism (Williams et al., 2015; Pearce et al., 2018; Moe et al., 2023). The division between groups or individuals with differing values also depends on the social media platform. A study of news consumption on Facebook and Reddit revealed that Facebook exhibited greater segregation between users with opposing views (Cinelli et al., 2021). In other words, discussions of news on Reddit are more similar to the open forum community type, while on Facebook these discussions are more similar to echo-chambers.

Information cascades also contribute to the polarisation of online spaces. An information cascade is a situation in which individuals observe and adopt the behaviour of others, allowing information and opinions to quickly disseminate throughout a network (Tokita et al., 2021). Social media are prone to information cascades, as there is a tendency for users to relay content shared by their connections without seeing the source material. These cascades may alter users' beliefs and behaviour, as well as their social connections; information spread by Twitter users has been shown to increase or decrease the number of users that follow them, for example (Tokita et al., 2021).

2.1.4 Climate Change and Conflict

Despite scientific evidence about the reality of the climate crisis, public acceptance of this evidence is mixed (Corner et al., 2012). The effects of climate change vary regionally, and similarly belief in climate change is spatially-dependent (Bennett at al., 2021). As well, there are various methods of taking action to mitigate or prevent the effects of climate change, including recycling, buying local products, and participating in protesting (Corner et al., 2012). While some argue that social media has aided in organising the public in taking collective action to mitigate climate change (Segerberg and Bennett, 2011), it has also been argued that global collective action (between states) is needed to meaningfully address climate change (de Swaan, 2023).

A strategic issue can be defined as a condition or event which will have significant effects on an organisation or its interests (Zhang, 2013). Based on this definition, climate change can be considered a strategic issue, as it has widespread impacts on industries and societies alike. According to a 2013 model, there are 4 key stages to the strategic issue management process of social media use in public diplomacy (Zhang, 2013). These are the fermentation stage (where information goes viral), the proactive phase (where a stakeholder/organisation becomes aware of information), the reactive phase (where there is a response to information), and the issue recession phase (where new information takes the spotlight). In the reactive phase, responses to information may cause conflict; in the context of public diplomacy, it is crucial for stakeholders to resolve these conflicts to achieve policy goals (Zhang, 2013). In a broader context, this conflict can be conceptualised as being between users in

response to information and opinions propagated by their social network (Tokita et al, 2021).

In the case of social network conflicts, conflict can extend beyond the content of information itself, and instead manifest as incivility between social media users. For instance, a 2017 study measuring incivility and sarcasm on Twitter in relation to climate change scepticism found correlations between discourse tone and political affiliation, though incidents of incivility in this study were low overall (Anderson and Huntington, 2017). Despite this, authors assert that sarcastic content and other attack-based tones are prevalent in social media (Anderson and Becker, 2018). As well, exposure to sarcastic comments targeted at individuals who believe climate change is a hoax have been found to increase belief certainty in and perceived risk of climate change in individuals who did not already believe climate change to be a serious issue.

Social media may improve understanding and coordination in addressing climate change; for example, Twitter has been used to streamline collective action by pooling organisational and information resources (Segerberg and Bennett, 2011). Contrastingly, climate change scepticism can be exacerbated through polarisation and information cascades in online spaces (Williams et al., 2015; Pearce et al., 2018; Moe et al., 2023). Given the prevalence of climate change scepticism and misinformation in online spaces, it is critical to assess their impact on the behaviour of social media users.

2.1.5 Moderation of Digital Content

While some argue that content on the internet should not be regulated in accordance with free speech principles, disrespectful use of social media enforces the need for regulation (Mello, 2022; McCosker and Johns, 2014). Cultural and nationalistic provocation such as racist content on social networking sites is one example; Australian government policy has seen a shift toward regulation of these types of media to embody better 'digital citizenship' (McCosker and Johns, 2014). Authors have argued that states tend to be key actors in regulating online content (Tai and Fu, 2020). In the case of China's social network WeChat, content regulation is dynamic, and seems to be relaxed and tightened in response to social tensions and public opinion.

Content moderation is an unpopular solution to non-state-operated social networks. Despite the prevalence of COVID-19 misinformation online leading up to 2022, social networks proved reluctant to intervene other than by labelling potentially false information as such (Gisondi et al., 2022). A cause of this reluctance may be that increased moderation may decrease user engagement and activity with a platform. Moderation reluctance may also result from the additional costs of implementing content filters on social media (Gisondi et al., 2022). Whether or not misinformation is filtered, opinion is unlikely to be moderated unless it is disrespectful or disobeys the rules of a social network. This is particularly detrimental to efforts to educate and inform with respect to climate change, as misinformation and scepticism may promote further climate

change scepticism, and hinder efforts to coordinate mitigation and adaptation efforts against the effects of climate change. Social media algorithms are also a subject of debate; algorithms sort, filter, and rank content to increase user interactions and engagement (Etter and Albu, 2021). While their purpose is not explicitly to reduce the visibility of content, given that algorithms preferentially show users content based on what they are likely to engage with, all other content is essentially filtered out.

2.1.6 Hypothesis

In this study, we hypothesise that exposure to misinformation and climate change scepticism will affect the value-action gap for people with pro-environmental attitudes. Specifically, we hypothesise that people exposed to misinformation and climate change scepticism will be more likely to take action to mitigate climate change by donating to an environmental non-governmental organisation. This hypothesis is based on prior research that misinformation may influence prosocial behaviour (Treen et al., 2020; Perez-Dueñas et al., 2018). We test this hypothesis using an online framed field experiment in the form of a charitable dictator game in which climate action is represented by the donation behaviour of participants. The results provide some insight into the impact of incidental misinformation and climate scepticism on donation behaviour, and into the potential impact of misinformation and climate scepticism on decision making among persons with pro-environmental attitudes.

2.1.7 Research Objectives

The goal of this study was to explore the hypothesis that exposure to climate misinformation and anti-climate change opinions increase both the donation frequency and amount donated to environmental non-governmental organisations in a charitable dictator game. Two research questions stem from this hypothesis:

1. What is the effect of social media information on climate action in individuals with pro-environmental values?

2. Do any demographic factors influence the relationship between exposure to information on social media and climate action?

2.2 METHODS
2.2.1 Data Collection
2.2.1.1 Overview

Participants were exposed to one of three randomised treatments: a social media post containing climate change misinformation, a post containing an anti-climate-change opinion, or an unrelated social media post (control treatment). After exposure to an experimental treatment, each participant had the

opportunity to donate a portion of their potential survey compensation to an environmental charity, which measures their environmental concern and climate action. The effect of social media information on their decision to donate and amount donated (Research Question 1) can be drawn from the differences in donation frequency and amount in each treatment group. The influence of demographic factors on the relationship between exposure to social media information and climate action (Research Question 2) can be evaluated by comparing donation frequency and donation amount across various salient characteristics, such as age, gender, and location.

2.2.1.2 Recruitment and Study Population

The target population of this study are adults with pro-environmental attitudes. Given that adults have greater purchasing power than children and adolescents, we predict that adults financially contribute more to environmental causes. Accordingly, we assert that adults would have greater experience with donating to environmental charities. Given that donation behaviour is a focus of this study, being above the age of majority is an inclusion criteria. As well, risk perception is influenced by social, political, and cultural factors (Bickerstaff, 2004); given that social, political, and cultural factors vary nationally (Kollmuss and Agyeman, 2002), and climate activism can be seen as an expression of risk perception, we also predict that climate activism would be correlated with country of residence. This research focuses on Canadian adults, then, as location is a potentially confounding variable with respect to environmental concern and action. Similarly, individuals with pro-environmental values are a focus of this study, as environmental concern is correlated with pro-environmental action (Kennedy et al., 2015). Therefore, one's degree of environmental concern is also a potentially confounding variable. The target sample size was 200 participants; with 200 participants, a Chi-Square power test with inputs of a Cohen's coefficient of 0.3 (medium effect size), 2 degrees of freedom, and significance level of 0.05 yields a power of 97.4%, which represents a sufficiently powered experiment.

Participants were recruited online, through social media. This approach allows for targeted, direct recruitment of remote populations, such as pro-environmental individuals (King et al., 2014). The principal researcher joined Facebook and Linked-In "Groups" and Reddit "Subreddits" (online communities) where membership consisted of environmentally conscious individuals; the inclusion criteria for these communities was if members had uploaded content related to the environment or climate change within the thirty days prior to the principal researcher joining the community, thus demonstrating the presence of active environmentally-conscious users. As well, groups with Canadian content were prioritised, to maximise the likelihood of recruiting Canadian participants. Recruitment information was posted in these groups as allowed, either with prior approval by moderators of those online spaces, or by following rules written by those communities. Social media recruitment was suitable for this study, as active participation on social media (i.e., the propensity to engage with and comment on

social media posts) is a salient characteristic of this study. Given that recruitment occurred on social media, in specific online communities, an implicit inclusion criterion is membership in at least one such community.

2.2.1.3 Salient Characteristics of Participants

Age, gender, location, environmental values, and social media participation are considered salient characteristics of this study. Exposure and behavioural responses to social media information and misinformation, as well as environmental values are predicted to vary with age, gender, and location. There is a substantial gender gap in not just environmental concern, but also risk perception with respect to environmental hazards (Finucane et al., 2000; Kahan et al., 2007). Similarly, women are more likely to donate their endowment in dictator games (Eckel and Grossman, 1998; Bilén et al., 2021). As well, youth are asserted to take more pro-environmental action than older adults by a minute margin (Arriagada and Pinault, 2022).

2.2.1.4 Study Design and Survey Stages

The study was conducted using the online tool LimeSurvey. The study procedure can be divided into five subsections: the measurement of salient characteristics, treatment exposure, treatment response, donation, and donation response. In sum, these stages contain 16 questions, and took approximately 5-10 minutes to complete. This is consistent with recommendations regarding the maximum number of survey questions (20) and maximum duration (13 minutes) of an online study; increases to the number of questions or duration are purported to impact respondent retention until the end of a survey (Bailey et al., 2015).

Participants' environmental values and demographic markers (age, gender, and location) were recorded in the first stage of the survey. For gender, participants were presented with four options: a) male, b) female, c) other, please specify, or d) prefer not to answer. For age, seven options were presented: age i) 18-24, ii) 25-34, iii) 35-44, iv) 45-54, v) 55-64, vi) over 65, or vii) prefer not to answer. Binning, the process of grouping data values, is a practice designed to prevent respondents from being dissuaded by perceived breach of privacy or over-specificity. Bins of 10 years after the age of 24 were chosen, as larger bins would not retain sufficient detail, and smaller bins could result in too few respondents in each bin. Participants were then asked to select their country of residence from a drop-down list; if they were a resident of Canada or the United States, they were instead asked to select their province or state of residence, respectively. Once again, a prefer not to answer option is presented. Each participant was also asked to manually enter their city of residence, or to choose a "prefer not to answer" option. In each case, a prefer not to answer option was presented to encourage participants to skip any questions they were not comfortable answering, while still participating in the remainder of the study.

Participants were then presented a series of questions to gauge their environmental values and opinions on climate change. These questions were adapted from the New Environmental Paradigm scale, and measure attitudes about the seriousness of the climate crisis, and the role that individuals can and should play to solve it (Dunlap, 2008). The questions were altered from the NEP scale primarily to avoid differences in interpretation by respondents; for example, where the NEP scale would say "humans are severely abusing the environment," "severely" was removed for this survey, as a respondent's perception of severity is an added point of complexity. More detail on the adapted NEP statements is provided in Appendix A. For each question, participants can choose one of five options on a Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," or a sixth option, "Prefer not to answer." The results of this series of questions were then translated to an effect score from 0 to 16, to represent how deviant each participant's responses were from a hypothetical ideal pro-environmental response. For example, given the above statement ("humans are abusing the environment"), the ideal response ("Strongly Agree") yields an effect score of 0; a respondent who answered "Strongly Disagree" would be awarded a score of 4. A score of 8 represents ambiguity with respect to environmental values, as the respondent would have indicated a balanced combination of pro and anti-environmental views. Respondents with an effect score of more than 7 were excluded from further analysis, given that the hypothesis focuses on the impact of information on pro-environmentalists. As well, biassed assimilation describes how individuals draw conclusions from new information in a biassed manner based on their preconceptions (Lord et al, 1979). For example, climate change sceptics are more likely to interpret ambiguous environmental reports as climate change scepticism than pro-environmentalists exposed to the same reports (Corner et al., 2012). For this reason, it was also necessary to exclude respondents with ambiguous environmental values (i.e., an effect score of 8) from further analysis. In total, 18 respondents were excluded in this manner.

A randomised treatment was applied to each participant in the second survey stage. Each participant was shown either a social media post containing climate change misinformation, a post containing an anti-climate-change opinion, or an unrelated post (control treatment). These social media posts were procured by the principal researcher in 2021, by searching for popular environment-related and unrelated hashtags on Facebook and Twitter, and manually screening for content containing anti-climate-change opinions or misinformation (for experimental treatments) or unrelated material (for control treatments). Two posts representing each treatment type were chosen. The posts were modified as needed, to remove personal details and for clarity; these modified posts are available in Appendix B. Treatment delivery was randomised in LimeSurvey by assigning each social media post a number from one to six; then, a random number was generated, and the post associated with that number was displayed. Selection bias describes an over-representation or under-representation of groups in a sample; for example, if all participants assigned to a treatment were

in the same income bracket, it would be impossible to conclude whether the treatment or the income had a causal relationship with the results. Similarly, confounding arises when an unobserved variable influences a relationship, leading to misinterpretations as to the relationship between the independent and dependent variable. Randomisation of control and experimental treatments is critical to balance unobserved variables between the treatments and to address unrepresentative samples in experiments, and thus offset confounding and selection bias, respectively (List, 2011).

In the third stage, each participant was asked whether they would reply to a similar post if they found it on social media, to gauge the level of engagement participants had with social media posts. Each participant was presented with three options: yes, maybe/sometimes, or no. If they chose the first or second option, they were then prompted to reply to the post. These responses serve to further inform as to the participant's engagement with social media and can also be used for secondary analysis.

Each participant was then entered in a lottery as compensation for their participation. The lottery consisted of a $100 cash prize and expected odds of 1/200; given an estimated survey completion time of 5-10 minutes, this results in an expected value of $3-6 per hour per participant. Each participant was then provided a brief overview of the Sierra Club, an environmental charity with branches in both Canada and the USA, and was asked if they wished to donate a portion of their potential winnings to this charity. Participants then chose a value of $0-100 from a dropdown list, where the initial value is blank, and ascends from $0 below this placeholder value. This is more realistic than descending from $100, as donors begin without the decision to donate, and work their way to a donation amount from a value of $0. Conversely, beginning the dropdown menu at $100 instead anchors participants' responses to that value.

In the fifth stage, each participant was asked to comment on the factors that impacted their decision to donate to the Sierra Club, to determine if any systematic barriers to charitable donations exist. It is asserted that a range of factors including culture, upbringing, and life events can inform competitiveness, altruism, and understanding of risk and reward (Murnighan and Wang, 2016); analysis of these donation decision responses could account for these factors.

2.2.2 Data Analysis
2.2.2.1 Effects of social media information on climate action
The effects of social media information were measured numerically using the average donation rates and average donation amounts across the different survey treatment groups. If a treatment group (independent variable) has a mean donation amount (dependent variable 1) or donation rate (dependent variable 2) higher than another, this represents more climate action. Comparisons were made using non-parametric alternatives to t-tests and to ANOVA. ANOVA, or Analysis of Variance, is a statistical test used to determine the differences in means between groups for parametric data. The Kruskal-Wallis test is an

alternative to one-way ANOVA, used for datasets that are non-parametric. It computes the probability of obtaining the observed data assuming that the null hypothesis, that the groups from which the observations are drawn have the same distribution, is true. Similarly, t-tests are suitable for parametric data. The Pearson chi-squared test and Fisher's exact test are used to assess the statistical significance of non-parametric data. They are used to compute the association between two categorical variables in a contingency table, the distinction being that the Fisher's exact test is used for small sample sizes.

2.2.2.2 Determining interaction effects between social media information and climate action

Data were stratified by age, gender, and location to determine if any additional factors further confound the relationship between social media information and climate action. For example, given that women tend to donate more than men in dictator games, it is possible that this disparity will exist in this experiment, regardless of the experimental treatment (Donate-Buendia, 2022). If the difference in average donation amount between men and women or donation probability varies from one treatment group to another, this speaks to the causal effect of the experimental treatment.

2.2.2.3 Pre-registration

Pre-registration describes outlining a study's hypothesis, methods, and analysis prior to data collection. Having and following a pre-registration plan improves scientific research by increasing transparency and reducing the potential for retroactively formulating hypotheses, selective reporting, and other data-driven decision making. Articulating a hypothesis in advance also promotes replicability and credibility. This study was pre-registered using the Open Science Framework repository (Giese, 2023).

2.3 RESULTS

Out of 232 participants, we classified 214 (92.2%) as having pro-environmental values according to the adapted NEP scale. Table 1 displays the dispersion of individuals of each gender across the treatment groups. Notably, some responses were re-worded to genderqueer, as this was entered in a variety of ways given that respondents had the ability to submit open-text responses. 1 participant labelled as genderqueer was assigned to the misinformation treatment group, representing only 0.48% of the sample.

Table 1. Gender by treatment type

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Gender	Female	30	35	40
	Genderqueer	3	2	1
	Male	42	24	31
	No answer	2	3	1

Similarly, Table 2 displays the ages of respondents by treatment group. Notably, few participants over the age of 64 were assigned to the misinformation treatment (n=2, 0.95%). Participants in each treatment group increase slightly as age decreases; however even in the 35 to 44 age group, only 7 respondents (3.3%) were assigned to the control group.

Table 2. Age by treatment type

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Age	18 to 24	19	22	23
	25 to 34	31	21	23
	35 to 44	11	7	11
	45 to 54	6	4	8
	55 to 64	4	6	5
	65 plus	3	3	2
	No answer	3	1	1

Table 3 illustrates the distribution of respondents from each location across the treatment groups. From this table, the proportion of total respondents residing in Canada can be computed (n=139, 64.95%). This is relevant, as the focus of this study is on respondents living in Canada.

Table 3. Country by treatment type

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Country	Canada	46	44	49
	Other	29	19	21
	No answer	2	1	3

Figure 1 illustrates the donation behaviour of all respondents with pro-environmental values (n=214). As well, the distribution demonstrates a tendency for respondents to donate common fractions (such as 1/4 or 1/2) of

their potential survey compensation. Bins of $10 were created along the x-axis to facilitate this visualisation, which led to reduced specificity.
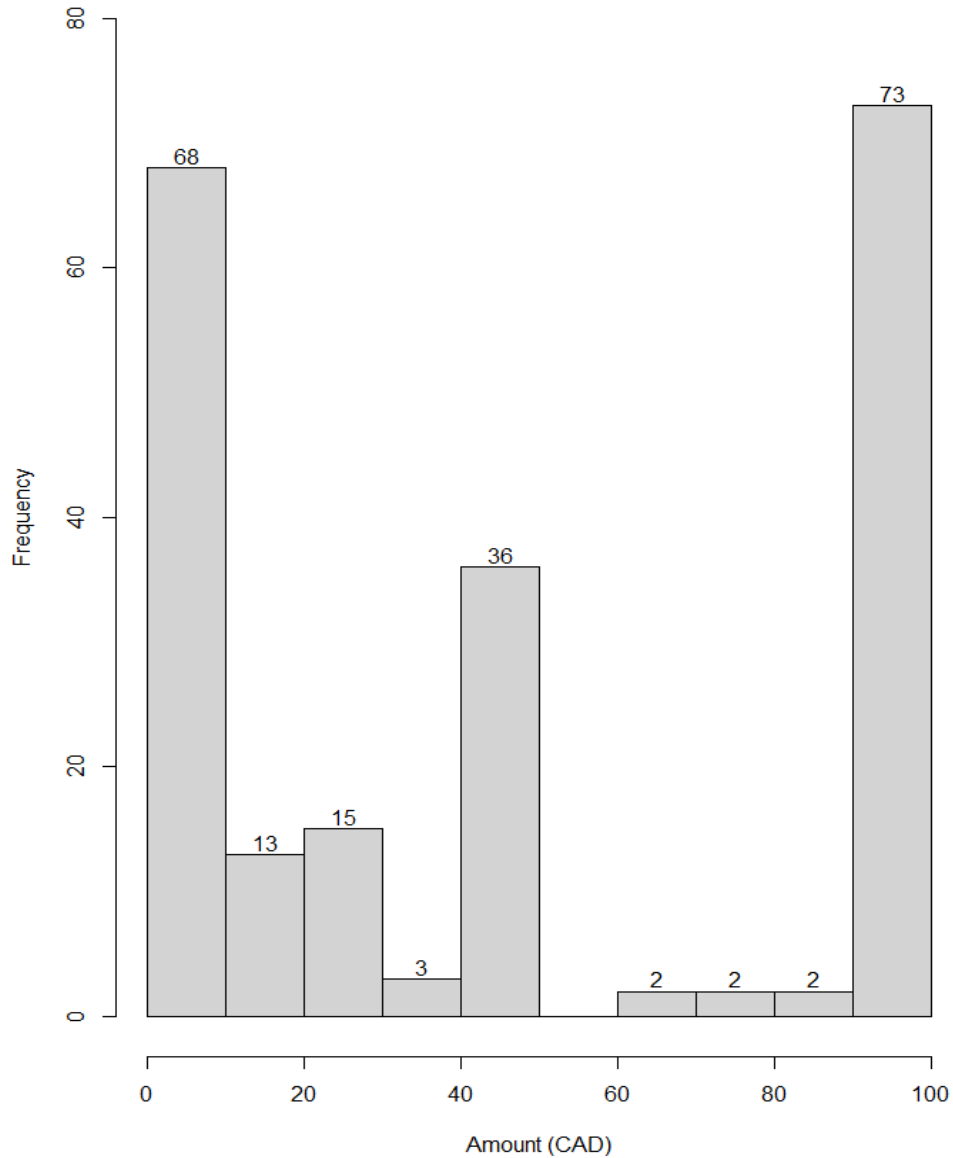
Figure 1. Amount donated by survey participants

Figure 2 illustrates the distribution of donation amounts by treatment type. The mean donation amounts across the treatment groups are $55.77 (climate change scepticism), $49.45 (control) and $42.29 (misinformation), but the differences were not statistically significant (Kruskal-Wallis test = 3.735, p=0.1545). Appendix C.1 presents these data as a table. We also compared the likelihood of donating across treatment groups: 81.8% (climate change

scepticism), 82.8% (control), and 73.9% (misinformation), and differences were not statistically significant (Pearson's test = 2.048, p=0.3591).
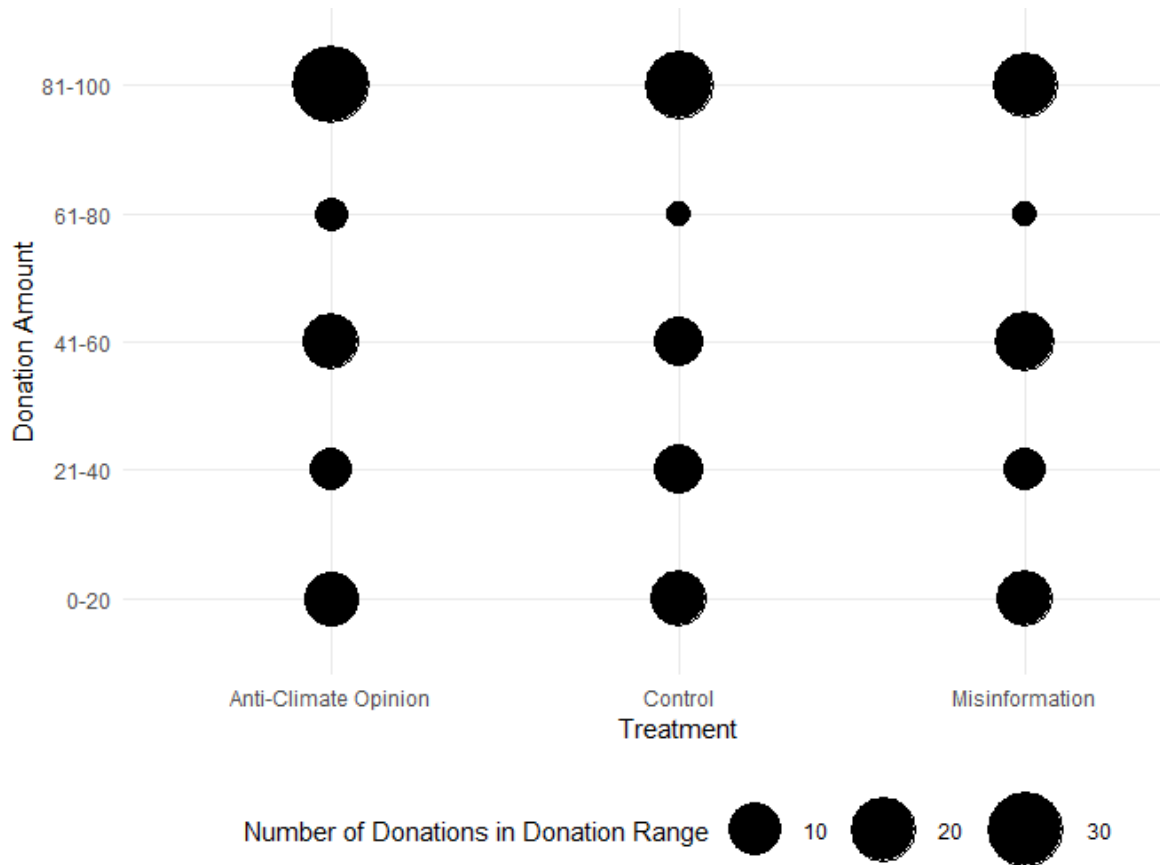
Figure 2. Scatterplot of donation amount by treatment type

The presence of interaction effects between the study treatment and climate action can be assessed by reviewing the distribution of donation amount responses by age, as shown in Figure 3. The mean donation amount across each age group are as follows: $39.38 (18-24), $53.87 (25-34), $58.62 (35-44), $52.33 (45-54), $39.67 (55-64), $68.62 (65+). Appendix C.2 presents these data in more detail, as a table. Neither the differences in donation amount by age (Kruskal-Wallis test = 7.945, p=0.1593) nor the differences in likelihood of donating by age (Pearson's test = 7.673, p=0.2631) were statistically significant.
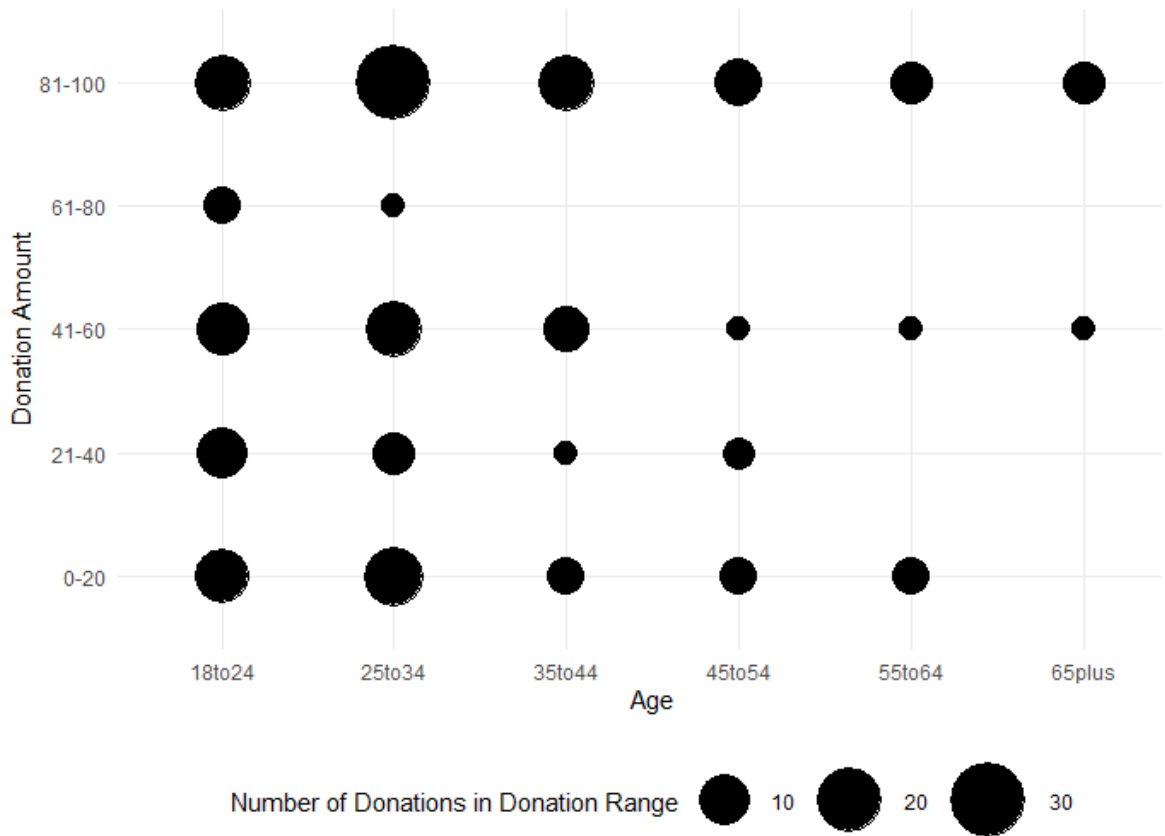
Figure 3. Scatterplot of donation amount by age

Average donation amount varied by gender: $48.59 (female), $40 (genderqueer), and $50.66 (male), though these differences were not statistically significant (Kruskal-Wallis test = 0.1515, p=0.927). A scatterplot of these data is presented below in Figure 4. Differences in donation likelihood by gender were also not statistically significant (Pearson's test = 2.812, p=0.5898). Appendix C.3 supplements these data.
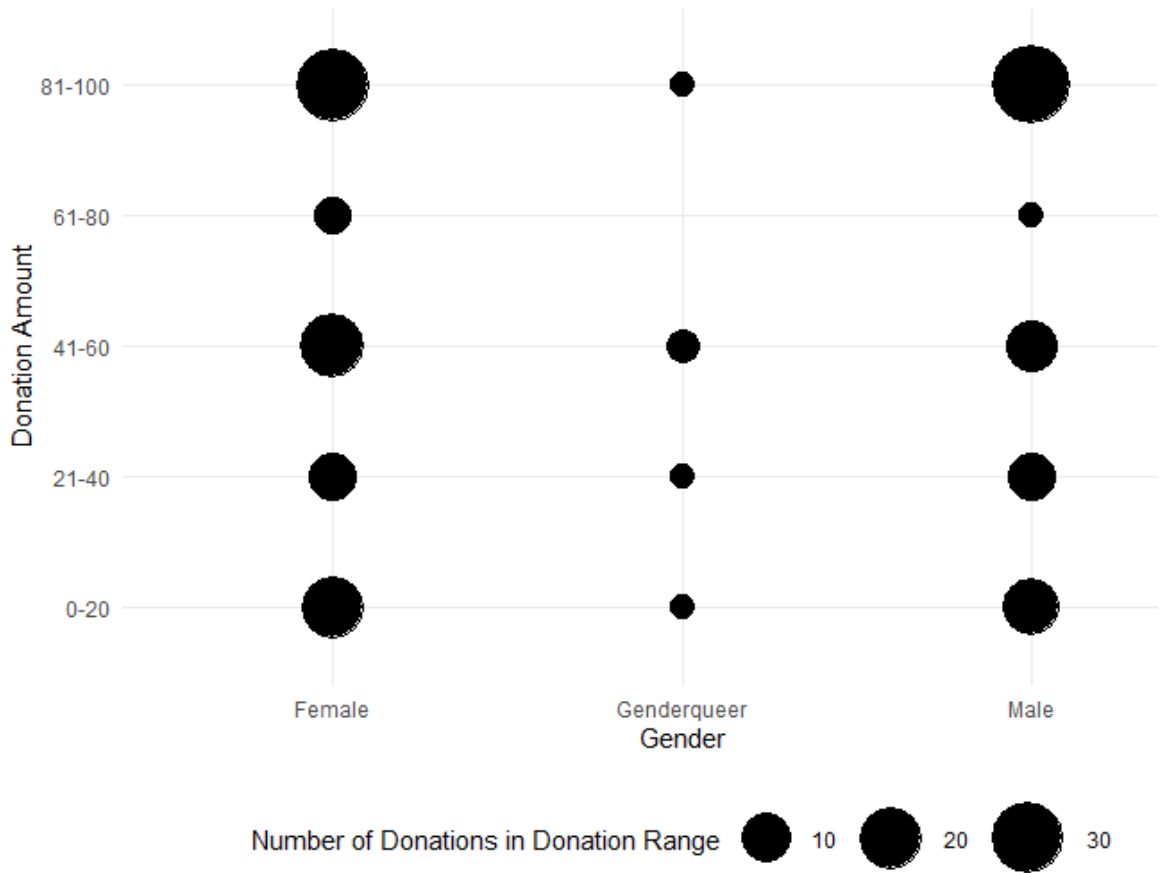
Figure 4. Scatterplot of donation amount by gender

Figure 5 demonstrates donation amounts by location as a scatterplot. Average donation amounts ranged from $45.07 (Canada) to $57.08 (else). Differences in donation likelihood by country were not statistically significant (Pearson's test = 3.324, p=0.1898), while differences in donation amount were near the accepted threshold for statistical significance (Kruskal-Wallis test = 3.555, p=0.05936). Appendix C.4 supplements these data.
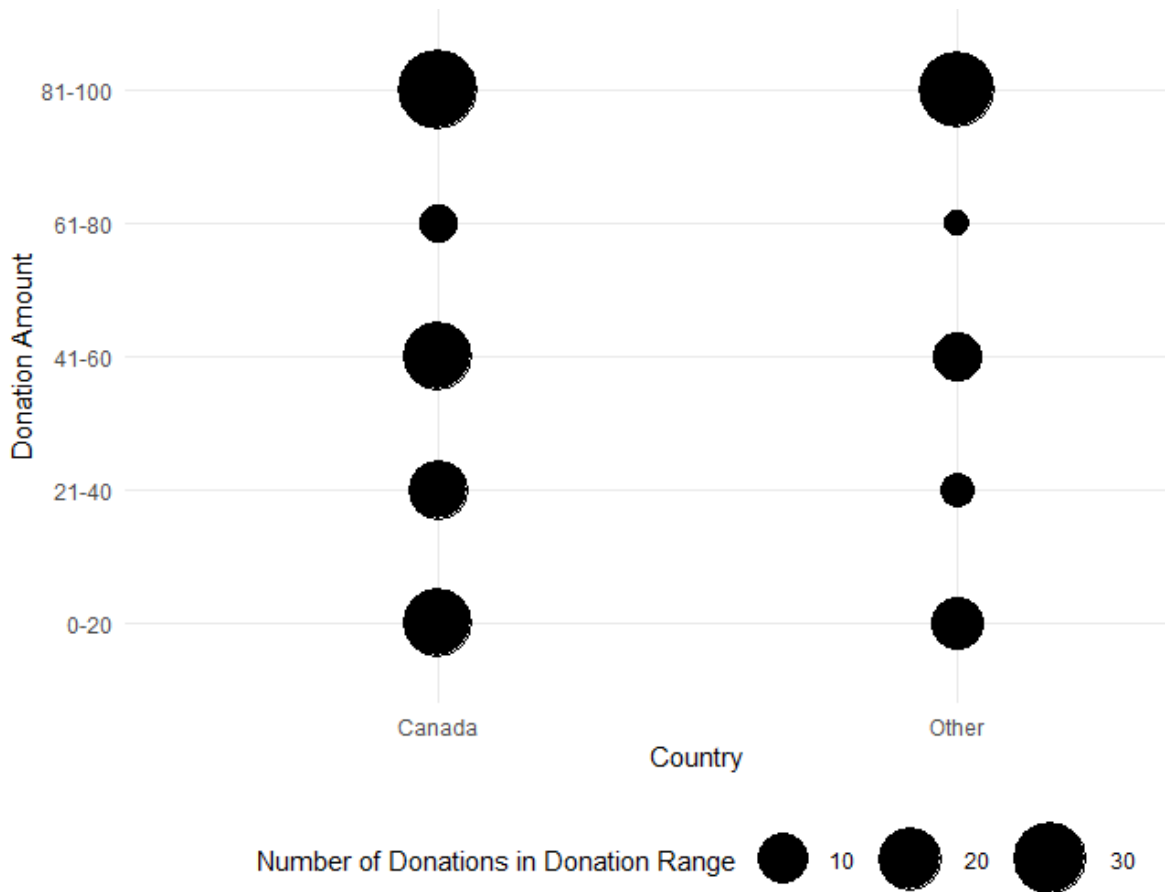
Figure 5. Scatterplot of donation amount by country

2.4 DISCUSSION

2.4.1 Research Question 1: Effect of Social Media Information

Figure 2 provides a visual representation of average donation amounts across the treatment groups. In this application, a p-value computed by a Kruskal-Wallis test represents the probability of observing the test statistic under the null hypothesis that the amount donated across the three treatment groups are similar. For the Pearson chi-squared test, the p-value measures the difference in proportions across the treatment groups under a null hypothesis of independence. For both comparisons of donation across treatment groups, using a significance value (Type I error rate) of 0.05, or 5%, neither null hypothesis can be rejected, and there is no evidence of difference in donation behaviour across the treatment groups. Given the statistical power of this study (97.4%), it is likely that this experiment would have measured a medium effect size should one have existed. These results suggest that individuals with pro-environmental values are resistant to climate change scepticism and misinformation. This implies that

efforts to filter or moderate misinformation do not impact climate action of pro-environmentalists.

Resistance to information and opinions on social media may also vary by the social media platform. Individuals are believed to be more receptive to attitudes of their peers than others (Williams et al., 2015), and individuals are more likely to encounter the opinions of their peers on some social network sites than others. This may cause participants to be more sceptical of the study treatment, given that the treatment was essentially a post by an anonymous user, and not a post written by a member of their network. This may have affected donation amount or likelihood; namely, given the hypothesis that donation amount and likelihood is negatively correlated with agreement with the content of the experimental treatments, increased scepticism may have inflated donation amount and likelihood.

Due to the incidental nature of the stimulus (i.e. the momentary exposure to a single social media post), the effect of the stimulus could similarly be incidental; however, rather than immediately prompt participants to donate, they were first asked to respond to the treatment post, as if they saw it on social media. We believed that responding to the treatment post would enhance the participants' engagement with the treatment. Instead, it is possible that responding to the post exhausted the effect of the stimulus, thus reducing donation likelihood and donation amount. Further study is needed to ascertain if there is a correlation between responding to social media posts as a method of pro-climate action, or if incidental exposure is insufficient to produce the hypothesised effect.

Similarly, it is possible that repeated exposure to the experimental treatment would influence effect size. Borah et al. 2021 found that youth were stressed by the ubiquity of climate change misinformation, not just incidental exposure to misinformation. This suggests that an experimental treatment consisting of multiple posts containing misinformation and anti-climate change opinions may have generated different findings. The present research provides some evidence that the minimum exposure required to influence a social media user to donate must be more than incidental.

Participants in this study may have been less impacted by the experimental treatments because they were aware that they were outside the context of a real social media platform. Knowing that the social media posts were presented to the participants for research purposes may have influenced their emotional response when compared to a real social media post. While this study was administered as a framed field experiment, it was a simulation of a social media experience, not a real one. In order to fully immerse participants in a field experiment setting, the treatment posts would have to have been delivered directly in the feed of the participant's social media. Moreover, the posts provided, while extracted from real social media posts, were not attached to a specific personality or identity. The weak effect here may provide some indirect evidence about the importance of identity and personality in science communication on

social media (Yiannakoulias, Tooby and Sturrock 2017). Celebrity figures, television personalities, and well known social media personalities may be more likely to elicit engagement, and may have had a greater impact on participants had they been attached to the experimental treatment in this study. Future research should consider adding a personality (or description of a personality).

While the time to complete the survey was not recorded in this study, this duration is likely related to whether or not participants skipped any questions. Notably, both the open text response questions in stage 3 and 5 are assumed to dramatically increase the completion time of the survey, due to the time required to devise and craft a response. As a result, persons who answered these open text response questions have a lower expected value than those who did not. Participants may be affected by a sunk cost, which occurs when individuals consider unrecoverable costs in decision making; one may overvalue decision outcomes, leading to inflated expected value. This may lead to suboptimal decision-making, as individuals may continue to devote resources to a recipient simply because they were already doing so, rather than for any logical reason. This would lead to an association between survey completion time and donation likelihood and amount, and obscure the relationship with experimental treatment.

2.4.2 Research Question 2: Interaction Effects

An interaction effect describes relationships in which two or more independent variables impact the dependent variable. In this study, age, gender, and location are factors which may influence the causal effect of the experimental treatment on donation likelihood and amount. Given the accepted significance threshold of 5%, the null hypothesis cannot be rejected for these factors, apart from location.

Prior literature would suggest that men donate less than women in dictator games (Eckel and Grossman, 1998; Bilén et al., 2021). Contrarily, we also found minimal differences to average donation amount based on gender, indicating that this disparity in donation behaviour may not exist among pro-environmentalists. Specifically, the average donation amount by males rose to 49.16% of the endowment, whereas in a meta-analysis of giving in charitable dictator games, the global endowment donation average (i.e. the average amount donated by males and females together) was only 32% (Bilén et al., 2021). Contrastingly, the global endowment donation average in this study was 50.96%. This implies that both men and women with pro-environmental values donate substantially more to pro-environmental causes than the aggregate give in dictator games in general. This highlights the importance of developing strong values with respect to nature or any other cause, as these connections seem to correlate with increased donation amount. It also implies that environmental concern elicits higher than average donations from survey participants, indicating that environmental concern is potentially a more imminent concern to men and women alike than many other causes.

2.4.3 Implications

While this study used climate change misinformation and opinion as experimental treatments, various other types of information and opinion were equally suitable. There is a wealth of observational research to suggest that negative vaccine information (Yiannakoulias et al., 2022), COVID-19 misinformation (Borah et al., 2021; Gisondi et al., 2022) and election misinformation and fake news (Wu et al., 2019) pervade onlines spaces. Despite some evidence as to the negative effects of this content in prior literature, this experiment did not replicate those findings. It is possible that the results of this study could be replicated by substituting the experimental conditions with content from any other subject area, and modifying the participant demographic to encompass individuals strongly aligned with a pole within the chosen subject domain. If these results are indeed generalisable, this would cement the importance of accruing knowledge, forming opinions, upholding values with respect to key issues, in order to be resistant to negative information and opinions.

The decision of whether or not to and the extent to which digital content should be moderated has been an ongoing debate (Mello, 2022; McCosker and Johns, 2014). Cost is a primary consideration in the anti-moderation argument (Gisondi et al., 2022). Moderation or filtration of digital content requires either additional staff to manually remove content, or additional computational resources for automated removal. Some predict that moderation reduces user engagement (Gisondi et al., 2022). Comparatively, moderation confers few benefits to a social network. This study provides some evidence that climate change misinformation and anti-climate change opinions increase user engagement, while maintaining donation behaviour of pro-environmentalists. This suggests that moderation would not necessarily be beneficial, as it would minimise communication between groups with opposing views, further polarising those groups. If these results extrapolate to other subject areas, or to the general population, this would greatly contest the utility of moderating digital content. Meanwhile, social media algorithms play a vital role in maintaining user engagement (Etter and Albu, 2021). Regardless of whether or not content is moderated, social media users effectively control their own experience based on the content they choose to engage with; despite evidence from this study that users who care about a subject tend to reply to misinformation and cross-attitudinal content, the solution to seeing this content may simply be restraint.

2.4.4 Strengths, Limitations, Future Work

This study placed high importance on the presentation of the experimental treatments to respondents; that is to say, we aimed to mimic real exposure to misinformation and anti-climate change opinions, by presenting the text from real social media posts. Given the similarity of this study to real-world conditions, this is considered a framed field experiment. Framed field experiments are noted for

being minimally invasive to participants (List, 2011). This reduces the extent to which results are impacted by the participant's knowledge that they are being observed, otherwise known as the Hawthorne effect.

As well, given the brief exposure to the experimental treatment, these interventions are minute. Treatments were not labelled as misinformation or climate scepticism, and instead left participants to draw their own conclusions about the content of the information they were shown. We assert that labelling the treatments would have inflated effect size, as participants would have had a heightened awareness of the experimental design. It is preferable to minimise pressures such as these to effect size, as this influences the external validity of the experiment.

We also acknowledge some limitations to this experiment. Analysis of the fifth stage of the survey, where participants commented on their decisions to donate, revealed a commonality – many respondents held negative views of the Sierra Club, the organisation that was chosen as the donation recipient. The choice of donation recipient was difficult; it is asserted that a specific recipient is necessary, otherwise donation decisions would be too intangible to participants to be meaningful. On the other hand, most non-governmental organisations suffer from either current or past controversy. Familiarity with the Sierra Club, then, may correlate with donation likelihood or amount.

This study produced qualitative data regarding participants' responses to the study treatments (stage 3) and insight regarding donation decision-making (stage 5). Sentiment analysis describes the distillation of statements to their base sentiment, either positive or negative. A sentiment analysis of the open-text responses from stage 3 and 5 of this study could ascertain whether the experimental treatment was linked to sentiment, and similarly whether sentiment was linked to donation behaviour.

As well, this experiment targeted adults with pro-environmental values, and did not meaningfully address donation behaviour of residents of any other specific nation. It is unclear how participant location affects the relationship between the experimental treatment and donation behaviour beyond what is demonstrated in Figure 5. Future research should consider comparing donation behaviour between specific nations, as global collective action is needed to address climate change.

While the treatments of this study presented anti-climate change information and opinion, it is also possible that pro-climate change misinformation and opinion have an effect on donation behaviour. Authors have asserted that pro-climate change misinformation may cause climate alarmism (Koonin, 2021), though the impact of this on donation behaviour requires further study. This is a pertinent avenue for exploration, as is the prevalence of pro-climate change misinformation on social media. There is little literature exploring climate alarmism, though whether this is the result of its relative rarity, lack of interest, or greater interest in anti-climate change behaviours is unclear.

There is little evidence as to the effect of more-than-incidental emotion on decision making. Youth canvassed in 2021 by Borah et al. asserted that repeated or sustained exposure to misinformation led to negative feelings such as sadness and anger. The effect of repeated exposure to misinformation or anti-climate change opinions has yet to be explored. It is possible that the incidental exposure provided by this experiment was insufficient to impact donation behaviour, though perhaps a critical amount of exposure would. Conversely, it is possible that oversaturation to these media may instead lead to feelings of hopelessness, which may negatively impact donation behaviour.

Finally, further research is needed to determine the processes which influence donation behaviour in pro-environmentalists. This study exhausted the possibility that minimal exposure to anonymised social media posts influences this behaviour, though other influences such as print media, televised media, and advertising were not explored by this experiment.

2.5 CONCLUSION

This study sought to establish whether views contrary to one's own values would nudge individuals to act (Research Question 1), and if so, what factors impacted that relationship (Research Question 2). We found that misinformation and anti-climate change commentary resulted in minimal differences to donation likelihood and amount to a pro-environmental charity. These results suggest that pro-environmentalists are resistant to climate-change misinformation and anti-climate change opinions presented through social media. Further research into whether these observations apply to the general population is necessary, as would research into the motivations and sentiment towards donating to environmental non-governmental organisations in general. If these results do generalise to the general population, this calls the necessity of filtering misinformation on social media into question, as there is some evidence that this content does not negatively affect prosocial behaviour. These results also suggest that the gender disparity in dictator game endowment giving may not exist in environmentalism, and that pro-environmental men and women donate substantially more to environmental causes than the aggregate give in dictator games in general (Bilén et al., 2021). Some have asserted that social media fosters division and polarisation between groups through the formation of "echo-chambers" of like-mindedness, furthering one's own beliefs and estranging them from others who do not share their views (Cinelli, 2021); however, it is also possible that moderation of misinformation and negative opinions discourages debate between social media users, which would increasing polarise online spaces and further entrench this gap in understanding.

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Appendix A – Adapted New Environmental Paradigm Statements

1. "Humans are abusing nature and the environment."

   This statement was chosen as anthropogenic climate change (the notion that humans play a role in deteriorating the state of the environment) is a key tenet of contemporary pro-environmental values.

   Strong agreement with this statement results in an effect score of 0.

2. "The 'ecological crisis' facing humanity is an over-exaggeration."

   This statement addresses the seriousness of the climate crisis; disagreement with it is considered a stronger pro-environmental Stance.

   Strong disagreement with this statement results in an effect score of 0.

3. "Each one of us can reduce the effects of climate change."

   Given that individuals are more likely to take pro-environmental action if they believe their contributions to be meaningful, agreement with this statement represents stronger pro-environmental values.

   Strong agreement with this statement results in an effect score of 0.

4. "Climate change is only caused by the pollution from industries."

   Allocating blame solely on corporations serves as an antithesis to statement #3.

   Strong disagreement with this statement results in an effect score of 0.

Appendix B – Survey Treatments
Misinformation

1. "Interesting -- studies show that wind farms have a warming effect on the climate"

2. "Peer-reviewed study reveals majority of scientists are skeptical of '#globalwarming crisis' #ecoscam #greenscam"

Climate Change Scepticism

3. "My deck is already covered in snow this morning, and it's not yet October. Thank goodness Canada is warming sooo much faster than the rest of the world, right @cathmckenna ? #cdnpoli #ABstorm #ABweather #ClimateScam"

4. "Two Canadian Coast Guard ships sent to rescue U.S. freighter stuck in ice. #globalwarming?"

Control

5. "In the largest single release of whole genomes ever, the #UKBiobank has unveiled to scientists the entire genomes of 200,000 people who are part of a long-term British health study."

6. "Until now, scientists eager to learn more about chimps' behavior could spend weeks combing through raw footage—but a new #AI system can do the grunt work for them."

Appendix C – Supplemental Tables

Appendix C.1: Donation amount by treatment type

		Treatment		
		Climate Change Scepticism	Control	Misinformation
	0	14	11	19
	1	0	1	0
	2	0	0	1
	5	1	1	1
	10	4	7	8
	15	2	0	1
	20	4	4	2
	25	3	2	5
Donation	30	2	3	0
Amount	40	0	3	0
(CAD)	50	13	8	15
	69	0	1	0
	70	0	0	1
	75	1	0	0
	80	1	0	0
	90	0	2	0
	99	1	0	0
	100	31	21	20

Appendix C.2: Donation amount by age

		Age						
		18-24	25-34	35-44	45-54	55-64	65 plus	No answer
	0	15	10	5	4	6	2	2
	1	0	1	0	0	0	0	0
	2	0	0	0	1	0	0	0
	5	0	2	0	0	1	0	0
	10	6	9	2	2	0	0	0
	15	2	0	1	0	0	0	0
	20	4	4	0	0	2	0	0
Donation Amount (CAD)	25	5	4	1	0	0	0	0
	30	4	0	0	1	0	0	0
	40	1	1	0	1	0	0	0
	50	11	13	7	1	1	1	2
	69	0	1	0	0	0	0	0
	70	1	0	0	0	0	0	0
	75	1	0	0	0	0	0	0
	80	1	0	0	0	0	0	0
	90	1	0	1	0	0	0	0
	99	0	0	0	0	0	1	0
	100	12	30	12	8	5	4	1

Appendix C.3: Donation amount by gender

		Gender		
	Female	Genderqueer	Male	No answer
0	18	1	23	2
1	0	0	1	0
2	1	0	0	0
5	1	0	2	0
10	14	1	4	0
15	1	0	2	0
20	4	0	6	0
25	3	0	7	0
30	4	1	0	0
40	1	0	1	1
50	22	2	11	1
69	0	0	1	0
70	1	0	0	0
75	1	0	0	0
80	1	0	0	0
90	0	0	2	0
99	0	0	1	0
100	33	1	36	2

Donation Amount (CAD)

Appendix C.4: Donation amount by country

		Country		
		Canada	Other	No answer
	0	28	13	3
	1	1	0	0
	2	0	1	0
	5	1	2	0
	10	15	4	0
	15	2	1	0
	20	7	3	0
	25	9	1	0
Donation	30	4	1	0
Amount	40	3	0	0
(CAD)	50	27	8	1
	69	0	1	0
	70	1	0	0
	75	1	0	0
	80	1	0	0
	90	0	2	0
	99	1	0	0
	100	38	32	2

CHAPTER THREE: EFFECT OF SOCIAL MEDIA INFORMATION ON REPLY BEHAVIOUR

3.1 INTRODUCTION

3.1.1 Background

Historically, the definition of 'information' has been overlooked or ill-defined in academic research (McKinney Jr. and Yoos II, 2010). A minimalist definition of information is data that is meaningful or valuable to a recipient (Davis and Olson, 1985). The representation view of information argues that information must include a sign, object, and observer; for example, dark clouds (a sign) foretell a storm (object) to a hiker (observer) (McKinney Jr. and Yoos II, 2010). Information, then, is a model of something to someone (Floridi, 2005). As well, the intent of a communicator can shape the representation of information; ultimately, how information is interpreted relies on its observer.

Over time, the format in which information is conveyed has varied, with a preference for speed and ease of diffusion. News stories spread online through social media disseminate much faster and to a wider network than other news stories (Al-Rawi, 2019). Over two-thirds of American adults have used social media to read the news; 20% of American adults report doing so on a regular basis (Wu et al., 2019). While print media is at least partially regulated by the speed and cost of publishing and distribution, digital media is not limited by these factors. This has led news outlets and governments to resort to social media platforms such as Twitter to efficiently disseminate crucial information (Eysenbach, 2020).

Misinformation has been defined as false or inaccurate information that is deliberately created, though it may be intentionally or unintentionally propagated (Wu et al., 2019). Misinformation exists in many forms, including but not limited to disinformation (purposeful misinformation), fake news (false information often unknowingly shared), and rumour (unverified information). Given that content is often not checked for veracity before being uploaded online, it can be argued that social media has helped spread misinformation (Eysenbach, 2020). Some have argued that misinformation on Twitter resulted in an 'infodemic', or crisis of unreliable information, shortly after the onset of the COVID-19 pandemic.

Depending on the communicator, content, and observer, misinformation can also have varying effects on an observer. Primarily, the content of misinformation can mislead, misinform, and deceive (Treen et al., 2020). Acknowledging information as misinformation can be harmful as well; misinformation related to the COVID-19 pandemic led youth respondents to feel stress, confusion, frustration, annoyance, and anger, often due to the overwhelming presence of misinformation, rather than the content of the information itself (Borah et al., 2021). Misinformation and normative statements can also influence action; for example, negative vaccine information may contribute to vaccine hesitancy (Yiannakoulias et al., 2022). These negative

reactions to misinformation may exist in many subject areas, not just in epidemiology.

Like misinformation, opinions can also impact their observer. Opinion describes a communicator's subjective value judgement of an object or idea. Authors assert that social media and other online spaces are a nexus for the opinion formation of observers on a variety of issues, as social networks can heavily influence opinions and behaviour (Williams et al., 2015). Opinion formation can either be in support or against a subject; as an example of the latter, anti-climate change misinformation is asserted to cause scepticism, contrarianism, and denial, while pro-climate change misinformation may cause climate alarmism (Treen et al., 2020, Koonin, 2021).

3.1.2 The Value-Action Gap in Environmentalism

The disparity between one's values, intentions, or beliefs and corresponding action is known as the value-action gap (Kollmuss and Agyeman, 2002). Policymakers must take value-action gaps into account, as bridging these gaps helps achieve desired goals, such as the goal of increasing action to prevent or offset climate change. Both climate concern and climate action have historically been measured through statements of intent, often using surveys of willingness to pay (Streimikiene et al., 2019). Behaviour, rather than intent, may be more meaningful, particularly when measured experimentally, given that hypothetical stated values of intent can overstate real behaviour by up to a factor of three (List and Gallet, 2001). Notably, as of 2009, 72.3% of Canadians indicated a gap between their intentions and their actions with respect to environmentalism (Kennedy et al., 2009). Researchers have speculated that lack of knowledge, information, time, money, as well as systemic barriers are key reasons for this disparity (Kollmuss and Agyeman, 2002). Given that belief in climate change is correlated with climate action, understanding the effects of climate change information, misinformation, and opinions on pro-environmentalists is critically important.

The charitable dictator game, a derivative of the ultimatum game, is an experimental design used to measure real behaviour, and is useful for measuring statements of intention with respect to environmentalism (Hoover et al., 2018; Kahneman et al., 1986). In the dictator game, one player (the "dictator") is allocated a sum of money (the "endowment"), and is given the option to split the sum with another player (the "recipient"). This game helps researchers explore questions related to altruism in economic decision-making. In the charitable dictator game, the recipient is represented by a non-governmental organisation such as a charitable fund. The charitable dictator game is a suitable analogy for charitable donations to an environmental charity, as the dictator has full control over their decision to give money and the amount given.

Prior research involving the dictator game has focused on the influence of positive incidental emotions on decisions to share money. Incidental emotions are momentary, induced emotions unrelated to the task at hand that have an impact

on decision making (Forgas 1995). Forgas explored the role of incidental emotions in impacting argument processing, finding that positive moods led to favourable argument evaluations, while negative moods led readers to be more critical. Fear, sadness, anger, and other negative emotions may drive specific donation behaviours, such as increasing or decreasing the likelihood of donating, as well as increasing or decreasing the donation amount (Kollmuss and Agyeman, 2002; Loewenstein, 2000).

A variety of studies involving dictator games have found changes to donation amount or donation probability based on incidental emotion. A 2016 charitable dictator game study found that some positive emotions such as awe increase the amount donated by the dictator, while a 2018 dictator game study found that induced negative moods increased the probability of giving money to a recipient (Ibanez et al., 2016; Perez-Dueñas et al., 2018). As well, stress was found to increase donation frequency in subjects without strong pro-environmental beliefs, while lowering the average amount donated by both pro and non-environmentalists in yet another dictator game study (Sollberger 2016). Anger is also thought to influence decision making (Andrade and Ariely, 2009), but there has been little research as to its impact in environmental contexts. In 2019, Shreedhar and Mourato used audio-visual media of endangered animal species to explore its causal effect on charitable giving to conservation-related charities. They found that donations correlated with the treatment to which respondents were exposed, insinuating that media content influences prosocial behaviour (Shreedhar and Mourato, 2019).

3.1.3 Social Media, Social Networks, and Polarisation

Social media can be defined as an outlet for broadcasting information with a broad audience, whereas social networks are tools for connecting with others (Edosomwan et al., 2011). Given these definitions, these terms are mutually inclusive, as users on social networks may broadcast information whilst simultaneously connecting with others, though this may not always be the reality. Network analysis of social media reveals two main types of online communities: open forums, where members have mixed attitudes or values, and echo-chambers, where members are all like-minded individuals, or those who share similar views or values (Williams et al., 2015). Authors assert that echo-chambers are much more common than open forums on social media. Prior research has shown that individuals tend to alter their social media connections with a preference for information and opinions they agree with (Tokita et al., 2021), thus creating echo-chambers within one's social network. Given that echo-chambers do not present users with a diversity of information or opinion (Moe et al., 2023), they tend to cement one's existing beliefs. This can have a polarising effect on the broader social media community, as it can further divide groups with differing values (Cinelli, 2021). This is especially evident with respect to political polarisation (Tokita et al., 2021), as well as climate change belief and scepticism (Williams et al., 2015; Pearce et al., 2018; Moe et al., 2023). The

division between groups or individuals with differing values also depends on the social media platform. A study of news consumption on Facebook and Reddit revealed that Facebook exhibited greater segregation between users with opposing views (Cinelli et al., 2021). In other words, discussions of news on Reddit are more similar to the open forum community type, while on Facebook these discussions are more similar to echo-chambers.

Information cascades also contribute to the polarisation of online spaces. An information cascade is a situation in which individuals observe and spontaneously adopt the behaviour of others, allowing information and opinions to quickly disseminate throughout a network (Tokita et al., 2021). Social media are prone to information cascades, as there is a tendency for users to relay content shared by their connections without seeking the source material. These cascades may alter users' beliefs and behaviour, as well as their social connections; information spread by Twitter users has been shown to increase or decrease the number of users that follow them, for example (Tokita et al., 2021).

3.1.4 Climate Change and Conflict

Public acceptance of the climate crisis is mixed, despite overwhelming scientific evidence of its reality (Corner et al., 2012). Climate change effects vary regionally, and similarly belief in climate change is spatially-dependent (Bennett at al., 2021). As well, there are various methods of taking action to mitigate or prevent the effects of climate change, including recycling, buying local products, and participating in protesting (Kennedy et al., 2009). While some argue that social media has aided in organising the public in taking collective action to mitigate climate change (Segerberg and Bennett, 2011), it has also been argued that global collective action (between states) is needed to meaningfully address climate change (de Swaan, 2023).

A strategic issue can be defined as a condition or event which will have significant effects on an organisation or its interests (Zhang, 2013). Climate change can be considered a strategic issue based on this definition, as it has widespread impacts on industries and societies alike. According to a 2013 model, there are 4 key stages to the strategic issue management process of social media use in public diplomacy (Zhang, 2013). These are the fermentation stage (where information goes viral), the proactive phase (where a stakeholder/organisation becomes aware of information), the reactive phase (where there is a response to information), and the issue recession phase (where new information takes the spotlight). In the reactive phase, responses to information may cause conflict; in the context of public diplomacy, it is crucial for stakeholders to resolve these conflicts to achieve policy goals (Zhang, 2013). In a broader context, this conflict can be conceptualised as being between users in response to information and opinions propagated by their social network (Tokita et al, 2021).

In the case of social network conflicts, conflict can extend beyond the content of information itself, and instead manifest as incivility between social

media users. For instance, a 2017 study measuring incivility and sarcasm on Twitter in relation to climate change scepticism found correlations between discourse tone and political affiliation, though incidents of incivility in this study were low overall (Anderson and Huntington, 2017). Despite this, authors assert that sarcastic content and other attack-based tones are prevalent in social media (Anderson and Becker, 2018). As well, exposure to sarcastic comments targeted at individuals who believe climate change is a hoax have been found to increase belief certainty in and perceived risk of climate change in individuals who did not already believe climate change to be a serious issue.

Understanding and coordination in addressing climate change may be improved by social media; for example, Twitter has been used to streamline collective action by pooling organisational and information resources (Segerberg and Bennett, 2011). Contrastingly, climate change scepticism can be exacerbated through polarisation and information cascades in online spaces (Williams et al., 2015; Pearce et al., 2018; Moe et al., 2023). Given the prevalence of climate change scepticism and misinformation in online spaces, it is critical to assess their impact on the behaviour of social media users.

3.1.5 Moderation of Digital Content

While some argue that content on the internet should not be regulated in accordance with free speech principles, disrespectful use of social media enforces the need for regulation (Mello, 2022; McCosker and Johns, 2014). Cultural and nationalistic provocation such as racist content on social networking sites is one example; Australian government policy has seen a shift toward regulation of these types of media to embody better 'digital citizenship' (McCosker and Johns, 2014). Authors have argued that states tend to be key actors in regulating online content (Tai and Fu, 2020). In the case of China's social network WeChat, content regulation is dynamic, and seems to be relaxed and tightened in response to social tensions and public opinion.

Content moderation is an unpopular solution to non-state-operated social networks. Despite the prevalence of COVID-19 misinformation online leading up to 2022, social networks proved reluctant to intervene other than by flagging potentially false information as such (Gisondi et al., 2022). A cause of this reluctance may be that moderation may decrease user engagement and activity with a platform. Moderation reluctance may also result from the additional costs of implementing content filters on social media (Gisondi et al., 2022). Whether or not misinformation is filtered out, opinion is unlikely to be moderated unless it is disrespectful or disobeys the rules of a social network. This is particularly detrimental to efforts to educate and inform with respect to climate change, as misinformation and scepticism may promote further climate change scepticism, and hinder efforts to coordinate mitigation and adaptation efforts against the effects of climate change. Social media algorithms are also a subject of debate; algorithms sort, filter, and rank content to increase user interactions and engagement (Etter and Albu, 2021). While their purpose is not explicitly to reduce

the visibility of content, given that algorithms preferentially show users content based on what they are likely to engage with, all other content is essentially filtered out.

3.1.6 Hypothesis

In this study, we hypothesise that exposure to misinformation and climate change scepticism will affect the value-action gap for people with pro-environmental attitudes. Specifically, we hypothesise that people exposed to misinformation and climate change scepticism will be more likely to engage with these types of information in online spaces by replying to them, thus taking action. This hypothesis is based on observational research regarding reactions to information and opinions disseminated online (Williams et al., 2015; Anderson and Huntington, 2017). As well, we hypothesise that individuals exposed to climate change misinformation and climate change scepticism will be more likely to donate to environmental causes; this hypothesis is based on prior research that misinformation may influence prosocial behaviour (Treen et al., 2020; Perez-Dueñas et al., 2018). We test these hypotheses using an online framed field experiment in the form of a charitable dictator game in which climate action is represented by both the reply and donation behaviour of participants to the treatment post they were shown. The results provide insight into the impact of incidental misinformation and climate scepticism on reply and donation behaviour, and into the potential impact of misinformation and climate scepticism on decision making among persons with pro-environmental attitudes.

3.1.7 Research Objectives

The goal of this study was to explore the hypothesis that exposure to climate misinformation and anti-climate change opinions influence behaviour. More specifically, we hypothesise that exposure to misinformation and anti-climate change opinions increase social media response behaviour (both the proportion of readers who reply to a post and the hostility of the response) as well as the donation frequency and amount donated to environmental non-governmental organisations in a charitable dictator game by participants who reply on social media. Two research questions stem from this hypothesis:

1. What is the effect of climate-related social media information on social media reply behaviour in individuals with pro-environmental values?

2. Is donation behaviour correlated with social media reply behaviour, and what is the effect of climate-related social media information on donation behaviour of individuals who reply to social media posts?

3.2 METHODS
3.2.1 Data Collection
3.2.1.1 Overview

Participants were exposed to one of three randomised treatments: a social media post containing climate change misinformation, a post containing an anti-climate-change opinion, or an unrelated social media post (control treatment). After exposure to an experimental treatment, each participant had the opportunity to reply to the post they were shown, which measures their environmental concern and climate action. Then, they were prompted to donate a portion of their potential survey compensation to an environmental charity; donation behaviour also serves as a measure of their climate action. The effect of social media information on their reply behaviour (Research Question 1) can be drawn from the differences in reply probability and tone hostility in each treatment group. The correlation between social media reply behaviour and donation behaviour (Research Question 2) can be evaluated by comparing donation frequency and donation amount for those who did and did not reply to the treatment post.

3.2.1.2 Recruitment and Study Population

The target population of this study are adults with pro-environmental attitudes. Given that adults have greater purchasing power than children and adolescents, we predict that adults financially contribute more to environmental causes. Accordingly, we assert that adults would have greater experience with donating to environmental charities. Given that donation behaviour is a focus of this study, being above the age of majority is an inclusion criteria. As well, risk perception is influenced by social, political, and cultural factors (Bickerstaff, 2004); given that social, political, and cultural factors vary nationally (Kollmuss and Agyeman, 2002), and climate activism can be seen as an expression of risk perception, we also predict that climate activism would be correlated with country of residence. This research focuses on Canadian adults, then, as location is a potentially confounding variable with respect to environmental concern and action. Similarly, individuals with pro-environmental values are a focus of this study, as environmental concern is correlated with pro-environmental action (Kennedy et al., 2015). Therefore, one's degree of environmental concern is also a potentially confounding variable. 56 participants met the requirements for Research Question 1, as they responded to the treatment post; an ad-hoc Chi-Square power test with inputs of 50 participants, a Cohen's coefficient of 0.5 (large effect size), 2 degrees of freedom, and significance level of 0.05 yields a power of 96.7%, which represents a sufficiently powered experiment.

Participants were recruited online, through social media groups (online communities). This approach allows for targeted, direct recruitment of remote populations, such as pro-environmental individuals who actively participate on social media (King et al., 2014). The principal researcher joined Facebook and Linked-In "Groups" and Reddit "Subreddits" where membership consisted of

environmentally conscious individuals; the inclusion criteria for these communities was if members had uploaded content related to the environment or climate change within the thirty days prior to the principal researcher joining the community, thus demonstrating the presence of active environmentally-conscious users. As well, groups with Canadian content were prioritised, to maximise the likelihood of recruiting Canadian participants. Recruitment information was posted in these groups as allowed, either with prior approval by moderators of those online spaces, or by following rules written by those communities. Social media recruitment was suitable for this study, as active participation on social media (i.e., the propensity to engage with and comment on social media posts) is a salient characteristic of this study. Given that recruitment occurred on social media, in specific online communities, an implicit inclusion criterion was membership in at least one such community.

3.2.1.3 Salient Characteristics of Participants

Age, gender, location, environmental values, and social media participation are considered salient characteristics of this study. Exposure and behavioural responses to social media information and misinformation, as well as environmental values, are predicted to vary with age, gender, and location. There is a substantial gender gap in not just environmental concern, but also risk perception with respect to environmental hazards (Finucane et al., 2000; Kahan et al., 2007). Similarly, women are more likely to donate to environmental causes, independent of the influence of exposure to social media information (Eckel and Grossman, 1998; Bilén et al., 2021).

3.2.1.4 Study Design and Survey Stages

The study was conducted using the online tool LimeSurvey. The study procedure can be divided into five subsections: the measurement of salient characteristics, treatment exposure, treatment response, donation, and donation response. In sum, these stages contain 16 questions, and took approximately 5-10 minutes to complete. This is consistent with recommendations regarding the maximum number of survey questions (20) and maximum duration (13 minutes) of an online study; increases to the number of questions or duration are purported to impact respondent retention until the end of a survey (Bailey et al., 2015).

Participants' environmental values and demographic markers (age, gender, and location) were recorded in the first stage of the survey. For gender, participants were presented with four options: a) male, b) female, c) other, please specify, or d) prefer not to answer. For age, seven options were presented: age i) 18-24, ii) 25-34, iii) 35-44, iv) 45-54, v) 55-64, vi) over 65, or vii) prefer not to answer. Binning, the process of grouping data values, is a practice designed to prevent respondents from being dissuaded by perceived breach of privacy or over-specificity. Bins of 10 years after the age of 24 were chosen, as larger bins would not retain sufficient detail, and smaller bins could result in too few

respondents in each bin. Participants were then asked to select their country of residence from a drop-down list; if they were a resident of Canada or the United States, they were instead asked to select their province or state of residence, respectively. Once again, a prefer not to answer option is presented. Each participant was also asked to manually enter their city of residence, or to choose a "prefer not to answer" option. In each case, a prefer not to answer option was presented to encourage participants to skip any questions they were not comfortable answering, while still participating in the remainder of the study.

Participants were then presented a series of questions to gauge their environmental values and opinions on climate change. These questions were adapted from the New Environmental Paradigm scale, and measure attitudes about the seriousness of the climate crisis, and the role that individuals can and should play to solve it (Dunlap, 2008). The questions were altered from the NEP scale primarily to avoid differences in interpretation by participants; for example, where the NEP scale would say "humans are severely abusing the environment," "severely" was removed for this survey, as a respondent's perception of severity is an added point of complexity. More detail on the adapted NEP statements is provided in Appendix A. For each question, participants can choose one of five options on a Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," or a sixth option, "Prefer not to answer." The results of this series of questions were then translated to an effect score from 0 to 16, to represent how deviant each participant's responses were from a hypothetical ideal pro-environmental response. For example, given the above statement ("humans are abusing the environment"), the ideal response ("Strongly Agree") yields an effect score of 0; a respondent who answered "Strongly Disagree" would be awarded a score of 4. A score of 8 represents ambiguity with respect to environmental values, as the respondent would have indicated a balanced combination of pro and anti-environmental views. Respondents with an effect score of more than 7 were excluded from further analysis, given that the hypothesis focuses on the impact of information on pro-environmentalists.

A randomised treatment was applied to each participant in the second survey stage. Each participant was shown either a social media post containing climate change misinformation, a post containing an anti-climate-change opinion, or an unrelated post (control treatment). These social media posts were procured by the principal researcher in 2021, by searching for popular environment-related as well as unrelated hashtags on Facebook and Twitter, and manually screening for content containing anti-climate-change opinions or misinformation (for experimental treatments) or unrelated material (for control treatments). Two posts representing each treatment type were chosen. The posts were modified as needed, to remove personal details and for clarity; these modified posts are available in Appendix B. Treatment delivery was randomised in LimeSurvey by assigning each social media post a number from one to six; then, a random number was generated, and the post associated with that number was displayed. Selection bias describes an over-representation or under-representation of

groups in a sample; for example, if all participants assigned to a treatment were in the same income bracket, it would be impossible to conclude whether the treatment or the income had a causal relationship with the results. Similarly, confounding arises when an unobserved variable influences a relationship, leading to misinterpretations as to the relationship between the independent and dependent variable. Randomisation of control and experimental treatments is critical to balance unobserved variables between the treatments and to address unrepresentative samples in experiments, and thus offset confounding and selection bias, respectively (List, 2011).

In the third stage, each participant was asked whether they would reply to a similar post if they found it on social media, to gauge the level of engagement participants had with social media posts. Each participant was presented with three options: yes, maybe/sometimes, or no. If they chose the first or second option, they were then prompted to reply to the post. These responses serve to measure a participant's social media reply behaviour. This consists of their likelihood of replying to a post on social media, as well as the tone of their reply.

Each participant was then entered in a lottery as compensation for their participation. The lottery consisted of a $100 cash prize and expected odds of 1/200; given an estimated survey completion time of 5-10 minutes, this results in an expected value of $3-6 per hour per participant. Each participant was provided a brief overview of the Sierra Club, an environmental charity with branches in both Canada and the USA, and was then asked if they wished to donate a portion of their potential winnings to this charity. Participants then chose a value of $0-100 from a dropdown list, where the initial value is blank, and ascends from $0 below this placeholder value. This is more realistic than descending from $100, as donors begin without the decision to donate, and work their way to a donation amount from a value of $0. Conversely, beginning the dropdown menu at $100 instead anchors participants' responses to that value.

In the fifth stage, each participant was asked to comment on the factors that impacted their decision to donate to the Sierra Club, to determine if any systematic barriers to charitable donations exist. It is asserted that a range of factors including culture, upbringing, and life events can inform competitiveness, altruism, and understanding of risk and reward (Murnighan and Wang, 2016); analysis of these donation decision responses could account for these factors.

3.2.2 Data Analysis
3.2.2.1 Reply tone classification

The treatment post replies made by respondents in stage 3 are used to assess the reply behaviour of respondents, notably the tone of their responses. To assess these tones, several classification methods were used. First, the principal researcher qualitatively evaluated the content of the replies to find common themes. Several themes were present, including inquisitive (respondent asks for more information), contrasting (respondent offers differing information), argumentative (respondent angrily or profanely responds to the treatment),

sarcastic (respondent uses sarcasm in their reply), or insulting replies (respondent insults the author of the post), or agreement (respondent agrees with the treatment post). These themes can be divided into two categories: combative (argumentative, sarcastic, or insulting) or other (agreement, contrasting, inquisition).

The principal researcher then trained two natural language processing models, a bag-of-words model and a long short-term memory model, to recognise combative and other tones, using a 4800 entry dataset compiled by the principal researcher using ChatGPT (where each entry in the model training dataset is 1 sentence belonging to one of the themes identified in the survey responses dataset). These models were then used to predict the tones of the survey response dataset entries, to supplement the principal researcher's manual classification. In assessing the accuracy of a language model, it is critical to compute the model's sensitivity (true positive rate), specificity (true negative rate), and sensitivity error (false negative rate) and specificity error (false positive rate). Using the principal researcher's classification as the "true" values, the bag of words model used in Figure 3.1 yielded a sensitivity of 12.5% and a specificity of 75%; the long short-term memory model yielded a sensitivity of 0% and a specificity of 100%. While neither model is considered sufficiently accurate, given that the long short-term memory model classified all treatment post replies as the same tone, only the manual classification and the bag of words model classification were used beyond this point.

3.2.2.2 Effects of social media information on reply behaviour

The effects of social media information on reply behaviour were measured numerically using the reply rates across the different survey treatment groups. If a treatment group (independent variable) has a reply rate (dependent variable 1) or combative tone rate (dependent variable 2) higher than another, this represents differing social media reply behaviour. Comparisons were made using non-parametric alternatives to t-tests and to ANOVA. ANOVA, or Analysis of Variance, is a statistical test used to determine the differences in means between groups for parametric data. The Kruskal-Wallis test is an alternative to one-way ANOVA, used for datasets that are non-parametric. It computes the probability of obtaining the observed data assuming that the null hypothesis, that the groups from which the observations are drawn have the same distribution, is true. Similarly, t-tests are suitable for parametric data. The Pearson's chi-squared test and Fisher's exact test are used to assess the statistical significance of non-parametric data. They are used to compute the association between two categorical variables in a contingency table, the distinction being that the Fisher's exact test is used for small sample sizes.

3.2.2.3 Correlation between social media reply behaviour and donation behaviour and effect on donation behaviour of respondents

Data were stratified by the presence of a response to the treatment post and by the tone of the response (both as manually classified and as predicted by the bag-of-words model, but not the long short-term memory model) to determine if these attributes correlate with donation behaviour. If the difference in average donation amount between respondents and non-respondents varies, this represents a correlation between reply and donation behaviour. Data were also stratified by age, gender, and location to determine if any additional factors further confound the relationship between social media information and climate action. For example, given that women tend to donate more than men in dictator games, it is possible that this disparity will exist for respondents in this experiment, regardless of the experimental treatment (Donate-Buendia, 2022). If the difference in average donation amount between men and women or donation probability varies from one treatment group to another, this speaks to the causal effect of the experimental treatment on respondents.

3.2.2.4 Pre-registration

Pre-registration describes outlining a study's hypothesis, methods, and analysis prior to data collection. Having and following a pre-registration plan improves scientific research by increasing transparency and reducing the potential for retroactively formulating hypotheses, selective reporting, and other data-driven decision making. Articulating a hypothesis in advance also promotes replicability and credibility. This study was pre-registered using the Open Science Framework repository (Giese, 2023).

3.3 RESULTS

Out of 232 participants, we classified 214 (92.2%) as having pro-environmental values according to the adapted NEP scale. Fifty-six (26%) participants with pro-environmental values replied to the treatment post they were shown (herein referred to as "respondents"). Figure 1 describes the proportion of participants who replied to the treatment post as a fraction of total participants assigned to that treatment group (20/77 to the anti-climate-opinion group, 26/73 to the misinformation group, and 10/64 to the control group). These differences in reply likelihood based on treatment type were statistically significant (Pearson's chi-square test=7.057, p=0.02935); participants primed with misinformation and anti-climate change opinions were more likely to reply to their treatment post than the control group.
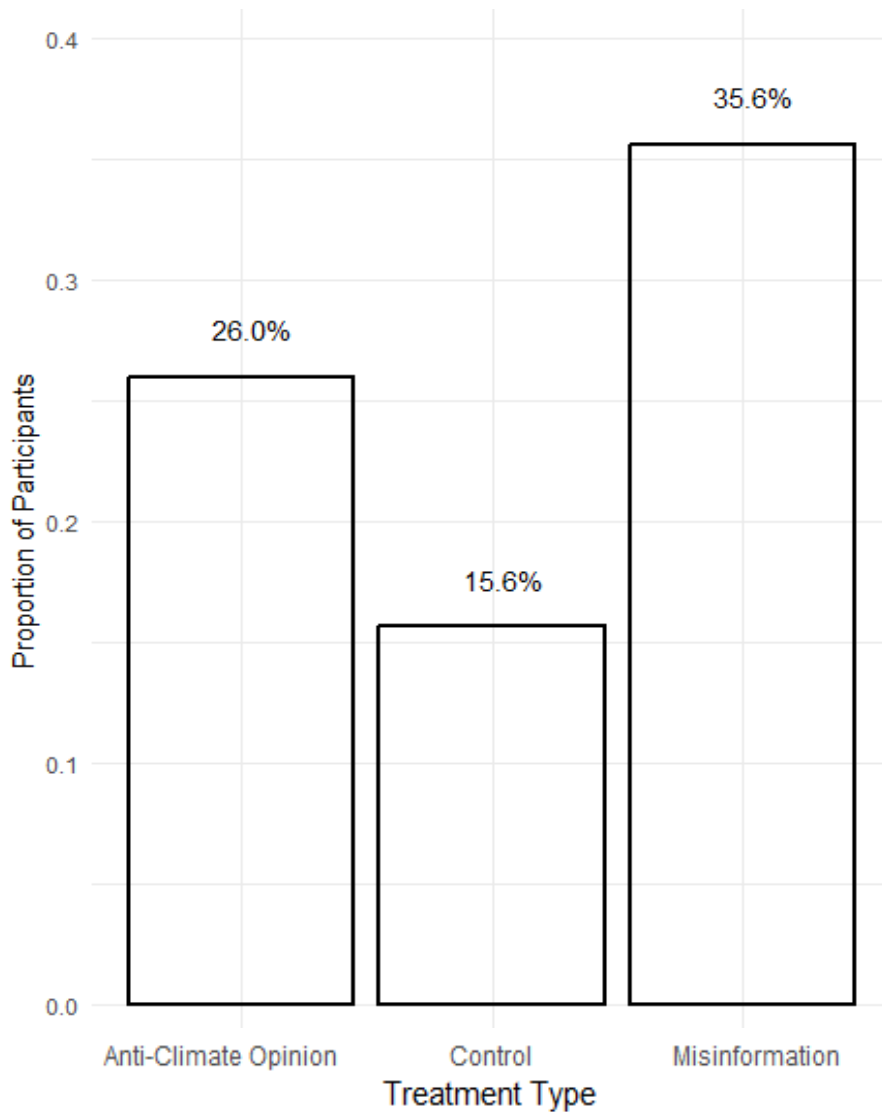
Figure 1. Proportion of participants with pro-environmental values who replied to the treatment post, grouped by treatment type

Figure 1.1 illustrates the proportion of replies to the treatment post which had a combative tone, as manually classified by the principal researcher (anti-climate-change-opinion n=6, misinformation n=2). These differences were outside of the threshold for statistical significance according to Fisher's exact test (p=0.05698).
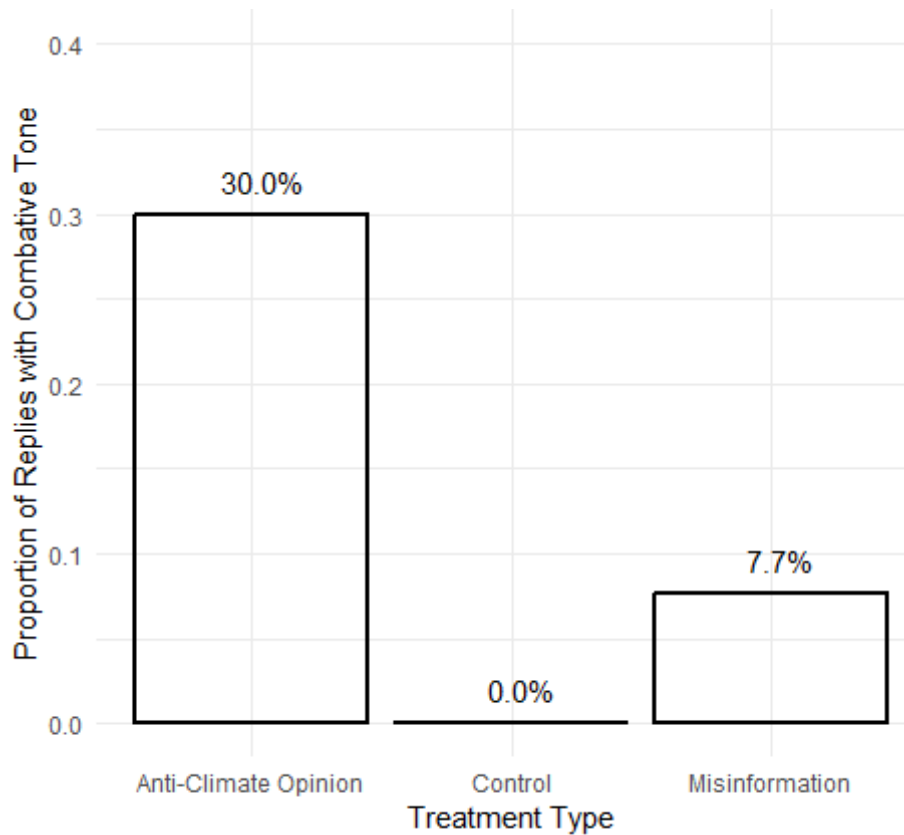
Figure 1.1. Proportion of replies to the treatment post which had a combative tone

Table 1 presents the self-designated gender of respondents across the treatment groups. Conversely, Appendix C.1 displays the dispersion of individuals of each gender across the treatment groups for all participants, not just those who replied to the treatment post. The count of treatment post replies was independent of gender, as these differences were not statistically significant (Fisher's exact test p=0.2730). Only 6/30 (20%) females assigned to the climate change scepticism treatment group chose to respond to the treatment post they were shown, while 14/42 (33.3%) of males responded to the same treatment; however, the probability of replying to each treatment type was also independent of gender (Fisher's exact test p=0.5141).

Table 1. Gender by treatment type for participants with pro-environmental values who replied to the treatment post

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Gender	Female	6	6	13
	Male	14	4	13

Table 2 demonstrates the count of respondents in each age group and treatment group. Meanwhile, Appendix C.2 displays the ages of all participants by treatment group. Notably, few participants over the age of 64 were assigned to the misinformation treatment (n=2, 0.93%). Responses per treatment group increase slightly as age decreases; however even in the 35 to 44 age group, only 7 participants (3.3%) were assigned to the control group. These age bins were aggregated as 18-44 and 45-plus to facilitate Fisher's exact test; differences in responses by age in Table 2 were not statistically significant, indicating that treatment responses are independent of age (Fisher's exact test p=0.1242). Only 4/50 (8%) participants aged 18-44 responded to the control post they were shown, compared to 14/41 (34.15%) and 19/57 (33.33%) participants aged 18-44 who responded to the climate change scepticism and misinformation posts, respectively; as a result, differences in reply probability based on age were statistically significant (Fisher's exact test p=0.0003717).

Table 2. Age by treatment type for participants with pro-environmental values who replied to the treatment post

| | | Treatment | | |
		Climate Change Scepticism	Control	Misinformation
	18 to 24	3	2	7
	25 to 34	7	2	8
Age	35 to 44	4	0	4
	45 to 54	3	2	2
	55 to 64	3	3	2
	65 plus	0	1	2

Table 3 contains location data for respondents by treatment type, in contrast to Appendix C.3, which illustrates the distribution of all participants from each location across the treatment groups. Using Appendix C.3, the proportion of total participants residing in Canada can be computed (n=139, 64.95%). This is relevant, as the focus of this study is on participants living in Canada. Differences in reply count by country of residence were not statistically significant (Fisher's exact test p=0.7550). While Canadian participants exposed to misinformation were less likely to respond (n=15, 30.6%) than other participants exposed to misinformation (n=11, 52.4%), these differences were not statistically significant (Fisher's exact test p=0.07604), indicating that reply likelihood is independent of country of residence. Only 1 (50%) respondent who was exposed to climate change scepticism did not report their country of residence.

Table 3. Country by treatment type for participants with pro-environmental values who replied to the treatment post

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Country	Canada	13	7	15
	Other	6	3	11

Figure 2 depicts the distribution of donation amounts and their mean values by respondents (mean=\$50.96) and non-respondents (mean=\$48.68) to the treatment posts. Neither the differences in amount donated (Kruskal-Wallis test=0.1352, p=0.7131) nor the correlation between replying and donating (Pearson's chi-square test=0.03497, p=0.8517) were statistically significant.
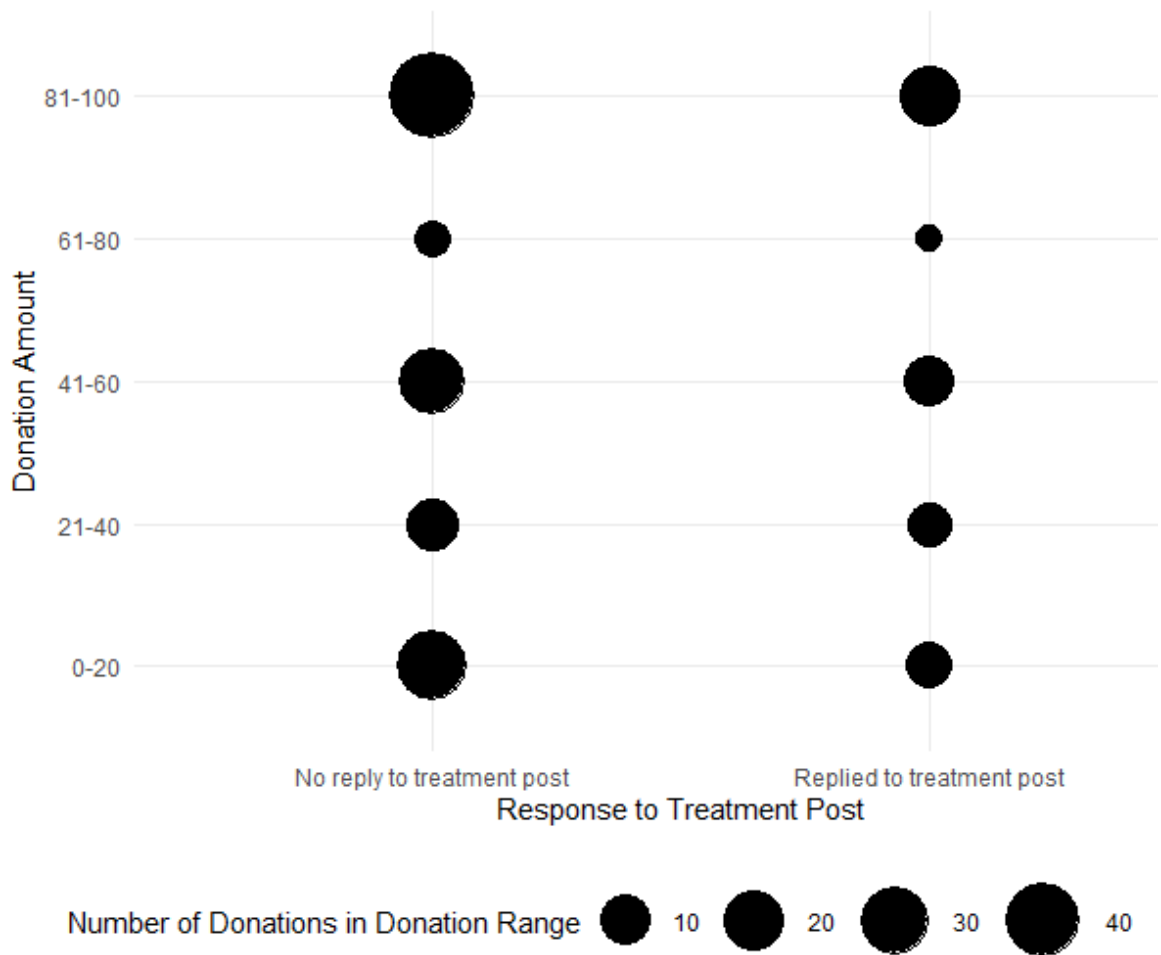
Figure 2. Scatterplot of amount donated by survey participants with pro-environmental values, grouped by their response to the treatment post

Figure 3 demonstrates the distribution of donation amounts based on the tone of the respondent's reply to the treatment post, as manually classified by the principal researcher. Mean values for these classes were also computed ($23.75 for combative responses and $55.5 for other responses). Despite the difference in means, both donation amount and likelihood were beyond the threshold for statistical significance (Kruskal-Wallis test=3.508, p=0.06108; Pearson's chi-square test=0.07071, p=0.7903). Within the "Other" class, 11 (19.64%) respondents requested the source or evidence of the information that was presented, while 9 (16.07%) respondents offered contrasting information to the treatment post.

Figure 3. Scatterplot of amount donated by participants with pro-environmental values who replied to the treatment post, grouped by the tone of their reply

Similarly, Figure 3.1 demonstrates the distribution of donation amounts based on the tone of the respondent's reply to the treatment post, as predicted by a bag-of-words natural language processing model created by the principal researcher ("Combative" mean=$48.46, "Other" mean=$51.72). Both a Kruskal-Wallis test and a Pearson's chi-square test found no differences in donation amount (Kruskal-Wallis test=0.13, p=0.7184) or likelihood (Pearson's chi-square test=0.8773, p=0.3489).
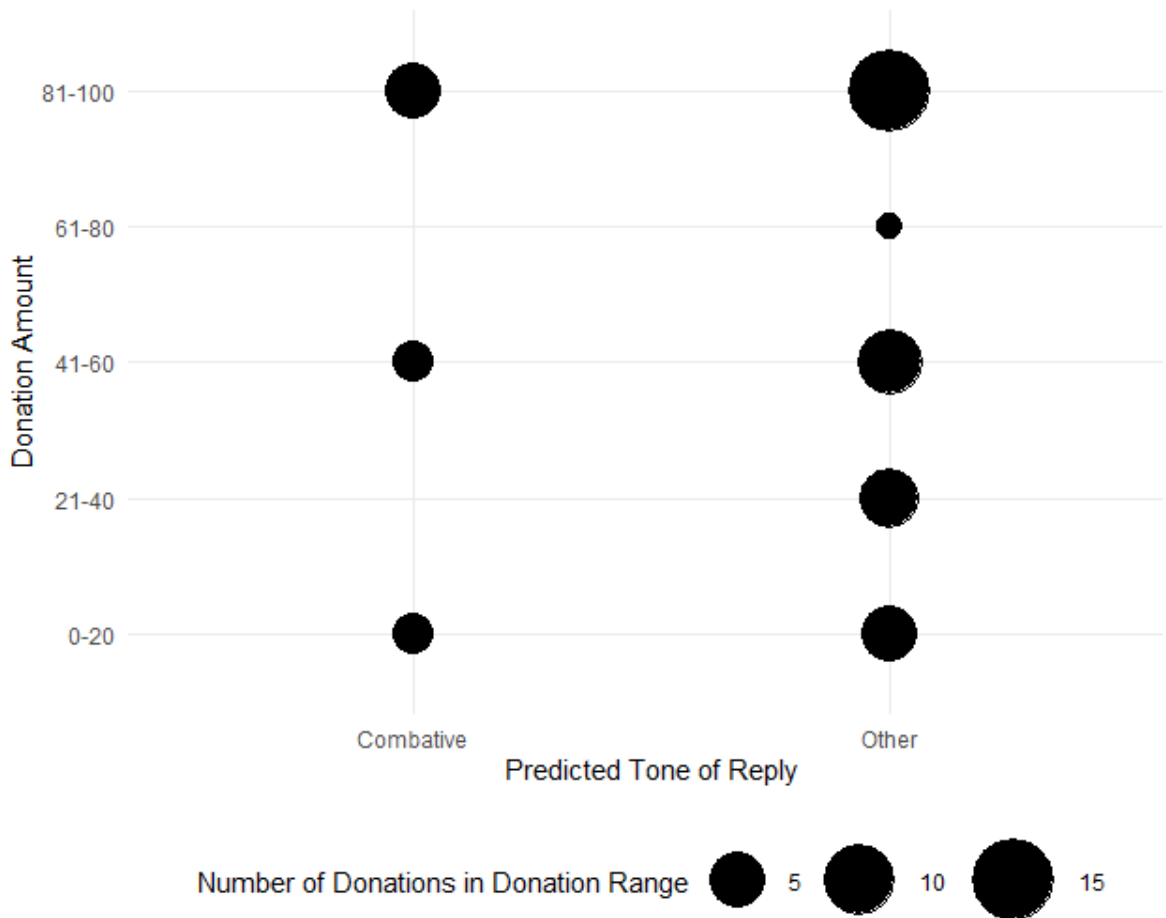
Figure 3.1. Scatterplot of amount donated by participants with pro-environmental values who replied to the treatment post, grouped by the tone of their reply as predicted by a Bag of Words model

Figure 4 describes the distribution of donation amounts by treatment type for participants who responded to the treatment post, as well as averages for each treatment group ("Anti-Climate-Opinion" mean=$47.75, "Control" mean=$59.4, "Misinformation" mean=$50.19). These average donation values differ from the average donation amounts for all participants ("Anti-Climate-Opinion" mean=$55.77, "Control" mean=$49.45 and "Misinformation" mean=$42.29) as shown in Appendix D.1. However, neither the differences in donation amounts nor donation likelihood between treatment groups for respondents (Kruskal-Wallis test=0.6895, p=0.7084; Pearson's chi-square test=3.345, p=0.1878) nor for all participants (Kruskal-Wallis test=3.735, p=0.1545; Pearson's chi-square test=2.048, p=0.3591) were statistically significant. These data are presented in more detail in Appendix C.4 and Appendix C.5.
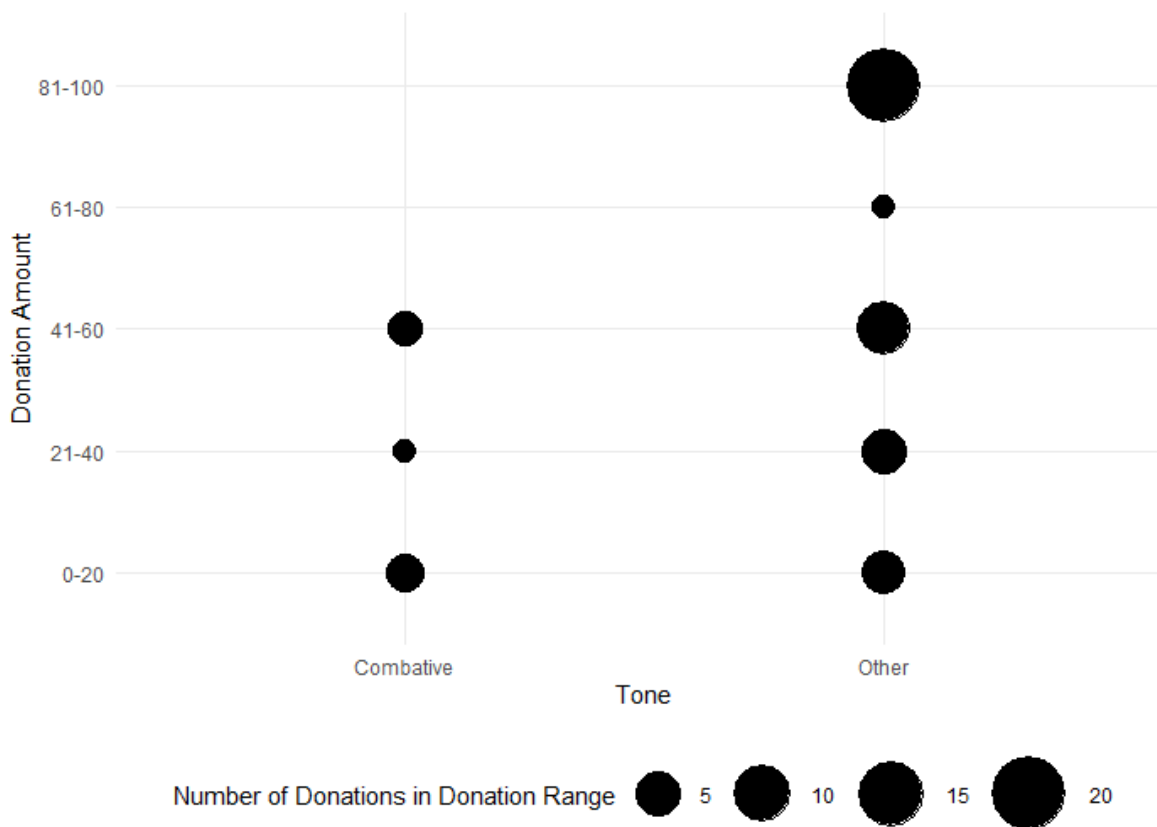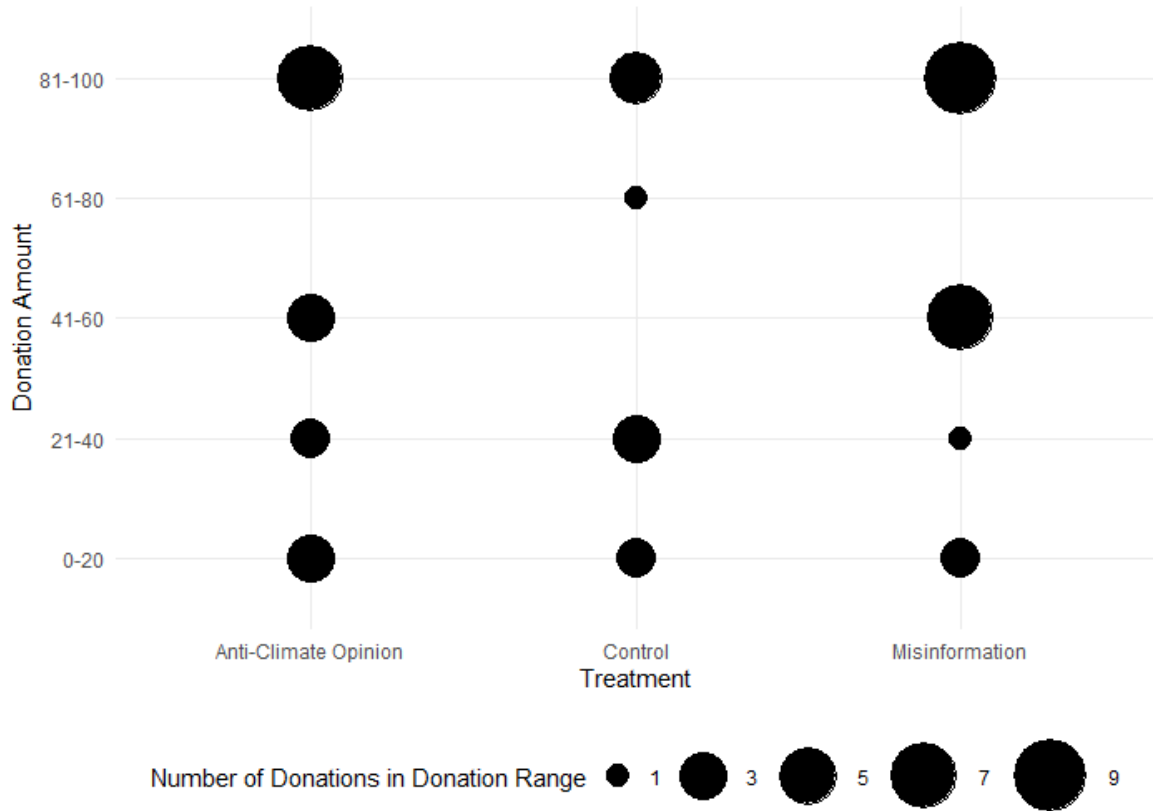
Figure 4. Scatterplot of amount donated by participants with pro-environmental values who replied to the treatment post, grouped by treatment post

Figure 5 assesses the distribution of donation amounts of respondents by age. The mean donation amounts of each age group are $50.78 (18 to 44) and $51.32 (45 plus). The donation averages for all participants are shown in Appendix D.2. As well, neither the differences in donation amounts nor donation likelihood for respondents were statistically significant (Kruskal-Wallis test=0.00965, p=0.9217; Pearson's chi-square test=0.408, p=0.523), as with the donation amounts and donation likelihoods for all participants (Kruskal-Wallis test=7.945, p=0.1593; Pearson's chi-square test=7.673, p=0.2631). Appendix C.6 and C.7 present these data in tables.
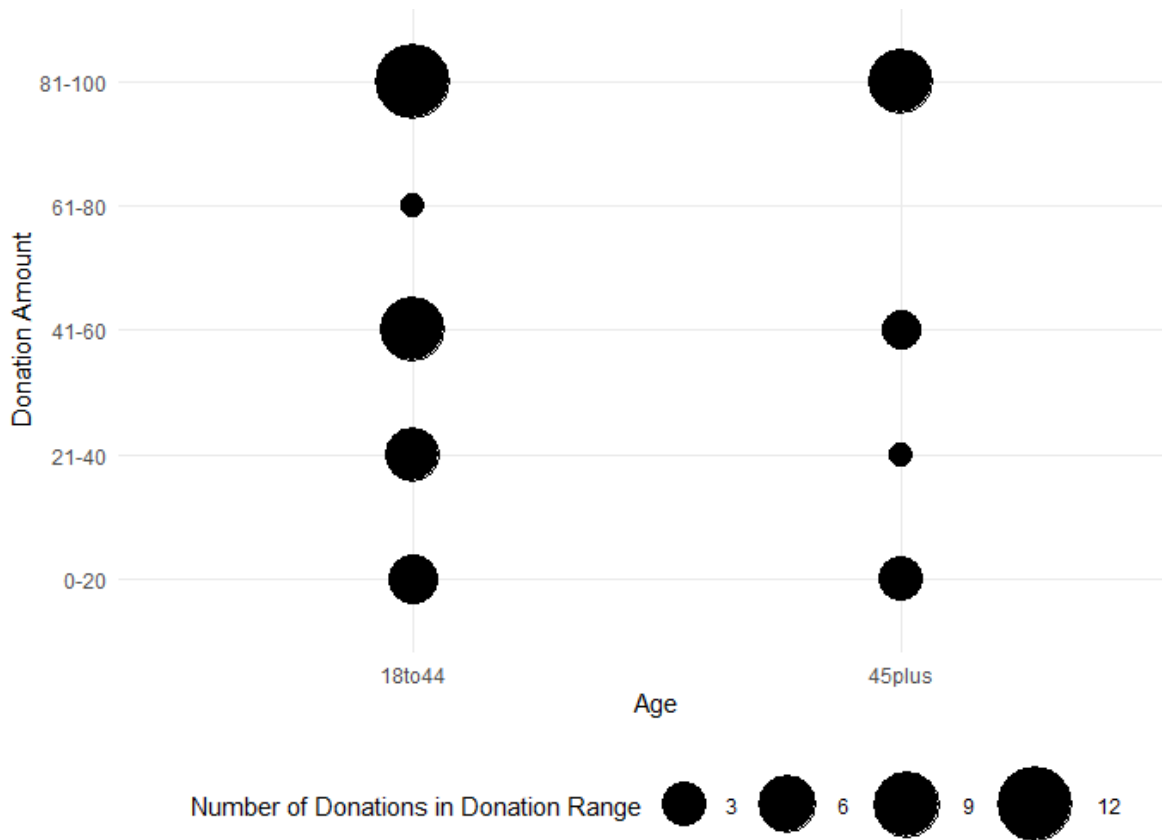
Figure 5. Scatterplot of donation amount by age for participants with pro-environmental values who replied to the treatment post, aggregated

Figure 6 demonstrates the distribution of donation amounts of respondents by gender ("Male" mean=$49.16, "Female" mean=$53.2), while Appendix D.3 illustrates the same for all participants ("Male" mean=$50.66, "Female" mean=$48.59, "Genderqueer" mean=$40), thought the differences in donation amount and likelihood among respondents (Kruskal-Wallis test=0.1338, p=0.7146; Pearson's chi-square test=0.05474, p=0.815) and among all participants (Kruskal-Wallis test = 0.1515, p=0.927; Pearson's chi-square test = 2.812, p=0.5898) were not statistically significant. Appendix C.8 and C.9 supplement these data.
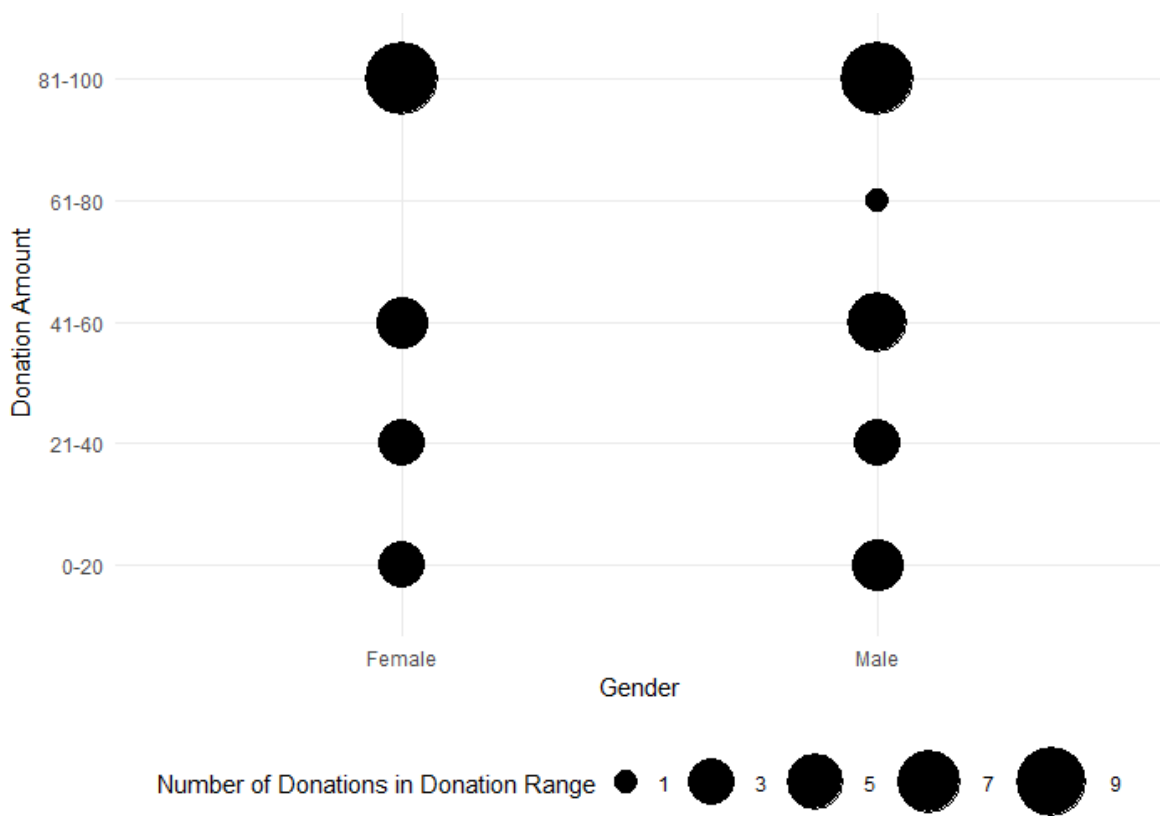
Figure 6. Scatterplot of donation amount by gender for participants with pro-environmental values who replied to the treatment post

Figure 7 demonstrates donation amounts by location of respondents, as well as average donation amounts by location ("Canada" mean=$43, "Other" mean=$67.45). For all participants (Appendix D.4) average donation amounts ranged from $45.07 (Canada) to $57.08 (else). Differences in donation likelihood and amount by country were not statistically significant for all participants (Pearson's chi-square test=3.324, p=0.1898; Kruskal-Wallis test=3.555, p=0.05936), while differences in donation amount for respondents were statistically significant (Kruskal-Wallis=6.063, p=0.04825). Differences in donation likelihood were not statistically significant, however (Pearson's chi-square test=4.2, p=0.1225). Appendix C.10 and C.11 provide additional detail of these data, as tables.
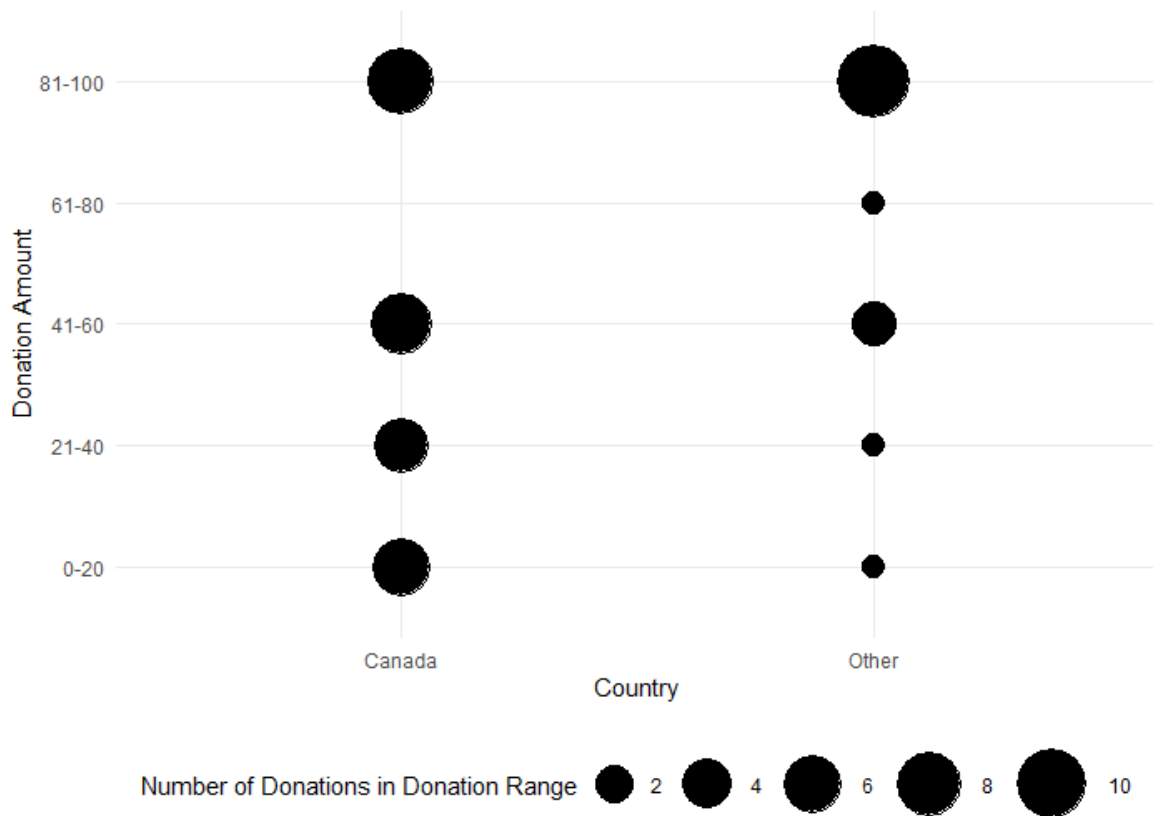
Figure 7. Scatterplot of donation amount by country for participants with pro-environmental values who replied to the treatment post

3.4 DISCUSSION

3.4.1 Research Question 1: Effect on reply behaviour

Figure 1 represents the proportion of all participants with pro-environmental values who replied to the treatment post they were shown. In this application, a p-value computed by a Pearson's chi-squared test measures the difference in proportions across the treatment groups under a null hypothesis of independence. Using a significance value (Type I error rate) of 0.05, or 5%, the null hypothesis can be rejected (Pearson's chi-square test=7.057, p=0.02935), and there is evidence of differing reply behaviour across the treatment groups and dependent on age (Fisher's exact test p=0.0003717). Meanwhile, Figure 1.1 illustrates the proportion of replies to each treatment which had a combative tone. The null hypothesis cannot be rejected in this case (Fisher's exact test p=0.05698). These results suggest that climate change scepticism and misinformation in online spaces may influence individuals with pro-environmental values to reply; misinformation is more likely to elicit a reply than any other type of information, and misinformation and climate change scepticism correlated with notable increases to reply probability for individuals 18-44 years of age compared

to individuals exposed to the control condition. This implies that efforts to filter or moderate misinformation would impact reply behaviour of pro-environmentalists, namely by reducing the frequency of replies. Conversely, climate change scepticism and misinformation have minimal effects on reply tone.

Aside from combative replies, there were several other common themes among participants' replies to the treatment; 11/56 (19.64%) respondents requested the source or evidence of the information that was presented. Meanwhile, 9/56 (16.07%) respondents offered contrasting information to the treatment post. The latter demonstrates an effort to correct or educate the fictitious author of the treatment post, and in doing so, to minimise climate misinformation and scepticism online. This is encouraging, as prior literature would suggest that social media users tend to excise individuals with opposing views from their social networks rather than have cross-attitudinal discussions (Tokita et al., 2021; Williams et al., 2015). These discussions are promising, as they present the opportunity for education, new opinion formation, and action.

Depending on the platform, social media may or may not be anonymous, and this anonymity may impact behaviour. 'Cyberbullying' describes bullying in online spaces; anonymous social media are asserted to increase the likelihood of cyberbullying and conversely authors suggest that reducing anonymity would reduce this behaviour (Barlett et al., 2018). More broadly, we posit that anonymity likely results in users more readily sharing any contrasting or combative content, due to the unlikelihood of facing physical consequences for their digital actions. Given that participation in this study was anonymous, it is possible that participants were more likely to respond to the treatment post than they would have been if the treatment post appeared in a social network of their peers.

Resistance to information and opinions on social media may also vary by the social media platform. Individuals are believed to be more receptive to attitudes of their peers than others (Williams et al., 2015), and individuals are more likely to encounter the opinions of their peers on some social network sites than others. This may have caused participants to be more sceptical of the study treatment, given that the treatment was essentially a post by an anonymous user, and not a post written by a member of their network. This scepticism on the part of the participant may have elicited inquisitive or contrasting replies, thus inflating reply likelihood. Similarly, given the hypothesis that donation amount and likelihood is negatively correlated with agreement with the content of the experimental treatments, increased scepticism may have inflated donation amount and likelihood.

Due to the incidental nature of the stimulus (i.e. the momentary exposure to a single social media post), the effect of the stimulus could similarly be incidental. Participants were first asked to respond to the treatment post, as if they saw it on social media, rather than immediately prompted to donate. It is possible that responding to the post exhausted the effect of the stimulus, thus reducing donation likelihood and donation amount. Further study is needed to ascertain if immediately prompting participants to donate would impact effect

size. As well, it is possible that if the order of donating and replying were reversed, we would see a decrease in reply frequency, if the effect of the treatment post is indeed incidental.

Conversely, it is possible that repeated exposure to the experimental treatment would influence effect size. Borah et al. 2021 found that youth were stressed by the ubiquity of climate change misinformation, not just incidental exposure to misinformation. This suggests that an experimental treatment consisting of multiple posts containing misinformation and anti-climate change opinions may have generated different findings. The present research provides evidence that minimal exposure is enough to elicit a response from pro-environmentalists on social media; it is yet unclear where more-than-incidental exposure would increase or decrease this effect.

Some participants in this study may have been less impacted by the experimental treatments because they were aware that they were outside the context of a real social media platform. Knowing that the social media posts were presented to the participants for research purposes may have influenced their emotional response when compared to a real social media post. While this study was administered as a framed field experiment, it was a simulation of a social media experience, not a real one. In order to fully immerse participants in a field experiment setting, the treatment posts would have to have been delivered directly in the feed of the participant's social media. Moreover, the posts provided, while extracted from real Facebook and Twitter posts, were not attached to a specific personality or identity. Celebrity figures, television personalities, and well known social media personalities may be more likely to elicit response and engagement (Yiannakoulias, Tooby and Sturrock 2017), and may have had a greater impact on participants had they been attached to the experimental treatment in this study. Future research should consider adding a personality, or a description of a personality.

While the time to complete the survey was not recorded in this study, this duration is likely related to whether or not participants skipped any questions. Notably, both the open text response questions in stage 3 and 5 are assumed to dramatically increase the completion time of the survey, due to the time required to devise and craft a response. Resultantly, persons who answered these open text response questions have a lower expected value than those who did not. Participants may be affected by a sunk cost, which occurs when individuals consider unrecoverable costs in decision making; one may overvalue decision outcomes, leading to inflated expected value. This may lead to suboptimal decision-making, as individuals may continue to devote resources to a recipient simply because they were already doing so, rather than for any logical reason. This would lead to an association between survey completion time and donation likelihood and amount, and obscure the relationship with the experimental treatment.

3.4.2 Research Question 2: Correlation between reply behaviour and donation behaviour and effect on donation behaviour of respondents

Given the minimal difference in average donation amount by respondents ($50.96) and non-respondents ($48.68) to the treatment posts and the minimal difference in donation likelihood by these groups, neither were statistically significant This indicates that donation behaviour may be motivated by a different process than reply behaviour. Similarly, given that both manual classification and BOW model classification of treatment post reply tone yielded minimal differences to donation amount and likelihood based on tone, reply tone is also not a strong predictor of donation behaviour. Further research is needed to determine the processes which influence donation behaviour in pro-environmentalists.

Minimal differences to donation amount and frequency based on experimental treatment (Figure 4), age (Figure 5) and gender (Figure 6) indicate that these factors are not correlated to donation behaviour of individuals who replied to their experiment treatment. Conversely, differences in donation amount (but not likelihood) based on location of respondents (Figure 7) were statistically significant (Kruskal-Wallis=6.063, p=0.04825; Pearson's chi-square test=4.2, p=0.1225). This may indicate that Canadians are more critical of the efficacy of donations as a method of combating climate change; or, respondents may have taken issue with the designated organisation, the Sierra Club. Canadians are more likely to have information about the Sierra Club than other participants, given that the Sierra Club has a Canadian chapter. Responses in Stage 5 of the survey suggest that some respondents had previous, negative information in relation to the Sierra Club; this could have negatively impacted donation amounts.

Prior literature would suggest that men donate less than women in dictator games (Eckel and Grossman, 1998; Bilén et al., 2021). Contrarily, we also found minimal differences to average donation amount based on gender, indicating that this disparity in donation behaviour may not exist among pro-environmentalists. Specifically, the average donation amount by males rose to 49.16% of the endowment, whereas in a meta-analysis of giving in charitable dictator games, the global endowment donation average (i.e. the average amount donated by males and females together) was only 32% (Bilén et al., 2021). Contrastingly, the global endowment donation average in this study was 50.96%. This implies that both men and women with pro-environmental values donate substantially more to pro-environmental causes than the aggregate give in dictator games in general. This highlights the importance of developing strong values with respect to nature or any other cause, as these connections seem to correlate with increased donation amount. It also implies that environmental concern elicits higher than average donations from survey participants, indicating that environmental concern is potentially a more imminent concern to men and women alike than many other causes.

3.4.3 Implications

These results suggest that the reply behaviour of pro-environmentalists is more sensitive to exposure to the experimental treatment than donation behaviour. It is possible that participants viewed replying as a benign task with little upside or downside, whereas donating would have resulted in the loss of potential winnings. In other words, when something tangible is at stake, individuals are more resistant to the experimental treatment than when something intangible is at stake. In a broader sense, this may speak to how pro-environmental individuals value the opportunity cost of time compared to that of money. If participants were more willing to spend time than money in this experiment, this may extrapolate to behaviour in real-world contexts. Rather than asking individuals to donate money, non governmental organisations may have more success in encouraging other forms of participation. It is unclear whether directly presenting these options to participants would yield the same results as in this experiment, however; participants may have been more willing to reply in this experiment due to not being presented with an estimate of the time required to reply to the treatment post, while participants may be less willing to volunteer their time if they are provided with a time estimate, or if the estimated duration is longer than they are comfortable with. As well, it is possible that there is an intercept between the opportunity cost of time and money; in other words, there may be a point at which rather than volunteering time, participants would instead prefer to donate. It is also possible that the order of stages in this experiment impacted participant behaviour. If participants were first prompted to donate, then prompted to reply to the treatment post, this may have yielded different results; namely, we would expect to see an increase in donation amount and likelihood, due to the prompt to donate immediately following the experimental treatment.

In 2015, Kennedy et al. explored the notion that the scientific community may not be 'counting what counts' with respect to pro-environmental behaviour, arguing that traditional measures were not sufficiently broad to capture the range of climate mitigating behaviours employed by the public. Similarly, while donations may be a more direct example of climate activism, reply behaviour has the potential to influence others to take climate action as well (Williams et al., 2015). For instance, while it is possible that witnessing someone else donate to a cause may indirectly persuade others to donate through social pressure or social desirability bias, it is also possible that cross-attitudinal discussions on social media could meaningfully change one's mindset with respect to serious issues, which could cause profound changes to behaviour. This latter point is significantly more nuanced and tedious to measure, and thus represents a substantial challenge in ascertaining the long-term effects of cross-attitudinal discussions on social media.

While this study used climate change misinformation and opinion as experimental treatments, various other types of information and opinion were equally suitable. There is a wealth of observational research to suggest that negative vaccine information (Yiannakoulias et al., 2022), COVID-19

misinformation (Borah et al., 2021; Gisondi et al., 2022) and election misinformation and fake news (Wu et al., 2019) pervade onlines spaces. Despite some evidence as to the negative effects of this content in prior literature, this experiment instead found promising results. It is possible that these results could be replicated by substituting the experimental conditions with content from any other subject area, and modifying the participant demographic to encompass individuals strongly aligned with a pole within the chosen subject domain. However, these results do not encompass all observers; further research is necessary to adequately measure the effect of misinformation and anti-climate change opinions on the general population. If these results are indeed generalisable, this would cement the importance of accruing knowledge, forming opinions, upholding values with respect to key issues, in order to be resistant to negative information and opinions.

The decision of whether or not to and the extent to which digital content should be moderated has been an ongoing debate (Mello, 2022; McCosker and Johns, 2014). Cost is a primary consideration in the anti-moderation argument (Gisondi et al., 2022). Moderation or filtration of digital content requires either additional staff to manually remove content, or additional computational resources for automated removal. Some predict that moderation reduces user engagement (Gisondi et al., 2022). Comparatively, moderation confers few benefits to a social network. This study provides some evidence that climate change misinformation and anti-climate change opinions increase user engagement, while maintaining donation behaviour. This suggests that moderation would not necessarily be beneficial, as it would minimise communication between groups with opposing views, further polarising those groups. If these results extrapolate to other subject areas, this would greatly contest the utility of moderating digital content. Meanwhile, social media algorithms play a vital role in maintaining user engagement (Etter and Albu, 2021). Regardless of whether or not content is moderated, social media users effectively control their own experience based on the content they choose to engage with; despite evidence from this study that users who care about a subject tend to reply to misinformation and cross-attitudinal content, the solution to seeing this content may simply be restraint.

3.4.4 Strengths, Limitations, Future Work

This study aimed to closely mimic real exposure to incidental misinformation and anti-climate change opinions to participants by presenting the text from real social media posts. This study is considered a framed field experiment given its similarity to real-world conditions. Framed field experiments are minimally invasive to participants (List, 2011), which reduces the extent to which results are impacted by the participant's knowledge that they are being observed, otherwise known as the Hawthorne effect.

As well, given the brief exposure to the experimental treatment, these interventions are minute. Treatments were not labelled as misinformation or

climate scepticism, and instead left participants to draw their own conclusions about the content of the information they were shown. We assert that labelling the treatments would have inflated effect size, as participants would have had a heightened awareness of the experimental design. It is preferable to minimise pressures such as these to effect size, as this influences the external validity of the experiment.

We also acknowledge some limitations to this experiment. Analysis of the fifth stage of the survey, where participants commented on their decisions to donate, revealed a commonality – many respondents held negative views of the Sierra Club, the organisation that was chosen as the donation recipient. The choice of donation recipient was difficult; it is asserted that a specific recipient is necessary, otherwise donation decisions would be too intangible to participants to be meaningful. On the other hand, most non-governmental organisations suffer from either current or past controversy. Familiarity with the Sierra Club, then, may correlate with donation likelihood or amount.

This study used natural language processing models to supplement the principal researcher's classification of open-text response tone. While this was reasonably effective, and did not come to differing conclusions from the manual classification (with respect to differences in donation amount or likelihood), sensitivity and specificity analysis of the bag-of-words model (12.5% and 75%, respectively) and the long short-term memory model (0% and 100%, respectively) yielded significant room for improvement in the models' accuracy.

This study produced qualitative data regarding participants' responses to the study treatments (stage 3) and insight regarding donation decision-making (stage 5). Sentiment analysis describes the distillation of statements to their base sentiment, either positive or negative. A sentiment analysis of the open-text responses from stage 3 and 5 of this study could ascertain whether the experimental treatment was linked to sentiment, and similarly whether sentiment was linked to donation behaviour.

As well, this experiment targeted adults with pro-environmental values, and did not meaningfully address donation behaviour of residents of any other specific nation. It is unclear how participant location affects the relationship between the experimental treatment and donation behaviour beyond what is demonstrated in Figure 5. Future research should consider comparing donation behaviour between specific nations, as global collective action is needed to address climate change.

There is little evidence as to the effect of more-than-incidental emotion on decision making. Authors have asserted that repeated or sustained exposure to misinformation led to negative feelings such as sadness and anger in youth, not just incidental exposure (Borah et al., 2021). The effect of repeated exposure to misinformation or anti-climate change opinions has yet to be explored. It is possible that the incidental exposure provided by this experiment was insufficient to impact donation behaviour, though perhaps a critical amount of exposure would. Conversely, it is possible that oversaturation to these media may instead

lead to feelings of hopelessness, which may negatively impact donation behaviour.

Further research is needed to determine the processes which influence donation behaviour in pro-environmentalists; this study exhausted the possibility that minimal exposure to anonymised social media posts influence this behaviour after first replying to a post, and instead only influence reply behaviour. The effect of reply behaviour on other social media users and online spaces would also benefit from further research. Finally, research into the intent of social media users in replying to content they disagree with online is a pertinent avenue for exploration, as the varying tones of respondents would suggest various motivations for participating in online discussions.

3.5 CONCLUSION

This study sought to establish whether views contrary to one's own values would nudge individuals to reply on social media, and if so, in what manner (Research Question 1); as well, we sought to determine whether donation behaviour correlated with social media reply behaviour (Research Question 2). We found that misinformation and anti-climate change commentary resulted in statistically significant differences to reply likelihood (p=0.02935); reply likelihood was also dependent on the age of participants (p=0.0003717). Meanwhile, the experimental treatments resulted in minimal differences to reply tone. Donation behaviour of pro-environmentalists was not correlated with the experimental treatments, reply behaviour, nor any demographic factors, with the exception of location of residence; residence in Canada was strongly and negatively associated with donation amount (p=0.04825). These results suggest that climate-change misinformation and anti-climate change opinions presented through social media may influence the reply behaviour of pro-environmentalists. Further research into the effect of this reply behaviour on other social media users and online spaces, as well as whether or not these observations apply to the general population and other subject domains, is necessary, as would research into the intent of social media users in replying to content they disagree with online. These results also suggest that the gender disparity in dictator game endowment giving does not exist in environmentalism, and that pro-environmental men and women donate substantially more to environmental causes than the aggregate give in dictator games in general (Bilén et al., 2021). These results call the necessity of moderating misinformation and scepticism in online spaces into question, as there is some evidence that this content does not negatively affect prosocial behaviour, and instead may encourage cross-attitudinal discussion. If these results do generalise to the general population, this suggests that propagation of misinformation and climate change scepticism on social media may in fact help to foster discussion in these topics; while a non-traditional measure of climate activism, the long-term impacts of social media discussions may be a pertinent avenue for exploration.

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Appendix A – Adapted New Environmental Paradigm Statements

1. "Humans are abusing nature and the environment."

    This statement was chosen as anthropogenic climate change (the notion that humans play a role in deteriorating the state of the environment) is a key tenet of contemporary pro-environmental values.

    Strong agreement with this statement results in an effect score of 0.

2. "The 'ecological crisis' facing humanity is an over-exaggeration."

    This statement addresses the seriousness of the climate crisis; disagreement with it is considered a stronger pro-environmental stance.

    Strong disagreement with this statement results in an effect score of 0.

3. "Each one of us can reduce the effects of climate change."

    Given that individuals are more likely to take pro-environmental action if they believe their contributions to be meaningful, agreement with this statement represents stronger pro-environmental values.

    Strong agreement with this statement results in an effect score of 0.

4. "Climate change is only caused by the pollution from industries."

    Allocating blame solely on corporations serves as an antithesis to statement #3.

    Strong disagreement with this statement results in an effect score of 0.

Appendix B – Survey Treatments
Misinformation

1. "Interesting -- studies show that wind farms have a warming effect on the climate"

2. "Peer-reviewed study reveals majority of scientists are skeptical of '#globalwarming crisis' #ecoscam #greenscam"

Climate Change Scepticism

3. "My deck is already covered in snow this morning, and it's not yet October. Thank goodness Canada is warming sooo much faster than the rest of the world, right @cathmckenna ? #cdnpoli #ABstorm #ABweather #ClimateScam"

4. "Two Canadian Coast Guard ships sent to rescue U.S. freighter stuck in ice. #globalwarming?"

Control

5. "In the largest single release of whole genomes ever, the #UKBiobank has unveiled to scientists the entire genomes of 200,000 people who are part of a long-term British health study."

6. "Until now, scientists eager to learn more about chimps' behavior could spend weeks combing through raw footage—but a new #AI system can do the grunt work for them."

Appendix C – Supplemental Tables

Appendix C.1: Gender by treatment type for participants with pro-environmental values

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Gender	Female	30	35	40
	Genderqueer	3	2	1
	Male	42	24	31
	No answer	2	3	1

Appendix C.2: Age by treatment type for participants with pro-environmental values

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Age	18 to 24	19	22	23
	25 to 34	31	21	23
	35 to 44	11	7	11
	45 to 54	6	4	8
	55 to 64	4	6	5
	65 plus	3	3	2
	No answer	3	1	1

Appendix C.3: Country by treatment type for participants with pro-environmental values

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Country	Canada	46	44	49
	Other	29	19	21
	No answer	2	1	3

Appendix C.4: Donation amount by treatment type for participants with pro-environmental values

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Donation Amount (CAD)	0	14	11	19
	1	0	1	0
	2	0	0	1
	5	1	1	1
	10	4	7	8
	15	2	0	1
	20	4	4	2
	25	3	2	5
	30	2	3	0
	40	0	3	0
	50	13	8	15
	69	0	1	0
	70	0	0	1
	75	1	0	0
	80	1	0	0
	90	0	2	0
	99	1	0	0
	100	31	21	20

Appendix C.5: Donation amount by treatment type for participants with pro-environmental values who replied to the treatment post

		Treatment		
		Climate Change Scepticism	Control	Misinformation
Donation Amount (CAD)	0	5	0	7
	5	0	1	0
	10	1	1	1
	20	2	0	1
	25	1	0	1
	30	1	1	0
	40	0	2	0
	50	3	0	7
	69	0	1	0
	100	7	4	9

Appendix C.6: Donation amount by age for participants with pro-environmental values

		Age						
		18-24	25-34	34-44	45-54	55-64	65 plus	No answer
Donation Amount (CAD)	0	15	10	5	4	6	2	2
	1	0	1	0	0	0	0	0
	2	0	0	0	1	0	0	0
	5	0	2	0	0	1	0	0
	10	6	9	2	2	0	0	0
	15	2	0	1	0	0	0	0
	20	4	4	0	0	2	0	0
	25	5	4	1	0	0	0	0
	30	4	0	0	1	0	0	0
	40	1	1	0	1	0	0	0
	50	11	13	7	1	1	1	2
	69	0	1	0	0	0	0	0
	70	1	0	0	0	0	0	0
	75	1	0	0	0	0	0	0
	80	1	0	0	0	0	0	0
	90	1	0	1	0	0	0	0
	99	0	0	0	0	0	1	0
	100	12	30	12	8	5	4	1

Appendix C.7: Donation amount by age for participants with pro-environmental values who replied to the treatment post

		Age					
		18-24	25-34	35-44	45-54	55-64	65 plus
Donation Amount (CAD)	0	4	3	0	2	3	0
	5	0	0	0	0	1	0
	10	1	1	0	1	0	0
	20	0	2	0	0	1	0
	25	0	2	0	0	0	0
	30	2	0	0	0	0	0
	40	0	1	0	1	0	0
	50	2	2	4	0	1	1
	69	0	1	0	0	0	0
	100	3	5	4	3	3	2

Appendix C.8: Donation amount by gender for participants with pro-environmental values

		Gender			
		Female	Genderqueer	Male	No answer
Donation Amount (CAD)	0	18	1	23	2
	1	0	0	1	0
	2	1	0	0	0
	5	1	0	2	0
	10	14	1	4	0
	15	1	0	2	0
	20	4	0	6	0
	25	3	0	7	0
	30	4	1	0	0
	40	1	0	1	1
	50	22	2	11	1
	69	0	0	1	0
	70	1	0	0	0
	75	1	0	0	0
	80	1	0	0	0
	90	0	0	2	0
	99	0	0	1	0
	100	33	1	36	2

Appendix C.9: Donation amount by gender for participants with pro-environmental values who replied to the treatment post

		Gender	
		Female	Male
Donation Amount (CAD)	0	5	7
	5	0	1
	10	3	0
	20	0	3
	25	0	2
	30	2	0
	40	1	1
	50	4	6
	69	0	1
	100	10	10

Appendix C.10: Donation amount by country for participants with pro-environmental values

|		Country		
		Canada	Other	No answer
Donation Amount (CAD)	0	28	13	3
	1	1	0	0
	2	0	1	0
	5	1	2	0
	10	15	4	0
	15	2	1	0
	20	7	3	0
	25	9	1	0
	30	4	1	0
	40	3	0	0
	50	27	8	1
	69	0	1	0
	70	1	0	0
	75	1	0	0
	80	1	0	0
	90	0	2	0
	99	1	0	0
	100	38	32	2

Appendix C.11: Donation amount by country for participants with pro-environmental values who replied to the treatment post

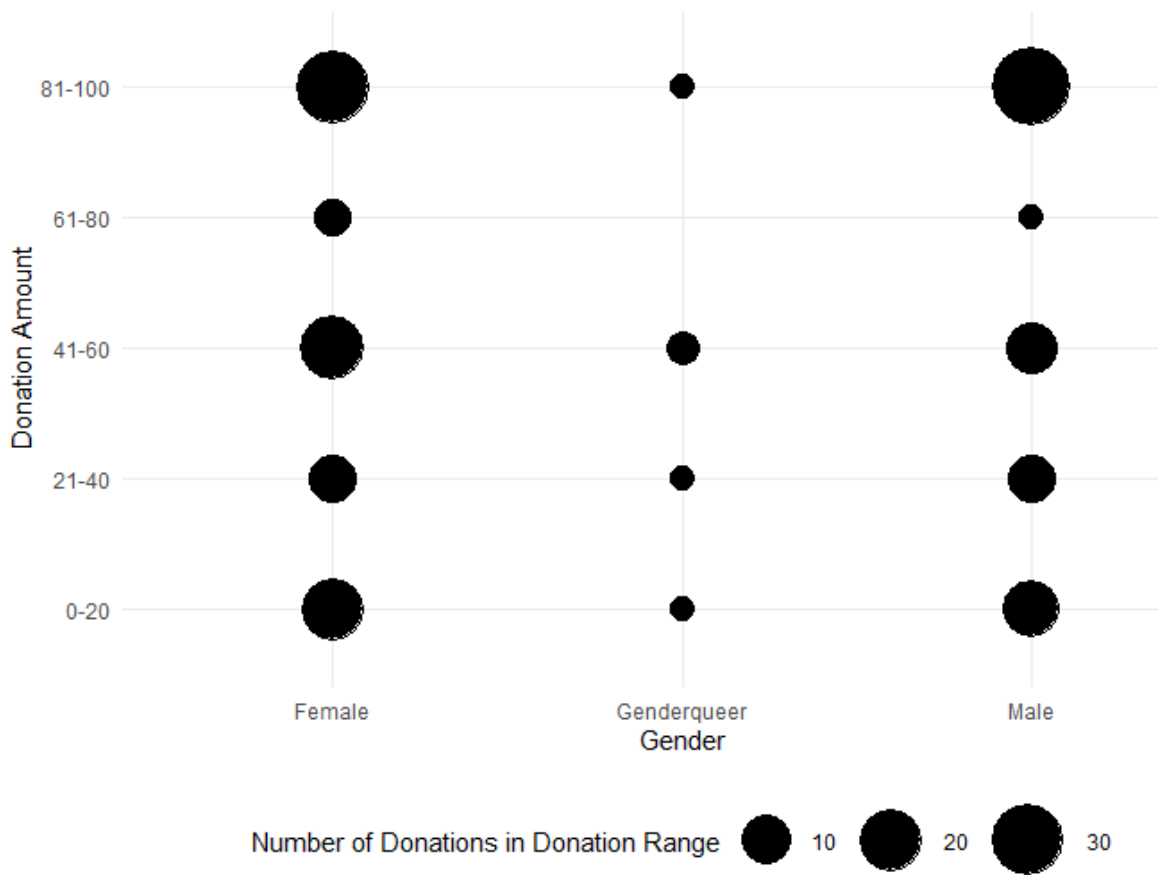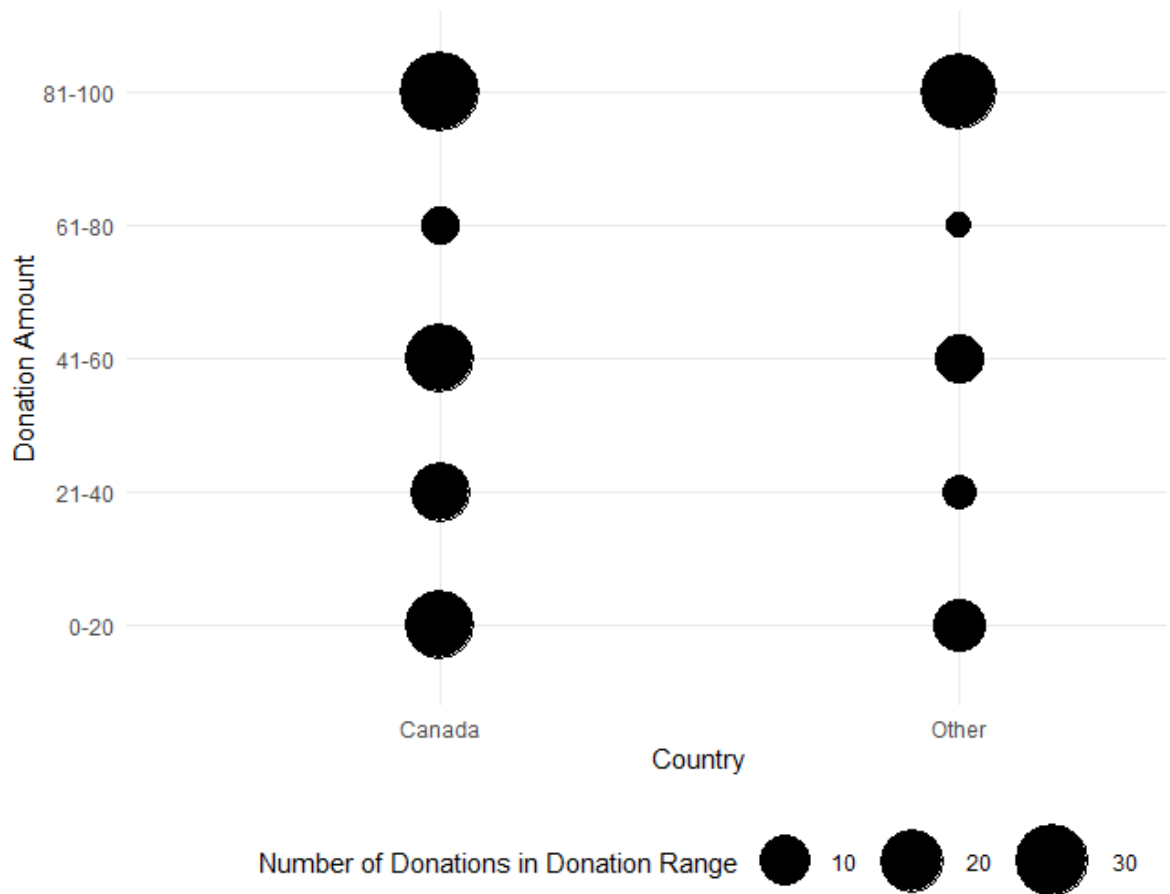|		Country		
		Canada	Other	No answer
Donation Amount (CAD)	0	8	3	1
	5	0	1	0
	10	3	0	0
	20	3	0	0
	25	1	1	0
	30	2	0	0
	40	2	0	0
	50	7	3	0
	69	0	1	0
	100	9	11	0

Appendix D – Supplemental Figures
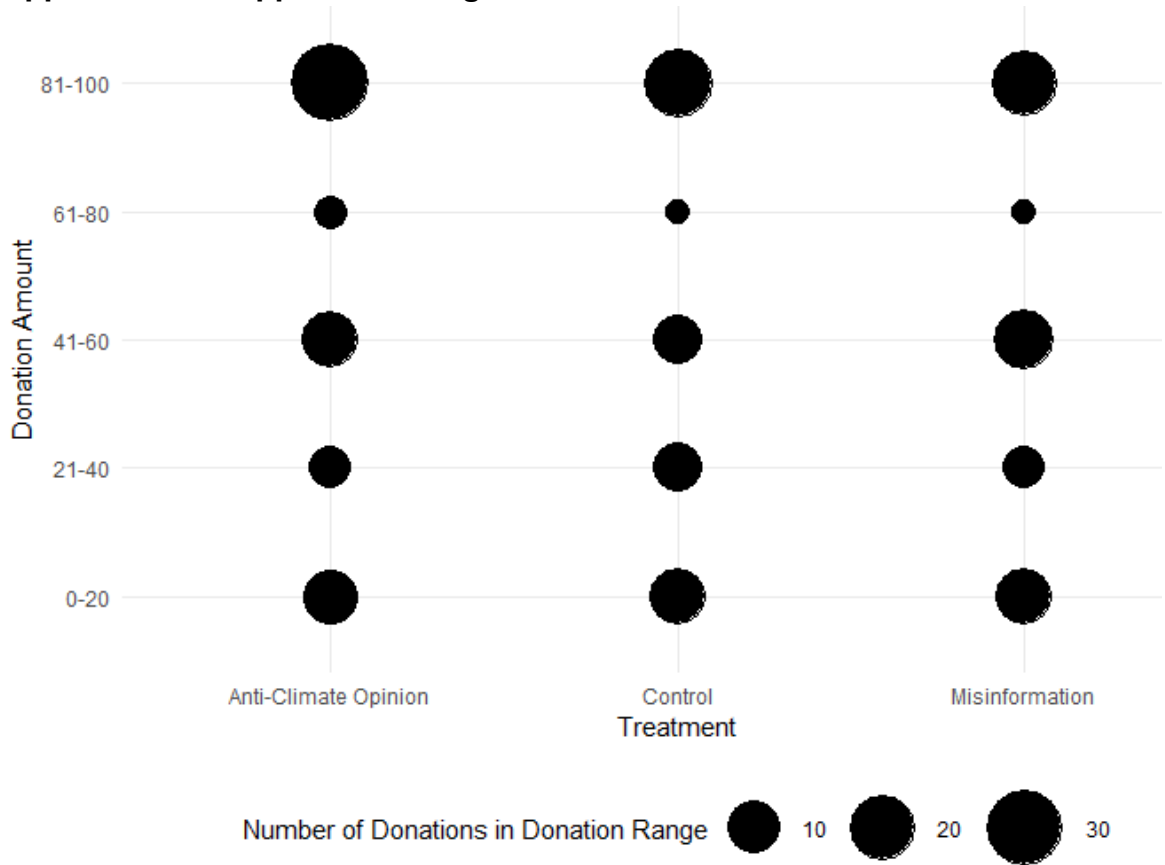
Appendix D.1: Scatterplot of donation amount by treatment type for participants with pro-environmental values
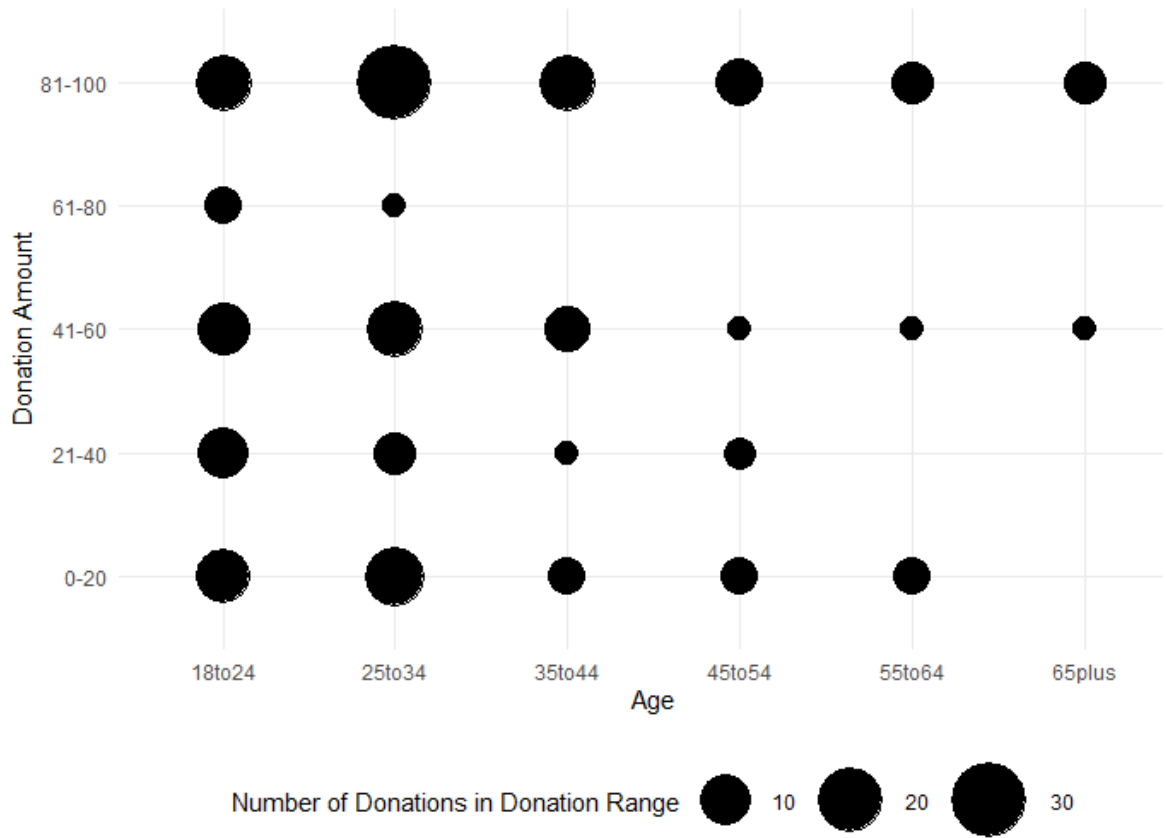
Appendix D.2: Scatterplot of donation amount by age for participants with pro-environmental values

Appendix D.3: Scatterplot of donation amount by gender for participants with pro-environmental values

Appendix D.4: Scatterplot of donation amount by country for participants with pro-environmental values

CHAPTER FOUR: CONCLUSION
4.1 INTRODUCTION
This study sought to measure the effect of exposure to climate change misinformation and anti-climate change opinions on the action of pro-environmentalists. Chapter 2 used a charitable dictator game to measure donation amount variation by treatment group, age, gender and location of participants, and presented these findings using scatter plot graphs. Chapter 3 measured participants' reply frequency by treatment group, age, gender and location, compared average donation amounts between respondents and non-respondents, between respondents who responded in a combative tone and those who did not, and between respondents when grouped by treatment, age, gender, and location.

4.2 SUMMARY OF MAJOR FINDINGS
Chapter 2 revealed that misinformation and anti-climate change commentary result in minimal differences to donation likelihood and amount to a pro-environmental charity. Age, gender, and location were not correlated with donation likelihood nor amount.

These results suggest that pro-environmentalists are resistant to climate-change misinformation and anti-climate change opinions presented through social media. These results also call into question the necessity of moderating misinformation and climate scepticism in online spaces, as there is some evidence that this content does not negatively affect prosocial behaviour. Further research into whether these observations apply to the general population is necessary, as would research into the motivations and sentiment towards donating to environmental non-governmental organisations in general. If these results do generalise to the general population, this calls the necessity of filtering misinformation on social media into question. It is asserted that social media fosters division and polarisation between groups through the formation of "echo-chambers" of like-mindedness, furthering one's own beliefs and estranging them from others who do not share their views (Cinelli, 2021). It is possible that moderation of misinformation and negative opinions discourages debate between social media users, which would serve to further entrench this gap in understanding.

In Chapter 3, we found that misinformation and anti-climate change commentary resulted in statistically significant differences to reply likelihood (p=0.02935); reply likelihood was also dependent on the age of participants (p=0.0003717). Meanwhile, the experimental treatments resulted in minimal differences to reply tone. Donation behaviour of pro-environmentalists was not correlated with the experimental treatments, reply behaviour, nor any demographic factors, with the exception of location of residence; residence in Canada was strongly and negatively associated with donation amount (p=0.04825). These results suggest that climate-change misinformation and anti-climate change opinions presented through social media may influence the

reply behaviour of pro-environmentalists. Further research into the effect of this reply behaviour on other social media users and online spaces, as well as whether or not these observations apply to the general population and other subject domains, is necessary, as would research into the intent of social media users in replying to content they disagree with online. These results also call the necessity of moderating misinformation and scepticism in online spaces into question, as there is some evidence that this content does not negatively affect prosocial behaviour, and instead may encourage cross-attitudinal discussion. If these results generalise to the general population, this suggests that propagation of misinformation and climate change scepticism on social media may in fact help to foster discussion in these topics; while a non-traditional measure of climate activism, the long-term impacts of social media discussions may be a pertinent avenue for exploration.

4.3 CONCLUSIONS

This study measured reply and donation behaviour of pro-environmentalists exposed to climate change misinformation and anti-climate change opinions to determine whether these media affect behaviour. The results paint a mixed picture of the impact of these media; they suggest that reply behaviour is more sensitive to exposure to the experimental treatment than donation behaviour. They also suggest that the gender disparity in dictator game endowment giving does not exist in environmentalism, and that pro-environmental men and women donate substantially more to environmental causes than the aggregate give in dictator games in general (Bilén et al., 2021). These results call the necessity of moderating misinformation and scepticism in online spaces into question, as there is some evidence that this content does not negatively affect the prosocial behaviour of pro-environmentalists, and instead may encourage cross-attitudinal discussion. These results do not represent all observers, however; further research is necessary to adequately measure the effect of misinformation and anti-climate change opinions on the general population. If these results generalise to the general population, this suggests that propagation of misinformation and climate change scepticism on social media may in fact help to foster discussion in these topics. As Kennedy et al. suggested in 2015, environmental social science may occasionally be narrow-sighted, and neglect to 'count what counts' with respect to pro-environmental action. While social media discussions are certainly a non-traditional measure of climate activism, their long-term impacts may be a pertinent avenue for exploration, as they may lead to increases in pro-environmental action.

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