Conceptualising climate – How public understanding of weather and climate influences perceptions of climate change globally

by

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Abstract

Although there is a growing body of literature exploring influences on public perceptions of climate change, little work has focused on how levels of conceptual understanding of deep time, namely the difference between weather and climate influence these perceptions. An online survey was distributed globally for the first time and used to measure respondents' levels of conceptual understanding of weather and climate and perceptions of the risks associated with climate change. Data was also gathered on respondent media trends to identify any key sources of information on climate change for respondents. 669 completed questionnaires were received with respondents being globally dispersed across 62 nations. Results were analysed to evaluate the relationship between the levels of conceptual understanding of weather and climate and concern with climate change amongst respondents. Analysis was also completed to assess how the media influences this relationship.

Results were presented for the Full Population (n=669) as well as regionally across European (n=303), North American (n=142), South American (n=20), African (n=57), Asian (n=99) and Oceania (n=44) response populations.

The results show little variation exists between levels of conceptual understanding of weather and climate and perceptions of climate change across all populations, despite a significant knowledge gap existing between perceived and actual levels of conceptual understanding of weather and climate. This challenges previous research which has demonstrated a link between levels of conceptual understanding and perceptions of the risks posed by climate change. The results did demonstrate a relationship exists between respondents demonstrating 'Very Low' or 'Low' levels of conceptual understanding of weather and climate and relying on social media for the majority of information on climate change.

The results establish the salience of clear communication online to educate the public on the difference between weather and climate is key to improve levels of conceptual understanding. This research corroborates the findings of a large body of existing literature that global levels of concern with climate

change are high. The results also show respondents who demonstrate high levels of scepticism around the risks posed by climate change do not consider the long term effects of climate change to be significant, despite demonstrating high levels of agreement with the scientific consensus on the anthropogenic causes of climate change. The effects of the concept of psychological distance on influencing perceptions of climate change risk were also observed. Respondents who identified changes to their local environment were found to significantly correlate with levels of concern with climate change though no relationship was identified between levels of conceptual understanding of weather and climate and this effect.

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1 Introduction

There should be no debate that our planet's climate is changing (Powell, 2011). There is a broad consensus that anthropogenic climate change exists amongst the scientific community, with 97% of actively publishing scientists agreeing climate-warming trends over the past century are extremely likely due to human activities (Cook et al. 2016, Maibach et al. 2014). Whilst a majority of the public today believe climate change is happening now and human activities are the main cause (Leal Filho et al. 2019) the levels of concern with climate change do not correlate this trend (Pidgeon, 2018). This disparity between public perceptions and scientific consensus on climate change is generally not caused by a lack of public understanding of the science, but in confusion around the communication methods and language used to describe it (Moser & Dilling, 2011).

This state of public opinion raises critical questions as to the efficacy of previous communication efforts through public education, outreach, and engagement approaches used to render a complex scientific issue meaningful and actionable for lay audiences (Moser & Dilling, 2011). A growing body of literature on public attitudes, as well as on other aspects of the communication process, can aid understanding not only of the larger trends in public opinion, but also the challenges and opportunities for more effective approaches to climate change communication.

Mitigation and adaptation to global climate change requires not only top down action from International leaders and decision makers, but also cooperation from corporations and consumers (Semenza et al. 2008). An individual’s perception of climate change is influenced not simply by the results of scientific models or statistics, but through a rich tapestry of internal and external elements (Lorenzoni et al. 2007). Internal factors may include an individual’s attitude towards risk and the familiarity of the individual with the hazard they are facing. External drivers include factors such as political rhetoric, popular culture and the media’s reporting of an issue. The outcome of this combination of risk factors determines an individual’s attitude towards climate change. It is this perception that ultimately shapes the lengths to which individuals, populations, and societies are willing to go

to adapt to and mitigate against the diverse risks posed by climate change to the planet and society.

Whilst a vast body of contemporary science has been dedicated to the changing climate it is also worth considering climate conceptually (Hulme, 2015). Understanding what and how people see climate today is essential for the scientific community to build a comprehensive and rounded perspective of how best to convey issues relating to it and thus how to best shape climate change rhetoric as a whole.

Climate is an idea with both statistical and social foundations. Both elements have changed through time. This means our understanding of climate is not limited to the statistical datasets of observations of an interconnected global physical system. It is also a social artefact with a rich cultural history (Hulme, 2015). It is this history which forms the bedrock of today's perceptions, claims and disputes about climate change, as well as shaping discourses on the issue around the world. It is imperative the barrier which exists between the natural world and society is removed to build a comprehensive understanding of climate as a concept (Hulme, 2009). By coupling these two elements it is possible to engage people more constructively with the scientific evidence for, debate surrounding and the multitude of strategies aimed at tackling climate change.

Throughout history and pre-history there has been a dynamic socio-climatic relationship. This has variously been elemental, creative and fearful. Today's society has an increasingly intimate relationship with the global climate. The globalisation of natural threats, events and disasters are increasingly publicised, reported on and documented (Hulme, 2008). In today's globalised world traditional perceptions, interpretations and attitudes surrounding climate have been transformed (Dunlap and York, 2008). It is the ease of access to a wealth of information, debate, scaremongering and hyperbole through both traditional and new media outlets that shape society's relationships with climate today more than ever before (Boykoff, 2005; Antilla, 2005; O'Neill & Boykoff, 2011).

Public perceptions of what constitutes a risk is influenced by what they hear, see and read in the media, whether it is from traditional printed broadsheet newspapers

or online news outlets. These outlets act as the most significant platform for the majority of the public to be informed on issues that affect our planet, from the risks to society from terrorism to economics and climate change. The manner through which the risks associated with an event, phenomena or issue are portrayed help to shape people's worldview and individual and collective perceptions of risk. The media have traditionally not reflected the general consensus of the scientific community on climate change. In 2013 the US media's reporting on climate change was found to have a ratio of 66:34 in favour of climate change (Donner and McDaniels, 2013). This was in sharp contrast to the 97:3 ratio that exists within the scientific community. The media's traditional pursuit for providing an objective and balanced argument by portraying both sides to the story has proved to be a misleading narrative in an effort to narrate a divisive and passionate debate. However, with climate change increasingly being beckoned into the international spotlight the debate on whether climate change is happening and the causes of climate change are being replaced by the debate on what represents effective climate change legislation. The scientific community need to continue to drive this trend by being more active critics and sources of news (Smith, 2005). Specialists need to be more available and more assertive in relation to what may come to be seen as the century's biggest story.

It cannot be said the lack of public engagement in mitigating the issue is a result of a lack of understanding of the risks posed by climate change, nor a lack of care about the issue. Rather, by better understanding the key agents shaping the public's perception towards climate and the risks posed by climate change it will be possible for the scientific community to communicate with the public more effectively. This will ultimately lead to more effective mitigation and adaptation strategies (Bord et al. 2000). By reviewing current communication strategies and channels this study aims to demonstrate that the public's conceptual understanding of weather and climate can provide important insights to assist framing communications on climate change and how it will impact society now and into the future.

2 Literature Review

2.1 Conceptualising climate and climate change

Climate cannot be experienced directly through our senses. It is an abstract, a composite of internal influencers, social history and scientific norms. Unlike physical elements such as rainfall which soaks through us, or the welcome cooling of a gentle breeze on a summer's day, climate is a constructed idea weaving individual elements together to create a more abstract concept (Hulme, 2009). Whilst it is possible to directly observe the individual threads of precipitation, temperature or wind speed in a given place at a given time, climate is an abstraction carrying with it a much richer tradition woven deep into culture globally. The essence of climate cannot be captured by meteorological measurements alone, but through a deeper understanding of how society perceives climate, nature and the world around it.

A vast body of contemporary science has been dedicated to the idea of a changing climate, be it historic analysis of ice core records, current meteorological assessments or future simulations using climate modelling (Hulme, 2015). However, it is also of upmost importance to consider climate as a social idea. Understanding what and how people perceive climate is essential for the scientific community to understand how best to communicate issues surrounding changes to the climate and natural world in an effective way to audiences.

2.1.1 Distinguishing between weather and climate

Whilst it is important to understand the conceptualisation of climate it is essential the distinction is made between the concepts of weather and climate. Weather involves short duration (minutes, days, months, years) atmospheric events at a particular location, whereas climate is weather conditions averaged over long-term periods (of at least three decades) and across wide geographical areas (National Climate Data Centre, 2008). Both variables have a temporal and geographical aspects. However, the distinctions between weather and climate are not clear-cut. Severe weather, such as tornadoes, and snowstorms may be widespread across wide regions, but the actual weather varies significantly from location to location (Lombardi and Sinatra, 2012).

Climate is an idea with both statistical and social foundations with both elements changing through time and space. Conceptually climate cannot be solely interpreted as an interconnected global physical system, a statistical object to be measured simply in meteorological terms. It is a social artefact with a rich and deep cultural history which has shaped civilisations for centuries (Hulme, 2015). It is this history which forms the foundations of today's perceptions, claims and disputes about climate and the changes it is experiencing. It is important the barrier between nature and culture is removed to better understand climate in a richer and more rounded way (Hulme, 2009). By coupling the social and statistical elements it is possible to engage with individuals more constructively and in terms which are meaningful rather than display a series of statistics on the risks posed by climate change.

The public are often found to be unable to determine the difference between weather and climate and a deep sense of confusion often surrounds the issue. Long-term changes in climate patterns and extreme weather events need to be interpreted by weather and climate experts within the context of climate change; individuals cannot be expected to detect or comprehend such complex linkages directly (Marlon et al., 2019). This confusion between weather and climate has been the focus of significant research efforts. Read et al. (1994) surveyed 144 members of the public regarding their understanding towards global climate change. The study contained six questions focusing on the differences between weather and climate. Their data suggest *"people were using information about local weather to make inferences about global climate"* (p. 974). They also suggest that people may use weather data from short-term periods, specifically "local weather excursions" (p. 974), to make judgments about long term climate trends. This trend will be discussed in greater depth in Section 2.4 (Climate through memory).

Similarly, Papadimitriou (2004) used open-ended questionnaires to survey 172 preservice elementary teachers about global climate change and found many cited recent weather events such as heatwaves as evidence of global warming. This lack of basic knowledge in determining the difference between weather and climate has a significant effect on shaping the narrative on climate change and the public's perception on climate change as an issue.

Lombardi and Sinatra (2012) surveyed 83 college students regarding their understanding of deep time in relation to comprehending the difference between weather and climate. Deep time, sometimes referred to as geological time, is an essential tool for understanding global climate change. Yet, it has been shown students often have a very poor understanding of deep time (Dodick and Orion 2003; Libarkin et al. 2005; Prather 2005). Dodick and Orion (2003) examined the ability of students to use an "active logical understanding of geological time" (p. 418) to understand changes to geophysical systems over very long time periods. The study highlighted that, in addition to other cognitive abilities, students must possess the "basic principles of diachronic thinking" (p. 436) in order to describe past geological systems. According to Montangero (1996), diachronic thinking involves activation of up to four temporal mental schemes that develop from infancy to adolescence: (1) transformation, (2) temporal organisation, (3) interstage linkage, and (4) dynamic synthesis. Students may well be coordinating these several temporal mental representations with background knowledge as they endeavour to understand a phenomenon involving deep time (Lombardi and Sinatra, 2012). The results of Lombardi and Sinatra (2012) revealed that with greater understanding of deep time there was an explanation for the variance in students' understanding of the distinctions between weather and climate, even with brief instruction.

2.1.2 Normal climates: statistical and cultural constructs

There has been a dynamic socio-climatic relationship which has existed throughout history and pre-history. This has variously been elemental, creative and fearful. Today, society is more connected to the environment and with climate than any previous generation thanks to globalisation and technological transformation. The traditional perceptions, interpretations and attitudes surrounding climate have been transformed through this process (Dunlap and York, 2008). The ease of access individual has to a wealth of information, debate, scaremongering and hyperbole through both traditional and new media outlets help frame society's relationships with climate today more than ever before (Boykoff, 2005; Antilla, 2005; O'Neill & Boykoff, 2011).

Climate scientists define a ‘normal’ climate as an aggregated set of meteorological measurements defined over a period of 30 years. The World Meteorological Organisation publishes aggregated global data from weather stations, the most recent being the period 1961 – 1990. This concept originated in 1872 with the initial International Meteorological Committee (IMC). Until well into the twentieth century, the concept was categorised by an average of the entire record of weather data available (Kunkel & Court, 1990). The idea of periodicity being associated with climate was first rationalised by Bruckner who suggested a 35 year climate cycle existed (Bruckner, 1980). Whilst Bruckner’s definition did not last the idea of the periodicity of climate persisted as did the debate in the appropriate length in time amongst the International Meteorological Organisation who settled on between 20-25 years (IMO, 1937 & Brooks 1949). It was not until 1950 and the establishment of World Meteorological Organisation (WMO) that the 30 year average was agreed as being the appropriate method of constructing normal climates (Hulme et al., 2009). Today we see this measurement of 30 years being widely used by the scientific community to define the time required to pass in order to establish a ‘normal’ climate statistically.

However, the very idea of a “normal climate,” like the concepts of both weather and climate cannot not be constructed in isolation through statistical analysis over any timescale. The ‘normal climate’ has a deeply significant place in global society and is entrenched in national, regional and international culture. It is something that can define nations and can be engrained in national stereotypes. In the UK for example it is perceived to always rain, regardless of season.

The idea of climate can be constructed in at least two vastly different ways: one that is divorced from human imagination with the strict use of meteorological statistics, and one that forms itself inside the imagination, through cumulative experiences, mental assimilation, social learning and cultural interpretations (Hulme et al., 2009). Each climate carries with it its own cultural interpretations and significance. The climate of the Sahara means something quite different to a Bedouin than it does to a European. The African climate has historically been interpreted by Western explorers, missionaries and colonisers as harsh, disease ridden and inhospitable due to its physical differences from the European

temperate climate. The European ideals of ‘normal climate' had no place in this physically different and alien environment (Nicholson, 1979; Adams & McShane, 1992; Pratt, 2007). These perceptions can be observed in the various physical observations of the climate these individuals recorded.

Taken in a social context the construction of a “normal climate” is deeply affected by a person’s individual and personal experiences and interactions with their local climate. This social importance has long been noted. Ellsworth Huntington’s 1915 book Civilisation and Climate refers to the concept as the “ideal climate,” (Huntington, 1915). This interpretation defines the ideal climate to be one that produces areas of high energy. This is demonstrated with increased levels of productivity. Throughout history this association between “normal” or “ideal” climates and usefulness to society has persevered. However, today’s perceptions of what constitutes a region’s “normal climate” are today mediated and deeply influenced by a host of social, economic and cultural factors (Wilhite & Glantz, 1987; Meyer, 2000**)**.

At a macro scale the clear gulf in political, economic and social wealth that is observed along the length of the border between the United States and Mexican is transferred directly into the respective communities’ perceptions of and interactions with climate. Whilst the physical, ecological and climatic settings are almost identical the social interpretations of weather and climate are very different on each side of the border. Arizonans, when asked about a drought now entering a second decade, commonly responded with the interrogative ‘what drought?’ *(Pennesi et al., 2007)*. South of the border where there is a greater individual and collective climate vulnerability due to poor water storage and management strategies the reality of drought was not lost on the local population. This example goes some way as to highlight the differences that exist at national level in the perceptions of what constitutes a normal climate.

Human interaction with climate is deeper than a set of meteorological measurements. It is a construct of complex cultural, social, economic and political factors as well as changes experienced by individuals locally that shape perceptions of what ‘normal’ climates are. By focusing on the concept of ‘normal’ climates it is possible to understand how the concepts of weather and climate are

themselves woven into cultural and societal thinking. These perceptions help frame attitudes towards climate change. In adopting this co-constructed approach toward our understanding of climate rather than a purely statistical one it is possible to offer a different way of thinking about the instabilities of past, present and future climates and how best to adapt to them.

2.1.3 Climate through memory

Whilst external elements influence individual perceptions of climate through the physical, ecological, social, economic and political elements it is the internal distortion, mutation and transformation of climate through memory which transforms an individual's perception of climatic change. This is a dynamic process constantly developing and changing through time and space as an individual experiences and interacts with climate and the elements which influence it.

It is imperative memory is not considered simply as a collection of ideas about past events. It must be interpreted as the psychological ability to recall past events in relation to more recent affective experiences and beliefs (Wilson & Ross, 2003; Levine & Safer, 2002; Friedman, 1993). It has been well documented over time memory bias occurs, even in individuals without physical or mental impediments (Hulme et al., 2008). These biases may manifest themselves in numerous ways including the recollection of incorrect dates, times, places, drivers and effects (Dodson et al., 2000; Bradburn, 2000). There is also a tendency for individuals to recall salient, catastrophic, or memorable events with a greater deal of clarity, from an overly warm summer to an earthquake (Pereira & Koifman, 1999). However, despite this recollection of significant events there is also a failing to recall factors such as time or place accurately.

Individuals have also been shown to recall personally salient weather events, although not necessarily with a high degree of detail regarding the exact timing or duration of each event. Significant experiences help shape and define an individual's perceptions and beliefs of their climate and influence perceptions of future changes associated with it. A notable example is the 'White Christmas Effect'. Despite meteorological records showing the likelihood of snow at Christmas for most of England is only 1 in every 10 years (Harley, 2003), the expectation of

snow at Christmas has been perpetuated throughout British culture via historic imaginary, media and oral history. The expectation of snowfall is reiterated and reinforced every festive season, becoming deeper engrained in individual perceptions of our winter climate. This is a powerful example of how science, public authorities, the media and the public collide in their different constructions of climate normality (Hulme et al., 2009).

In a changing climate an individual's memory of what makes a normal climate shifts. It has been shown that the reference point for normal conditions appears to be based on weather experienced between 2 and 8 years ago (Moore et al., 2019). This rapidly shifting normal baseline means warming noticed by the general public may not be clearly distinguishable from zero over the 21st century, with potential implications for both the acceptance of global warming and public pressure for mitigation policies (Howe, 2018). Zaval et al. (2014) demonstrated the influence of recent weather events in shaping levels of concern with climate change. It was found current temperature abnormalities are given undue weight and lead to an overestimation of the frequency of similar past events, thereby increasing belief in and concern for global warming.

This divergence in the public perception of 'normal climate' can be accounted for through a variety of methods, such as the older generations experiencing and recounting the unusually harsh winters in the late 1940s; or through their recent experiences of unusually mild winters in the 1990s and early 2000s for much of the population. Improvements in thermal comfort, provided by central heating systems, better insulation and energy efficiency also contribute to the collective perception of milder winters (Meze-Hausken, 2007).

Finally, it is how individuals contextualise long-term averages in individual experiences that may be the most significant contributing factor in shaping perceptions of a normal climate. The clear recollection of salient weather events become engrained in thinking and over time can give a distorted perspective of the historic 'normal climate' projecting unfounded expectations onto future climates (Rebetez, 1996). The recollection of these events rather than the longer term climatic averages defines the social context of local and global climate perception. By understanding how to contextualise these extreme scenarios in the context of

discussions concerning the risks posed by climate change it will be possible to communicate with the public more effectively.

Public engagement with these risks is deeply affected by memory and our ability to identify future risks. For the public the key time frame for individuals when considering their personal futures is considered to be two decades from the present at the most (Tonn et al., 2006). This is divergent from the majority of climate change projections and their subsequent mitigation policies, operating at a significantly greater timescales. The norm when projecting the impacts of climate change through modelling is to run simulations until 2050 or 2100 (IPCC, 2015). The importance of these milestones was corroborated by the 2015 Paris Climate Change Agreement (COP 21). The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C by 2100. However, whilst progress has been made in the years following the Paris Agreement it was noted that it is essential to address the psychological distance of climate change through the contextualisation of the long term effects on peoples' daily lives in order to increase public engagement with the issue of climate change (Lorenzoni and Pidgeon, 2006).

Memories, although biased, create individual and cultural identities, helping shape current and future perceptions of climate (Peterson, 2002; Gardner et al. 2000). Understanding how individuals recall and interpret these historic climates and weather events is key to unlocking how people perceive climate and climate change today. By acknowledging this complex, non-uniform relationship between memory and climate it can only help in understanding how best to communicate potential changes in the climate with the public and the risks associated with these changes.

2.2 Conceptualising danger

Society's perceptions of what constitutes danger and how this perception is translated to key risks cannot be considered to be a simple problem. Public perception of danger is influenced by an array of factors both from external and internal sources (Desai et al. 2011).

An individual's perception of what constitutes danger is influenced by a diverse range of deep-rooted psychological parameters which allow for certain dangers to take greater hold over people. One of the most perplexing problems in risk analysis is why some relatively minor risks or risk events, as assessed by technical experts, often elicit strong public concerns and result in substantial impacts upon society and economy (Kaperson et al., 1988). By understanding how perceptions of danger are generated it may go some way to understand how climate change is influenced by public perceptions of danger.

Causes of danger may be separated into two distinct forms; external and internal dangers. External danger is based on scientific risk analysis by subject experts (Desai et al. 2011). These dangers identified by experts only become 'real' once the danger is experienced or perceived to be a significant threat. Internal danger conversely is based upon an individual or collective experience or perception of insecurity, risk or lack of safety that constituted danger (Dessai et al. 2011). It is important that the internal perceptions of danger are thoroughly examined by scientific investigation or the policy making community when investigating danger and risk perception. By incorporating these internal dangers when communicating with the public it is likely that more popular, wider reaching and ultimately successful solutions to climate change will be found.

The elements that make up public perceptions of the dangers and risks associated with climate change are far from simplistic. The public find a complex and highly partisan definition of what danger is and are influenced by an array of internal and external agents and communicators. Their concepts of danger are also influenced by a menagerie of amplifiers from a cultural setting, constructing metaphors of risk and danger. From all this the public are left constructing their own opinions on the

risks posed by climate change, enhanced by their own individual experiences and cultural world views.

2.2.1 The conceptualisation of risk

Modern society has been preoccupied with the notion of risk (Beck, 1986; Short, 1984). The concept and study of risk is today comprised of a diverse patchwork of a multitude of different schools of thought. From the 'objectivist' and 'subjectivist' ideals, to the 'structuralistic' and 'individualistic' approaches, between life scientists and social scientists. However, there is a need to integrate these theories and ideas to construct a framework capable of including the technical analysis of risk and the cultural, social and individual response structures that shape the public experience of risk (Kaperson et al. 1988).

Traditional technical risk analysis focuses narrowly on the probability of events and the magnitude of the consequences (Freudenburg, 1988). Whilst these technical assessments of risk are essential in decisions regarding competing structural designs or materials it often is not suitable for providing adequate insight into societal decision making and perceptions. In this social context risk is not confined to a simplistic and rigid technical definition, i.e., the product of probability and magnitude (Raynor & Cantor, 1987). What human beings perceive as threats to well-being and how these threats are then evaluated both internally and externally and then translated as probabilities and magnitudes of unwanted consequences are significantly more complex. They are less a question of predicted physical outcomes than of values, attitudes, social influences, and cultural identity (Douglas & Wildavsky, 1982). This complex questioning of social values, attitudes and influencers stems directly out of the societal construct of climate and the conceptualisation of 'normal' climate (2.1.2). The personal, political and societal influences which shape perceptions of climate change inevitably influence an individual's risk estimations and evaluations in the context of climate change.

Research has demonstrated that contextual factors shape individual risk estimations and evaluations (Renn, 1990; Slovic, 1987). Identification of these factors such as voluntariness, personal ability to influence the risks, familiarity with the hazard and the catastrophic potential provides useful information about the

elements that individuals consider in constructing their interpretation of risks (Slovic et al. 1982; Renn, 1985, Renn et al., 1992). Furthermore, analyses of people's heuristics in making inferences have shed light on how risk information is generalised and evaluated (Kahneman & Tversky, 1979). However, these psychological studies fail to explain why individuals attend to certain characteristics of risk and ignore others (Renn et al., 1992). Moreover, these studies exclude the influences of social and cultural variance of risk interpretations.

Sociological analysis offers deeper insight into the social factors that influence risk experience (Clark, 1989). Studies may look at large scale disaster response preparedness (Perrow, 1984), social influences on the formation and shift towards risk-bearing activities (Gould et al., 1989) or the fairness in the distribution of risks and benefits (Kaperson & Kaperson, 1983). These sociological studies provide an understanding of the variability of risk interpretations amongst different groups and for pointing out the organisational problems that impede effective risk management and control.

An alternative approach to theorising risk is the cultural approach to risk (Douglas & Wildavsky, 1982; Rayner, 1987; Schwartz & Thompson, 1990). This approach states cultural beliefs and worldviews determine how people experience and interpret risks. A key focus of this model is the two cultural prototypes: the entrepreneurs and egalitarians. Entrepreneurs regard risk as an opportunity for development, whereas egalitarians tend to perceive risks as threats to their lifestyles and values (Renn et al,. 1992). However, this belief has been discredited due to the fact that there is very little empirical proof for these groups existing as well as the fact that individuals of one cultural group are still able to understand and accept the rationales of other groups as different but equally legitimate ways of dealing with an issue.

In order to understand, document and analyse how the risks are identified, understood and classified by society an integrated, multi-disciplinary framework is required. This was provided in 1988 by Kasperson et al. (1988). Their framework described a description of how risks are amplified by society, known as the social amplification of risk. Signals about risk are processed by individual and social amplification stations, from the scientist who communicates the risk assessment,

the media who report on the risk, cultural groups, interpersonal networks, and others who all provide commentary on the risk. Key steps of amplifications can be identified at each stage. The amplified risk leads to behavioural responses, which, in turn, result in secondary impacts. Models are presented that portray the elements and linkages in the proposed conceptual framework (Kasperson et al. 1988). Understanding how this amplification occurs can enable more effective communication on climate change.

2.2.2 The social amplification of risk

The concept of the social amplification of risk proposes events pertaining to be hazards interact with psychological, social, institutional, and cultural processes in ways which can heighten or attenuate individual and social perceptions of risk and shape risk behaviour (Renn et al., 1992). Behavioural patterns, in turn, generate secondary social or economic consequences that extend far beyond direct harm to humans or the environment, including significant indirect impacts such as liability, loss of trust in institutions, or alienation from community (Kasperson et al., 1988). These secondary effects often trigger demands for additional institutional responses and protective actions, or conversely place impediments in the path of needed protective actions. ‘Amplification’ is used to include both the intensifying and attenuating signals about risk. This means that overreaction and downplaying receive the attention in the model (Rayner, 1987). Amplification occurs at two stages: in the transfer of information about the risk, and in the response mechanisms of society.

The model conceptualises risk as partly a social construct and partly as an objective property of an event (Short, 1989, p. 405). By considering risk as both an objective property and a social construct it is possible to avoid the problems of total relativism on one hand and of technological determinism on the other (Renn et al., 1992). ‘Hazardous events’ are expressions of risk and remain largely irrelevant in the social context unless they are observed by humans and communicated to others (Luhmann, 1986). The consequences of these communications may lead to other physical transformations, such as changes in technologies, methods of land cultivation, or the composition of water, soil and air. The experience of risk is therefore not an experience of physical harm, but the result of a process by which

individuals or groups learn to acquire or create interpretations of hazards (Renn et al., 1992). In turn these interpretations provide rules of how to select, order, and express signals from the physical world.

Information held within the messages and signals are essential to understand how individual, groups and societies value the hazards themselves. Each message may contain factual, inferential, value- related and symbolic meanings (Lasswell, 1948). The factual information refers to the content of the message and its source. The inferential message refers to conclusions drawn from the evidence supplied. The value-related and symbolic meanings attached to the messaging both combine to provide symbolic meaning to the messaging. It has been demonstrated the source of communication is significant in triggering the attention of potential receivers of risk (Hovland, 1948). If for example an independent scientist or NGO publishes a paper the message may command greater public attention as it is deemed to be credible (Kasperson et al., 1988). By contrast, a press release by the oil industry may be seen as less credible unless other aspects compensate for the doubts about the impartiality of the source.

The societal response mechanisms to the transfer of information on risk are complex. Society's identification of salient dangers are not based solely on the information presented to them, but are influenced by a range of factors from an array of social actors, individuals and institutions who inadvertently or intentionally amplify particular risks. This social amplification of risk, may be addressed as three distinct elements; significant individuals (perceived experts in their field), institutions (these can be political, charitable or scientific) and wider social processes such as the emergence of risk cultures which can result in polarisation of risk perceptions (Hulme, 2009). These three elements combine to alter the signals of risk which exist within society and help form our collective landscapes of fear and perceptions of dangers. These factors influence society in the ranking of dangers and the collective understanding of what the salient dangers are in today's world.

By understanding how individuals and societies identify, classify and amplify risk and dangers it is possible to understand how to most effectively communicate the

risks posed by climate change, their prominence, and potential impact on both society and the environment.

2.2.3 The attenuation of risk

Whilst signals of risk are readily transmitted and influenced by complex social and physical factors, termed the social amplification of risk, attenuation also plays a significant role in shaping the risk landscape of the world.

The relatively low levels of interest by the public in the risks presented by such well-documented and significant hazards such as indoor radon, smoking, drinking, driving without seat belts, or highly carcinogenic aflatoxins in peanut butter serve as examples of the social attenuation of risks (Kaperson et al., 1988). Whereas large disaster events such as the accident at the Three Mile Island nuclear reactor in 1979 demonstrate the amplification of risk factors far beyond the initial injury, death and property damage to the deep social repercussions and secondary effects such as distrust of new technologies (Heising & George, 1986). These indispensable, everyday risks are forgotten or put aside to cope with the magnitude of the risks encountered on a daily basis. This may also lead to potentially serious adverse consequences through underestimation of the risk by an individual or an inadequate response by the authorities to mitigate the danger.

Research on perceptions of climate change have suggested public awareness of the issue is high (Defra, 2006). In 2005 an overwhelming majority of people believed the world's climate is changing and action should be taken to mitigate it (Poortinga et al. 2006; Pidgeon et al. 2008). Pearce et al. (2017) demonstrates that the data still shows a clear majority position among Americans that climate change is real, important and worrisome. The study also demonstrates that there is significant public support for the US to take policy action and invest in public education to address the risks posed by climate change.

The language of disaster used by the media, government and the scientific community alike when describing dramatic crisis events no longer has the same impact as it once did on public interest and fear. The natural disaster and the devastation caused by events such as Hurricane Katrina have entered a cycle of

repetition in the western news media which has led to the attenuation of the perceived risk (Cronon, 2006). This has, led to a muted and disinterested reception from a public increasingly used to disaster narratives being big stories, be they large-scale natural disasters, terrorist attacks, chemical spills or murders.

2.2.4 Psychological distance and construal level theory

Public concern with climate change as an issue remains high (Eurobarometer, 2009, Leal Filho et al. (2019). However, despite this high degree of public concern with climate change many individuals are unwilling to act in a sustainable manner (Energy Saving Trust, 2007) despite being aware of the risks of non-action. It has been suggested this may be a result of the perceived psychological distance from the issue (Spence et al. 2012). In particular, research has indicated people have traditionally believed climate change risks will only affect other people or nations, and those born far into the future making them less willing to take steps to mitigate the risks (Lorenzoni et al, 2006; Bord et al, 1998).

Construal Level Theory, developed by Liberman and Trope (2008), outlines four key elements that may explain such psychological distance from the environmental issue: spatial or geographical distance; temporal distance; distance between the perceiver and a social target, i.e. another individual or group; and hypothetically, e.g., how certain is it that an event will happen. Climate change is perceived to be distant across all four dimensions (Milfort, 2010). The theory proposes that psychological distance from climate change is directly linked to the way that people mentally represent it. It is proposed psychologically distant events are represented by abstract high-level construals composed of general decontextualised features, whereas psychologically close events are represented with concrete low-level construals made up of specific contextual details (Spence et al. 2012).

Furthermore, it is understood the psychological distance of stimuli are represented in similar mental space with each dimension interconnected. This means any changes to distance influence all other aspects of physiological distance. These conceptualisations are supported by a large body of experimental evidence. Studies have found processing psychologically distant information (e.g. geographically distant) is facilitated when participants are focused on distant

congruent stimuli (e.g. socially or temporally distant or uncertain), indicating that these are cognitively associated (Bar-Anan, 2007).

Notably, Construal Level Theory highlights the significance of psychological distance in promoting an individual to take action (Liberman and Trope (2008). The utility of psychological distance in determining behavioural choices is perhaps counterintuitive considering distant events may be more uncertain in nature. Interestingly though evidence demonstrates that focusing on distance helps people to make choices that are more in line with their more abstract, core perceptions and beliefs and therefore appears to help self-control (Spence et al., 2012). Representations of psychologically distant events seems to aid individuals in making more confident predictions about the future, and to more easily define behavioural choices (Liberman and Trope, 2008).

2.2.5 The psychological distance of climate change

There is limited evidence examining psychological distance within the domain of climate change research. However, there is a variety of evidence that speaks to these issues. Evidence suggests people perceive climate change as most likely to impact people and places which are geographically and temporally distant (Leiserowitz et al. 2010). In addition, the severity of impacts of climate change tend to be viewed as more serious for distant locations rather than in close proximity (Spence and Pidgeon, 2010).

Individuals also clearly distinguish between personal and societal impacts of climate change, with several studies finding personal risks associated with climate change are judged to be lower than societal risks (Leiserowitz et al. 2010; Spence and Pidgeon, 2010). This points to the importance of bridging this disassociation between the local and global impacts of climate change in order to promote personal action to mitigate its effects.

The proximity of individuals to perceived climate change related events such as flooding, or increased hurricane frequency or severity has been found to influence the physiological distance of climate change. Individuals who experience environmental issues first hand demonstrate significantly more concern and willingness to mitigate climate change themselves (Albright & Crow, 2019; Demski

et al., 2017 Spence et al., 2011; Zahran et al., 2006). Additionally, communities which have experienced environmental problems have been shown to produce a greater number of grass-roots environmental movements (Bullard 1990; Blake 2001). This suggests that framing climate change in terms of local events and geography will help to make the issue more salient (Lorenzoni and Pidgeon, 2006), by promoting engagement with climate change emotionally and cognitively, and will make the benefits of acting on climate change more tangible (Lorenzoni and Pidgeon, 2006). Yet, studies show that, whilst proximity is important in shaping personal efficacy towards mitigating climate change, other factors such as political ideology, and existing levels of concern with climate change and also significant influences in shaping perceptions of the issue (Zanocco et al., 2018).

Bridging the temporal distance of climate change is also a key issue. The fact discussions and debate around climate change are particularly focused on the prevention of future impacts may be particularly problematic for prompting action to mitigate it. Construal Level Theory suggests people are more likely to take greater risks with regards to decisions that are further away (Sagristano et al. 2002). Asking people to act to mitigate the impacts of climate change may be particularly unappealing considering it requires immediate and significant actions with rewards that are relatively distant in time, and also uncertain in effectiveness (Weber, 2010). By focusing people on the future it is possible to increase the consistency between environmental attitudes and behaviour (Rabinovich et al., 2010).

Risk perception studies have also suggested that individuals are more likely to engage in environmentally friendly behaviours if they perceive the risks of non-action as high, if they believe the phenomena to be threatening to their personal welfare, or if they perceive the personal benefits of action as higher than the perceived costs (Zahran et al. 2006).

There is considerable evidence for this value expectancy theory of behaviour (Mohai 1985; Rohrschneider 1990; Samdahl and Robertson 1989; Lubell et al. 2006). Studies show persons aware of (or perceiving) the harmful consequences of an environmental problem are more likely to adapt behaviours mitigating the problem (Stern et al. 1999; Clark et al. 2003; Black et al. 1985). Studies using

analogous measures of perceived harm (Manzo and Weinstein 1987; McKenzie-Mohr et al. 1995) and perceived risk (Der-Karabetian et al. 1996; Wakefield et al. 2001) corroborate these conclusions.

Numerous studies have also shown perceived risk to be a strong indicator of a citizen's willingness to pay more towards adaptation and mitigation policies (McDaniels et al. 1996; Stedman 2004; Berk and Schulman 1995, Berk & Fovell, 1999). Berk and Schulman (1995) show that willingness to pay the costs of global warming prevention depends on the severity of hypothetical climate scenarios considered.

By bridging the psychological distance associated with climate change and the perceptions of danger associated with the impacts of climate change it is possible to better communicate the saliency of the risks associated with the issue at a global scale locally to individuals, and communities. By bridging the gap and demonstrating the value of engaging with environmentally friendly activity it is demonstrated that the public are more willing to support environmental policies and action.

2.3 Communicating climate change science

To be successful in mitigating and adapting to the effects of global climate change there must be a significant degree of voluntary action undertaken by people (O'Neill & Hulme, 2009). However, multiple barriers exist to decarbonisation; cognitive, psychological and social. It is essential that the effects of global warming are effectively communicated to enable public engagement with the issue.

Something of a 'perfect storm' existed for the first part of the twenty-first century, making the communication of climate change challenging (2.1). This has limited the scientific community's role in enabling public engagement and support for action. This in conjunction with the politically polarising nature of climate change itself (Jamieson, 2011; Steffen, 2011, Dunlap and McCright, 2011; Hajer and Versteeg, 2011). The cognitive and psychological ways of processing information (Norgaard, 2011, 2.2), and the structural challenges pertaining to the media used for communication must all be considered and overcome in order to successfully communicate with the public on climate change.

For the purpose of this study Moser & Billing's 2011 definition of what is successful communication on climate change is used. Their definition states it is "communication which succeeds in bridging the science-action gap, by fostering public engagement with climate change." (Moser & Billing, 2011, p.162). Successful communication on climate change is underpinned by engagement at a societal, community and individual level. It must contain a cognitive dimension which requires individuals to grapple with and gain an understanding of the issue in order to elicit an emotional repose such as interest, concern or worry; and actively respond by way of changes in climate-relevant behaviour or political action (Lorenzoni et al. 2007; Moser 2009; Moser and Dilling 2007; NRC 2002). This definition of engagement illustrates three normative assumptions. First, whilst science alone is not sufficient to encourage people to action, science sufficiently establishes climate change is happening, is mostly a result of human activities, and represents a significant threat to the planet and society (Solomon et al. 2007; Parry et al. 2007). This evidence warrants immediate and significant actions to reduce climate change-related risks (Moser & Billing, 2011). The second is public support. In a democracy policy action requires public support, or consent, and the implementation of policies requires the active engagement of the public. The final factor is communication. This is an essential means to link scientists, politicians, and the public, and thus can and should play an important and constructive role in enabling public engagement with climate change.

2.3.1 Consensus on anthropogenic climate change

There should be no debate that our planet's climate is changing (Powell, 2011). A broad consensus that anthropogenic climate change exists amongst the scientific community, with 97% of actively publishing scientists agreeing climate-warming trends over the past century are extremely likely due to human activities (Cook et al. 2016, Maibach et al. 2014).

Since the publication of the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report in 2014 and the subsequent Paris COP21 Climate Change Summit in 2015 there has been a shift in public understanding of the consensus that exists amongst the scientific community. Today, the majority of the public believe climate change is happening now and that human activities are the main

cause of the change (Leal Filho et al. 2019). However, the levels of concern with climate change do not correlate with this understanding (Pidgeon, 2018). This disparity between public concern with climate change and scientific consensus is generally not caused by a lack of public understanding of the broad drivers of climate change, but in confusion around the communication methods and language used to describe it (Moser & Dilling, 2011).

Today, the public's lack of understanding of the risks posed by climate change is their lack of understanding of the long term impacts of the drivers of climate change. The public are known to dramatically underestimate how long drivers such as CO2 remains in the atmosphere and continue to change the climate (Steratore, 2019). Whilst continued increases in temperatures are likely to cause the public concern about climate change to grow this on its own is unlikely to yield a public consensus about the threat posed by climate change (Bergquist & Warshaw, 2019). This has combined with the politicisation of climate change. Whilst the COP21 summit in 2015 has broadly led to political acceptance of the scientific consensus on climate change the politicisation of the issue has led to a partisan stance adopted by the main political parties in the United States (Lorenzoni et al. 2005).

2.3.2 Scepticism and climate change

Whilst the public are generally worried about global warming (Leal Filho et al., 2019) a small but increasing number of climate change sceptics exist. These sceptics do not believe that there is any risk, nor are they concerned with other worrisome facts related to climate change. Sceptics regard the present scientific findings supporting climate change as false artefacts (Wang & Kim, 2018).

Two types of scepticism generally exist (Capstick & Pidgeon, 2014). The first, epistemic scepticism relates to doubts about the status of climate change as a scientific and physical phenomenon. The second is response scepticism. This relates to doubts individuals have around the efficacy of action taken to address climate change. The latter is more strongly associated with a lack of concern about climate change.

Despite the consensus amongst the scientific community (2.3.1) accusations by sceptics have steered climate researchers into an unproductive battle that is proving difficult for them to extricate themselves from. This has to some extent been a result of the problematic trend in the US media to project that substantive disagreement exists within the international scientific community as to the reality of anthropogenic climate change. However this concept is false (Oreskes, 2004). The result of this perceived disagreement has had a significant effect on public perceptions, especially in the United States (Leiserowitz, 2005). Naysayers (people who believe that climate change is not a reality) make up 7% of the US population. Most concerning is the political nature of these people, notably Republican Senator James Inhofe of Oklahoma. He stated on the floor of the Senate that “global warming is the greatest hoax ever perpetrated on the American people,” (Inhofe, 2004).

It is this headline grabbing rhetoric and by enlisting the help of the media which has allowed climate sceptics to continue their “very cynical and deeply interested campaign to discredit the science of climate change,” (Derneritt, 2001). These efforts are facilitated by professional journalist practice employed by news services across all platforms and formats (Antilla, 2005).

Globally, levels of scepticism have been shown to vary most significantly by region rather than political views or demographic (Leal Filho et al., 2019). It was found that South America, Asia and Africa demonstrate the highest degrees of scepticism. By contrast Europe, North America and Australia are found to demonstrate the lowest level of scepticism globally. This corroborates previous research (Maibach et al., 2014, Poortinga et al., 2011). It should be noted an imbalance in the literature toward studies of public perceptions in Western nations (particularly the United States), leaves much unknown about the progression of public understanding of climate change worldwide (Capstick et al., 2015).

The effect of scepticism on public conviction to act environmentally is significant. Individuals who are sceptical are less likely to behave sustainably; clearly without the belief that climate change is happening, there is little point in acting in an environmental mind-set. Similarly, the belief anthropogenic climate change is not a significant effect is also a necessary condition for considering that personal actions can have an impact on tackling climate change. In addition, people generally prefer certainty over uncertainty and there is some evidence that uncertainty may be used as a justification for inaction (Sagristano et al. 2002; Stoll-Kleemann et al. 2001). Indeed, the communication of uncertainty has been related to a reduced willingness to act to mitigate negative environmental outcomes (Kortenkamp et al. 2006).

2.3.3 The media as communicators and amplifiers of climate change

Public perception of what constitutes risk is affected by what they hear, see and read in the media, whether it is from traditional printed broadsheet newspapers or online news outlets. These outlets act as the most prominent platform for the majority of the public to be informed on issues that affect our planet. The manner through which the risks associated with an event, phenomena or issue are portrayed help to shape people's worldview and individual and collective perceptions of risk.

Most world citizens will not learn about climate change research directly from the cautious lexicon in scientific journals, but rather from the mass media (Newman et al., 2018, Wilson, 2000). The communication of climate change as an issue by the

media is traditionally one of extremes; in dialogue, viewpoints and choice of case studies. After all, the media “do not talk about issues ... they talk about stories, as that is what interests people,” (Radford, 2004). This affects the media’s communication of risk, uncertainty and wider use of metaphor to conjure landscapes of fear and attitudes to danger. As previously (2.2.2) discussed the metaphorical linking of the two global millennial stories; terrorism and climate change have had a significant effect in shaping landscapes of fear and danger in communicating climate change. Often what are portrayed in the media are not carefully worded scientific findings, but rather dramatic, eye catching and entertaining stories designed to attract and captivate audiences but do little to enlighten them about the risks associated with climate change.

Climate change is a difficult story to recreate for a daily news budget, whilst a short-term heatwave or flood event is much easier to visualise or portray. The global warming story is one of the most complex of modern day stories and involves abstract and probabilistic science, complex environmental legislation, political manoeuvring, uncertain economics all played out across a global stage (Wilson, 2000). This all creates a journalistic minefield which is almost impossible to navigate effectively in the constraints of journalistic methodology.

The media has long insisted that in order to report responsibly on events it must provide the public with a fair and balanced portrayal of a story. Until the COP meeting in Paris in 2015 disconnect existed between the scientific evidence and the media reporting of the risks and uncertainties posed by climate change. This led to the wide assumption amongst the public that a raging debate existed amongst the scientific community as to the dangers and risks associated with climate change (Boykoff, 2005; Antilla, 2005). This came as a distinct contrast to the general consensus of the scientific community, with some 14,000 papers published since 1993 supporting the existence of climate change and only 24 ruling against it (Powell, 2011). The media have traditionally not reflected the ratio of the body of scientific evidence well. In 2013 in the United States media reporting for and against climate change were found to have a ratio of 66:34 (Donner and McDaniels, 2013). The media’s traditional pursuit of providing balance and display

both sides to the story can provide the public with a misleading narrative that is somewhat segregated from scientific opinion (Anderson, 2019).

Several factors have been identified that impact on the media's reporting on climate change and their ability to report on the issue effectively (Wilson, 1998). Historically, there has been disconnect between reporters' understanding of the science of climate change. It has been shown that only 45% of reporters correctly identified the greenhouse effect as a scientific certainty (Lucas & Schmitz, 1998). Around one-third of reporters (34%) answer correctly that the global warming theory is accepted by the majority of scientists and only 30% of reporters incorrectly believed that global warming and the greenhouse effect are interchangeable terms. Additionally the study highlighted that a third of reporters believed there was still strong debate in the theory. These figures help shape the understanding of why reporting has focused on such a small area of the scientific debate, creating a 'he said, she said' reporting style which creates more uncertainty in public perceptions of climate change (Wilson, 2000).

However, with climate change making its way onto the global stage as a political issue thanks to the Paris COP meeting the manner in which climate change is reported has been somewhat transformed. The arguments of climate sceptics which once took up as much as 34% of media coverage (Donner & McDaniels, 2013) has been replaced by the debate on what represents effective climate change legislation. This has been dominated by the debate between the merits of the mitigation targets of 1.5 degrees Celsius and 2 degrees Celsius respectively. These targets were outlined by all major news outlets from CNN in the USA to the BBC in the UK. The media also acknowledged the severity of the threat posed by climate change as well as the success and relative limitations of the end product of the conference.

The media appear to have shifted their position on the communication of climate change to be more in line with scientific opinion following the 2015 COP 21 Summit in Paris and the subsequent signing of the Paris Climate Agreement. The question which remains is whether they are able to sustain this after global interest switch to new news stories on other issues. Alongside this there has been an alarming trend over the past two decades of traditional media outlets slashing budgets for

science reporting. Indeed over the period two thirds of newspapers publishing a weekly science section has declined by two thirds (Pew, 2009; Carroll, 2006). In addition the news agency CNN has scrapped its entire science, technology and environmental reporting unit (Boykoff, 2010). This has led to the trend of reporters to act as generalists rather than specialists (Boykoff, 2005). The effect of this has meant that many reporters misunderstand and therefore misrepresent the basic scientific principles of climate change in their reporting (Wilson, 2000). Newspapers themselves are alarmingly the principal source of knowledge for reporters with interviews and scientific journals coming a distant second and third (Wilson, 2000).

The blame for these worrying trends cannot be entirely laid at the feet of the media. The science community needs to be more active critics and sources of news (Smith, 2005). Specialists need to be more available and more assertive in relation to what may come to be seen as the century's biggest story. However, the media must be relied on to responsibly report on climate change. There needs to be a more careful approach to help distinguish convergent agreement from legitimately contentious issues (Boykoff, 2010). This can only be supported by the scientific community continuing to engage with the media and help drive the discussions on how best to address climate change.

2.3.4 New media and climate change

New media can be defined as media which are integrated, interactive and use digital code (van Dijk, 2006). It has been touted as 'one of the greatest tools in achieving a true democracy' (Dawson; cited in Head, 2009). It represents an emerging platform for mass communication using digital technology such to broadcast information globally. New media plays multiple roles providing information, facilitating engagement, widening participation. But it has also had the implication of providing disinformation and can increase division (O'Neill & Boykoff, 2010). Whilst there is still some way to go to understand the dynamics of new media's engagement with the public (Dietz & Stern, 2008) there can be little doubt these sources have the potential to shape public engagement with climate change.

New media have focussed on building communities, utilising social media platforms such as Twitter, YouTube, Facebook and Instagram to build an audience

far more effectively than that of the traditional media outlets. Old media (print, radio and television) are increasingly becoming second-tier commodities in favour of these new and 'improved' ways of consuming news and content. This is best highlighted by the disparity in the values between two companies. Whilst the $250 million Jeff Bezos paid for the Washington Post in 2013 is a significant amount of money, Facebook was valued at more than $100bn in 2012 when its shares were sold for the first time (BBC News, 2013). This disparity in valuation represents the economic reality that social media and new media are now the primary method of consumption of stories, facts and fake news.

Online social media and associated social networks are increasingly important forums for public debate and are known to influence individual attitudes and behaviours – yet online discussions and social networks related to climate change are not well understood (Williams et al., 2014). Understanding how climate change is presented and discussed online is rapidly coming an area of central importance (Schafer, 2012; Auer et al., 2014). Social media are already an important focus for information exchange, debate and opinion formation on a range of issues, including climate change. The literature currently has a substantial bias toward Twitter studies (Pearce et al., 2019). The literature also highlights the dominance of mainstream information sources for communicating climate change science across social media platforms, as well as the prevalence of "settled science" as a means of framing climate change, and the presence of polarisation and echo chambers within climate change debates.

The power of social media as a tool for communicating and engaging with the public on climate change has been highlighted by the events of Paris and earlier COP summits. The hazards posed by climate change conjure the expected landscapes of danger, fear and risk. The use of hashtags to tag posts on outlets such as Twitter and Instagram during the Copenhagen Climate Talks of 2009 were studied by Segerberg and Bennett (2011). They concluded that trending hashtags of #COP15 enabled people to express their views on the issue through a form of protest. This tagging of posts and the formation of groups of people around these posts provides a mechanism for people to engage meaningfully with one another on the issue. The trending hashtags of #ClimateMarch and #NoPlanetB as well the

multitude of placards calling for ‘action now’ are no different to the hashtag #PrayforParis and the passionate arguments for and against the bombing of Daesh in Syria in the aftermath of the terror attacks. Both sentiments derive from the deep-rooted beliefs in the frailty of human life and the need to preserve it as well as the sense of enduring hope of a better future which people rely upon for comfort. The communication languages and associations between the two issues have in some respects formulated the remarkably similar en-masse responses and outpourings of emotion to these highly provocative issues.

While the legacy media have traditionally been the focus of much of the scholarship around climate change communication, there is growing interest in the insights that data from social media can provide (Auer et al., 2014; Holmberg & Hellsten, 2015). It has been observed that increases in dialogue on climate change on social media have been shown to exist following extreme weather events (Roxburgh et al., 2019; Kirilenko et al., 2015). When extreme weather events occur, people often turn to social media platforms to share information, opinions and experiences. One of the topics commonly discussed is the role climate change may or may not have played in influencing an event. The significance of the physical distance from the extreme weather event and the influence on perceptions of climate change have been previously discussed (2.2.5). The influence of new media and social media in facilitating discussion on climate change is an important consideration in the perceptions of the risks posed by climate change.

The pervasiveness of new media in many people’s social exchanges and the inherent cultural lens through which we view climate change demands change in the way science is conducted and citizens engaged (Hulme & Ravetz, 2009).

2.3.5 Fake news and climate change

Effectively addressing climate change requires significant changes in individual and collective human behaviour and decision-making. The increasingly politicalised debate on climate science and the emergence of new media as a key communication and engagement tool has seen a rise and in ‘fake news’ and the distribution of disinformation aimed to disrupt action on climate change (van der Linden et al., 2017).

Vested-interest groups known as ‘Merchants of Doubt’ have orchestrated influential disinformation campaigns in which they publicly dispute the scientific consensus on various issues, including human-caused climate change (Elsasser & Dunlap, 2012; Oreskes & Conway, 2011). These campaigns have not only successfully undermined public understanding of the degree of scientific agreement on climate change, they have also increased existing political polarization (Dunlap & McCright, 2008) and limited deeper societal engagement with the issue (Dunlap & McCright, 2011; Washington & Cook, 2013). Identifying ways to effectively engage with the public about the issue across the political spectrum has proven difficult (van der Linden et al. 2017).

Research has demonstrated that by communicating the scientific consensus on human-caused climate change significantly increases public perception of the expert van der Linden et al. 2017). However, the introduction of misinformation contesting the existence of a scientific consensus neutralises the positive effect of highlighting normative expert agreement on the issue. However, van der Linden et al. (2017) demonstrated that by pre-emptively warning people about politically motivated attempts to spread misinformation helps promote and protect public attitudes about the scientific consensus.

2.4 Conclusions

Communication on climate change science has in this view been successful in engaging public and political interest, shaping debate and now calling for action to address the risk. However, upon deeper exploration, the understanding of climate change is superficial, with personal concern being relatively low and susceptible to be overwhelmed by more immediate, salient threats and interests. Whilst the majority of people are in favour of actions to support climate change they are unwilling to support things such as carbon taxes or increases to fuel prices (Moser, 2008).

Communication on climate change is only part of the picture. Raising awareness and discussing an issue does not directly result in behaviour change or policy action. Other factors, especially policy options, windows, and barriers, are all influential as is an understanding of the key drivers and influences of public

perceptions of risk and danger. Thus, for communication to be effective in leading to active engagement, it must be supported by policy, economic, and infrastructure changes that allow concerns and good intentions to be realised (Ockwell et al. 2009). In short, communication for social change must consist of efforts to increase the motivation to make a change and help to lower the barriers to realizing it (Moser and Dilling 2007). There is no easy answer to societal discussions of value-laden issues with big stakes for everyone involved (as heated debates over regulating carbon emissions and situating wind farms suggest). Thus, effective communication serves two-way engagement, which—ultimately—enables societal action.

Climate change is and will remain to be a wicked problem, a mind-bendingly complex problem, characterised by contradicting certitudes and thus defying elegant, consensual solutions (Rayner, and Malone, 1998). There will inevitably be social, economic and environmental costs associated with mitigating this problem, but there are equally positive social, economic and environmental opportunities to be made alongside these sacrifices. By engaging the public with the evidence for, projections of and possible mitigation strategies to combat climate change it will be possible to bring the public on board with tackling this vexing problem (Dietz, Dan & Shwom, 2007).

Effective communication with the public and policy makers must challenge individuals to gain an understanding of the issue in order to elicit an emotional repose such as interest, concern or worry; and actively respond by way of changes in climate-relevant behaviour or political action (Lorenzoni et al. 2007; Moser 2009; Moser and Dilling 2007; NRC 2002). In order to better communicate the dangers posed by climate change with the public the influences of the levels of conceptual understanding of weather and climate must first be understood. Neither can be understood as simply statistical datasets, but as a social artefact with a rich cultural history (Hulme, 2015). It is this history which forms the bedrock of today's perceptions, claims and disputes about climate change, as well as shaping discourses on the issue around the world. It is imperative the barrier which exists between the natural world and society is removed to build a comprehensive understanding of climate as a concept. By coupling these two elements it is

possible to engage people more constructively with the scientific evidence for, debate surrounding and the multitude of strategies aimed at tackling climate change.

This study aims to do this by assessing public understanding of the concepts of weather and climate and to identify if this level of understanding of the core concepts which underpin the science of climate change influence public perceptions of climate change. The study also aims to assess whether the public understanding of weather and climate is related to how they interact with climate change as an issue.

3 Aims

This study aims to extend previously limited research into the influence of how levels of conceptual understanding of weather and climate and the influence of this understanding on perceptions of climate change.

This is the first global study aimed at assessing the levels of conceptual understanding of weather and climate and aims to address a current imbalance in the literature where research has previously been focused primarily on Western nations (Leal Filho et al., 2019; Maibach et al., 2014; Porrtinga et al., 2011; Capstick et al., 2015). Levels of understanding will be assessed by continent in order to assess regional variation across the Full Population of respondents.

The study aims to assess variation in levels of public concern with the risks posed by climate change globally. Respondent concern with climate change will be compared with conceptual understanding of weather and climate to assess how levels of conceptual understanding amongst respondent influences perceptions of climate change.

The study also aims to assess how respondent levels of conceptual understanding of weather and climate and perceptions of climate change risk are influenced by how they interact and engage with the media on the issue.

3.1 Research Objectives

1. To assess how conceptual understanding of weather and climate varies at a global scale.
2. To assess how levels of concern with climate change varies globally and the relationship between this level of concern and the perceptions of the risks posed by climate change.
3. To assess how conceptual understanding of weather and climate influences perceptions of key metrics of climate change risk:
    i. Levels of concern with climate change
    ii. Psychological distance of climate change
    iii. Perceptions of the key risks posed by climate change

4. To assess how respondents interactions with the media influence conceptual understanding of weather and climate and shape perceptions of the risks posed by climate change.

4 Methodology

In order to address the aims of this research and assess variations in levels of conceptual understanding of the differences between weather and climate and the risks posed by climate change a survey methodology, distributed online via social media has been adopted. Survey methodologies have a long history of charting perceptions, choices and travel behaviours, making them a preferred method for capturing information on groups of individuals (Rushton, 1969, Gould & White, 1974). The methodology has been adopted across all branches of human geography and is now an essential research method for eliciting people's attitudes and opinions on social, political and environmental issues (Clifford et al., 2010).

This section details the reasoning for this methodology as well as assessing the limitations associated with the approach to research and the steps take to mitigate the influence of these potential issues.

4.1 Approach to questionnaire design

There are well established procedures for developing a "good" questionnaire that includes clear and effective questions (Flower, 2008). Questions may range from requests for respondents to provide factual information, to opinion based questions capturing attitudes and levels of agreement with an issue. By including both factual and opinion questions in survey design it allows for the testing of an assortment of attitudes, perceptions and beliefs on an issue.

Given the complex and deeply connected relationship individuals have with the natural world and the issue of climate change this study adopts a hybrid methodology combining the naturalist and anti-naturalist (interpretation) philosophical approaches to questionnaire design.

Naturalism treats individuals in a similar manner to the physical sciences requiring empirical evidence to validate a hypothesis. This method was utilised through the use of fixed-response and classification questions. The methodology is commonly used in survey research, and the principles for designing such questions have been in place for decades (Flower, 2008). The fixed-response method has numerous advantages for the investigation. Primarily the method allows researchers to acquire information on characteristics, behaviours and attitudes (McAfferty, 2010) in an efficient manner across a broad sample population. Moreover, the method also allows for a standardised analysis across the group, with a limited effect from variation in responses based on geographical dispersion (Fink & Kosecoff, 1998). However, the methodology is limited in the amount of detail it is possible to gather and the responses lack elements of detail, richness and personal viewpoints that can be gained from open-ended questions.

To capture a full spectrum of respondent perceptions of climate change the fixed response questions in this study make use of the Likert scale. The scale presents respondents with a range of responses anchored by two extreme, opposing positions (Robinson, 1998). As a result, five categories of agreement were used in this study: two extreme positions act as anchor points for the three response options for respondents to indicate their level of agreement with the question asked of them. As the Likert scale uses an odd number of questions the Likert scale it is possible for respondents to indicate a neutral response towards an issue, so as to reduce the impact of false weighting.

As part of the hybrid approach of the study to mitigate the limitations of fixed response surveys an anti-naturalist approach is also adopted. This methodology allows respondents to express their individual perceptions shaped by complex structures, their desires and rationality. This is especially significant when considering perceptions of climate change. To capture these beliefs open ended free-text questions were used alongside fixed response questions in a limited way to capture key metrics on the risk perceptions of individuals towards climate change and sources of information used to gather information on climate change. By employing a mixed methodology it allows for a richer volume of

information to be captured and a deeper level of analysis completed into people's perceptions, attitudes and habits (Sporton, 1999). This hybrid approach with a combination of Likert scale fixed response questions combined with limited free text response questions are the most suitable for self-administered questionnaire type surveys (Flower, 2008).

4.2 Question design considerations

The design of the questions is one of the most important aspects for minimising error in survey design (Sudman & Bradburn, 1974; Fowler & Mangione, 1990). Improving the design and evaluation of survey question is one of the least challenging components of the survey process. Compared with increasing size of a sample, or even the effort required to improve response rates, improving question design is the most straightforward (Flower & Cosenza, 2009).

A good question is one that produces answers which are reliable and valid measures of the research goals. Reliability is used here in the classic psychometric sense of the extent to which answers are consistent (Flower & Cosenza, 2009). When the state of what is being described is consistent, the answers are consistent as well (Nunnally, 1978). Validity, in turn, is the extent to which answers correspond to some hypothetical 'true value' of what is attempting to be measured (Cronbach & Meehl, 1995). The design of the questionnaire for this study followed the following four principles to attempt to mitigate the risk posed by poor question design (Babbie, 2003);

1. Questions need to be consistently understood. This is achieved by ensuring questions are key simple and by avoiding the use of complex phrases and long words which may confuse respondents.
2. Respondents need to have access to the information required to answer the question. Where appropriate, definitions of key terminology will be provided for all respondents. Respondents will also have the option to select that they are unsure or do not know the answer to a question.
3. The way in which respondents are asked to answer the question must provide an appropriate way to report what they have to say. By utilising

a mixed format through an internet distributed survey it is possible to design each question so as to provide adequate response options for respondents.

4. Respondents must be willing to provide the answers called for in the question. All respondents recruited for the study will be selected in accordance with the University of Nottingham's Code of Ethics.

A review of the literature was also completed to assess previous studies and to inform questionnaire design. The final questionnaire design is loosely based around the models adopted by Lombardi and Sinatra (2010) and Viscusi and Zeckhauser (2006). Both studies employed a hybrid approach to question design to assess perceptions of climate change and levels of understanding of the differences between weather and climate. However, both studies were limited in respondent numbers (83 and 250) and were distributed through the use of physical surveys to students. This survey follows their research in structure by first assessing respondent conceptual understanding of weather and climate and then perceptions of climate change, while also including a subsequent assessment of how respondents interact with the media on the issue of climate change as well as capturing anonymised demographic information.

Please refer to *Appendix A* for the Final Questionnaire used to test the aims of this research project.

4.3 Strategy for survey distribution

There are multiple strategies for gathering data for questionnaire surveys from face-to-face interviews, telephone interviews, postal surveys, drop and pick-up questionnaires and internet surveys. Each methodology has been well documented, its appropriateness discussed and effectiveness evaluated (Couper et al., 1998; Presser et al., 2004; Greene et al., 1989; Rossman & Wilson, 1989; Nadri, 2018).

So as to gather sufficient data and encourage respondent participation globally this study distributed questionnaires through the internet, rather than by performing interviews or postal surveys.

The primary delivery mode for the questionnaire was through the social media site Facebook. Facebook has been shown to be an effective tool for recruiting large samples of participants (Bullas, 2013; Samuels & Zucco, 2013; Gregori & Baltar, 2013; Christakis & Fowler, 2009). Facebook is available in virtually every country in the world, in over 70 languages, and in most countries it is the dominant online social network (Samuels & Zucco, 2013). Facebook had over 2.3 billion monthly active users worldwide as of July 2019 (Statista, accessed online 07/2019). It should be noted that the site is blocked in China, but is not blocked in Hong Kong or Macau (Ho, 2014) and among other relatively populous but internet-friendly countries it does not dominate in Iran, Japan, Russia, Vietnam, and Poland. However, despite these limitations the distribution method represents the most appropriate distribution mode for this study given the resources available.

The survey was distributed through Facebook groups, predominately through Buy-Sell groups which were launched in 2015. These open groups were used as the key platform to publicise the survey and to increase response numbers for it. The groups benefit from being diverse in the demographic of their membership and pervasive across all areas of the globe enabling the survey to be distributed to a great number of people. The survey was posed in over 100 Buy-Sell groups globally in order to encourage uptake.

The representativeness of the sample in this study is partially limited by the use of Facebook. Respondents were dominated by respondents under the age of 35, with this age group making up 74% (Table 2) of the total sample population. The effects of this age bias on the population have been discussed in *Section 5.1.2* below. The wider representatives of using Facebook as the distribution method for the study must be considered. Whilst there is an element of platform bias with using Facebook as the distribution source (Pearce et al. 2018) rather than adopting a multi-platform approach to distributing the study Facebook has over 1,871 million monthly users

(Kemp, 2017) and is significantly higher than all other platforms. Given the theoretical nature of the study and the assessment of the impact of the demographic of respondents the extent of platform bias on the results of this study are not considered to be pronounced.

4.4 Considerations for the use of internet surveys

Web based surveys have and a number of strengths and weaknesses like any other mode of data collection, such as telephone interviewing, in-person interviewing, or the user of self-administered questionnaires (Best & Krueger, 2004). The approach was chosen primarily in order to reach the wideset global audience.

Before the invention of the Internet, Kiesler and Sproull (1986) discussed the possibility of using computers to collect data in the social sciences. They warned; “Until such time as computers and networks spread throughout society, the electronic survey will probably be infeasible” (p. 403). Since then, due to the rapid development of computer technology and the massive uptake in Internet Connected Devices it is now possible to begin realising the potential benefits envisioned by Kiesler and Sproull (Gosling et al., 2004).

The potential advantages of using the Internet as a delivery mechanism for questionnaires have been comprehensively documented (Buchanan & Smith, 1999; Schmidt, 1997; Dillman, 2000; Madge & O’Connor, 2004). Compared with paper-based equivalents, web-based questionnaires are inexpensive and fast and can cover wide geographical areas. They are, therefore, an attractive proposition for researchers. However, the benefits that stem from the efficiency of delivery do not provide sufficient grounds in their own right to adopt the use of web-based questionnaires in preference to traditional paper-based ones. Consideration also needs to be given to quality of the data produced and the possible impact of the Internet mode of delivery on the information collected. The use of Internet based surveys have faced a number of challenges from the scientific community, and have often found editors and reviewers to be, at best, sceptical of the quality of their data and appropriateness as a research tool as their results differ from those

obtained through other methods (Mezzacappa, 2000; Krantz & Dalal, 2000; Denscombe, 2006; Ganassali, 2008).

Just as traditional survey practices were constrained and shaped by concern with survey error, the use of the abundant potential for innovation that the Internet provides should also be concerned with the mitigation of the four main sources of survey error: sampling, coverage, nonresponse, and measurement (Dilman & Smyth, 2007) so as to provide assurance that the survey methodology is appropriate to address the risk associated with the control.

Something that needs to be considered is how far the Internet mode of delivery might have an impact on the substantive content, coverage and nonresponse relating to the information respondents are willing to provide (Denscombe, 2006). However, research has found that there is, in fact, little or no difference in response characteristics between traditional paper-based questionnaires and digital ones (McCabe, 2004; Manfreda & Vehovar, 2002; Bandilla et al., 2003).

It is a widely held belief that the internet is the domain of the young and the use of the Internet as a survey tool puts unwarranted bias on the young in their response sample (Krantz & Dalal, 2000). A study by the Department of Commerce in 2000 found that of 48,000 households sampled Internet access rates were similar for three age groups: 53% for 9–17-yearolds, 57% for 18–24-year-olds, and 55% for 25–49 year olds. However, among the 50-and-over group, only 30% accessed the Internet (U.S. Department of Commerce, 2000). It was found that adults in the 50–64 age group were almost three times as likely to have access compared to the users in the 65 years and over group (Lenhart et al., 2003).

Srivastava et al. (2003) considered what age-related sampling biases would look like if they had occurred. A plausible scenario was that the Internet may be less familiar to older people, and thus older people may have to be higher in openness in order to seek out and participate in an Internet study. In fact,

Srivastava et al. found a small drop in openness with age, not the increase one would predict if older adults needed to be especially open in order to participate. If there was any openness-related sampling bias, it was sufficiently weak that it did not overwhelm the age effects. Srivastava et al. (2003) also tested another potential age-related sampling bias. If older people in the sample were unusually high in conscientiousness (because of selective mortality) or in openness (for the reasons described above), then the standard deviations for conscientiousness and openness should decrease with age because people at the low end of the continuum become less common as age increases. However, standard deviations did not decrease with age, providing more evidence that age-related sampling bias did not adversely affect the data.

It can be noted that whilst using Internet based, social media distributed surveys can be impacted by a number of limitations especially in relation to the demographics of respondents they are no less hazardous than traditional survey methods and are significantly more efficient at reaching a global audience, hence being appropriate for use in this study.

4.5 Behavioural decision hypothesis

Behavioural decision hypothesis (BDH) or 'home team betting' is a term employed to refer to the tendency of individuals to predict an outcome based on what they would like to happen (Viscusi & Zeckhauser, 2005). This phenomenon could be a result of a number of factors relating to over optimism with respondents normally concerned with benefits to the decision makers. Whilst this can be a result of bias, or to selective memory other possibilities remain such as herding or selective information revelation.

To address this, the questionnaire has been designed to identify this risk through the inclusion of the following questions: "*Globally, estimate the current number of deaths, illnesses and injuries caused by global warming*" and "*By 2100, estimate the number of deaths, illnesses and injuries caused by global warming*" (Appendix A). Viscusi & Zeckhauser (2005) found a positive correlation existed between responses indicating an increased

number of deaths and perceptions of the risks of climate change. Should the response population be found to be distorted as a result of BDH the responses will be adjusted in order to mitigate the effect on the response population.

4.6 Pilot study

A pilot study was conducted in April 2015, both online and in person so as to evaluate the design of the survey and the appropriateness of it for addressing the aims of the research.

The pilot phase was completed, firstly through an online survey tool with the respondents selected for testing via the University of Nottingham's email portal, and secondly through the random sampling of students on the University of Nottingham's campus who were then interviewed on completion of the survey. The use of face-to-face interviews in the pilot study are essential in order to assess the appropriateness of the survey design (Dilmann & Smyth, 2007).

A total of 35 respondents completed the survey in full in order to assess the design.

The major finding the pilot study highlighted was that the study was significantly too long, taking all of the 35 respondents approached in excess of 20 minutes to complete. As a result of these findings the survey design was reassessed, with the target time for completion reduced to 10 minutes to minimise potential drop-out rates.

4.7 Analysis

Analysis of this study have been divided into 3 phases:

The first phase is a descriptive analysis assessing the variation of the key aims and objectives globally and within their individual continual response populations.

The second phase assesses the extent to which relationships exist between these key metrics through three sections assessing how the levels of

conceptual understanding of weather and climate influence perceptions of climate change, climate change risk and media interactions with environmental issues.

The third phase assesses the significance of these relationships. Given the ordinal nature of the data the use of parametric statistical analysis methodologies is not possible to be performed on Likert Items (Boone & Boone, 2012). Likert-type items may be considered to be single questions making use of some aspect of the Likert response alternative (Clason & Dormody, 1994). Likert scales are formed when multiple Likert questions relating to the same area of investigation (a minimum of 4 questions) are combined and an average produced across these questions.

So as to understand the influence of the level of conceptual understanding of the differences between weather and climate on perceptions of climate change responses to questions 2.1-2.7 (Appendix A) relating to understanding of the difference between weather and climate were averaged and respondent average score compared with the average response for question 10.1-10.6 relating to perceptions of the risks posed by climate change. This allowed for a one-way ANOVA to be performed to assess the significance in the relationship between the two variables.

For other individual parameters this was not possible to be undertaken given the nature of the questionnaire. Consequently, results are presented as percentages of the total populations so as to understand the relationship between areas of interest.

5 Results

5.1 Demographics of Respondent Population

The survey was available online for a period of 40 days between 21/06/2017 – 30/07/2017 and was distributed via Facebook as discussed in Section 4 above. A total of 669 completed questionnaires were returned during the period with a survey completion rate of 72%. In all the respondents represent a sample of 62 nationalities distributed globally (Figure 1).

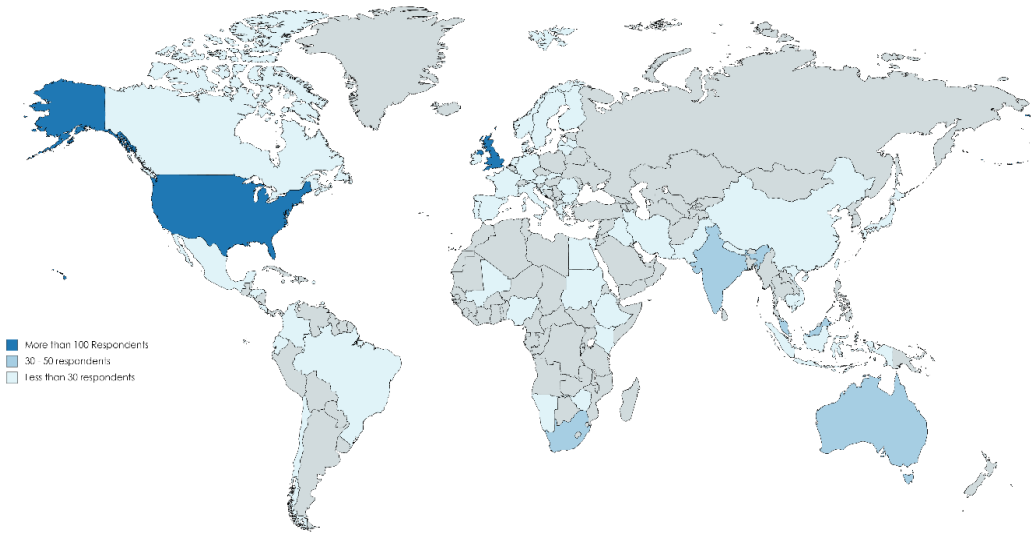


Figure 1: Map showing total response numbers by country.

The UK (215) and USA (132) dominated the respondent populations at a national level. Four other nations: Australia (43), India (34), South Africa (37), and Malaysia (34) were the only other states to provide response sizes of over 30. Fifty-six other nationalities were all represented, but returned less than thirty responses per nation. Four respondents did not declare their nationality. Please refer to Appendix B: Table 1 for the full breakdown of response numbers by nationality.

The response to the survey allowed for an assessment by continent. Respondent nationality was coded based on region to enable for the largest sample population to be assessed rather than limiting it on the basis on nationality.

5.1.1 Effects of gender on response distribution

Table 1 provides a breakdown of respondent gender for the Full Population as well as the proportionate breakdown between respondent nationality and gender. Respondents were provided with the following options: Female, Male, Other, Prefer not to say. Appendix B contains a breakdown of gender for the Full Population, Europe, North America, South America, Africa, Asia and Oceania response populations.

The Full Population was skewed towards female rather than male respondents. Responses were found to have 18% more female than male respondents. This trend was mirrored at a national level, within the Europe (26%), North American (20%), South American (35%) and Oceania (28%) response groups. Conversely, respondent populations from Africa and Asia were both significantly more closely distributed with both having a small male response weighting (6%).

Table 1: Table showing the total number of responses and the weighting of the population on the basis of Nationality and Gender.

Nationality	Total Number of Respondents	% Male	% Female	% Prefer not to say
Full Population	669	40%	58%	2%
Europe	303	36%	62%	2%
North America	142	39%	59%	1%
South America	20	30%	65%	5%
Africa	57	53%	47%	0%
Asia	99	52%	46%	2%
Oceania	44	36%	64%	0%

The effect of this skew on responses was assessed in two ways so as to address the risk associated with a skewed sample population. The first was through the analysis of the division between gender and the response to Question 1: *Do you believe you understand the difference between Weather and Climate?* (Appendix A). The second was the breakdown of responses to Question 8: *How concerned if at all are you about climate change, sometimes*

referred to as 'global warming'? (Appendix A). Please refer to Figures 2a and 2b below for the outcome of this analysis.

Figure 2a shows no significant variation existed with gender. For both types of responses a range of 3% was observed. When the regions are considered independently Europe and Asia demonstrated no gender bias in response and correlated strongly with the Full Population. However, when the Oceania, Africa, South America and North America response populations were considered female respondents were shown to indicate they had a lower level of conceptual understanding of the difference between weather and climate than Male respondents.

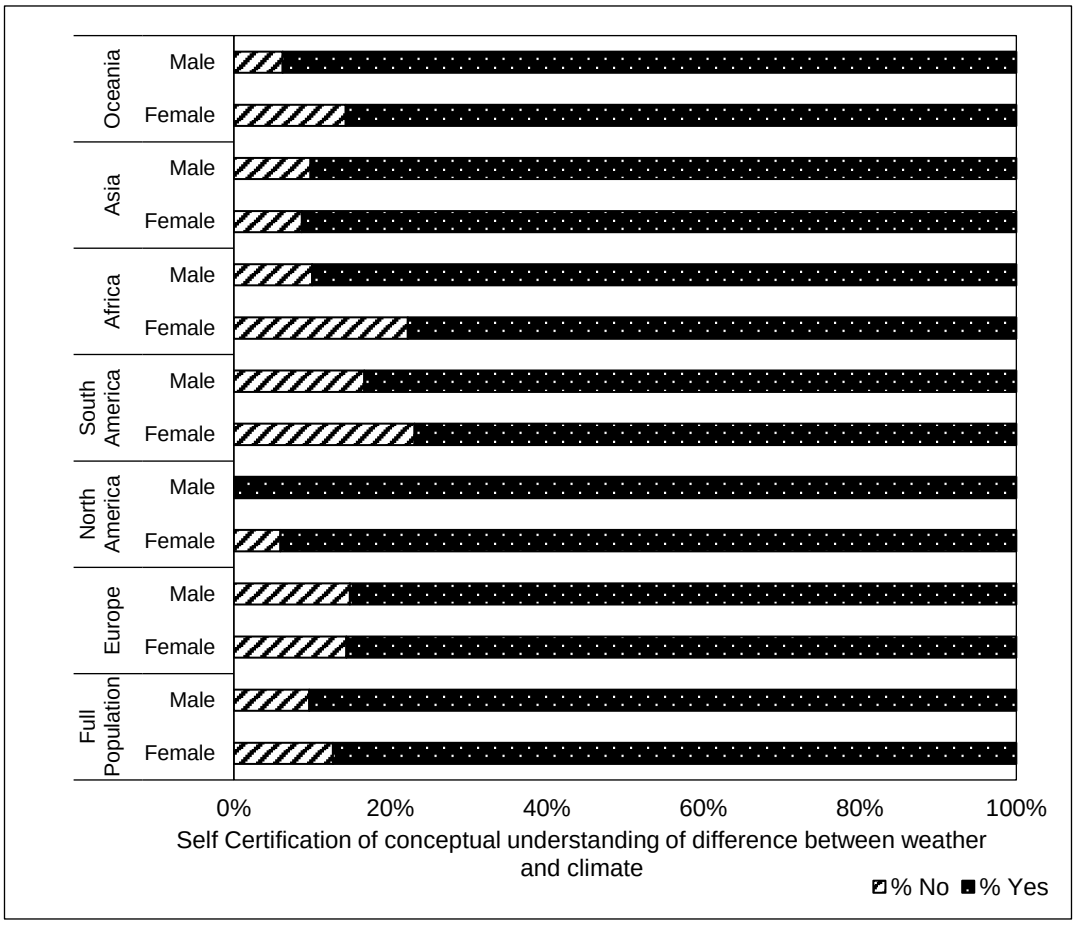


Figure 2a: Graph showing the difference in the response to Question 1 (Appendix A) between Female and Male Respondents for the Full Population and regional responses.

This correlation was reflected in the full response population documented in Figure 2b when levels of concern with the risks posed by climate change were assessed. The greatest variation in response population being the % Not at all

Concerned and % Extremely Concerned (3%). However, no significant variation existed in response populations caused by gender. This trend was correlated by the European response populations which did not produce significant levels of variation in gender.

In contrast, when the other continents were assessed significant variation in responses were present, with the highest degree of variation based on gender demonstrated by North America, South America and Africa. When respondent concern was ranked as either being Higher (Extremely concerned and Moderately concerned) or Lower (Not at all concerned and Slightly concerned) reduced variation was shown to exist in the response groups from Europe, Asia and Oceania as all showed no effects of gender bias. However, the North America, South America and Africa response groups all varied significantly in their responses.

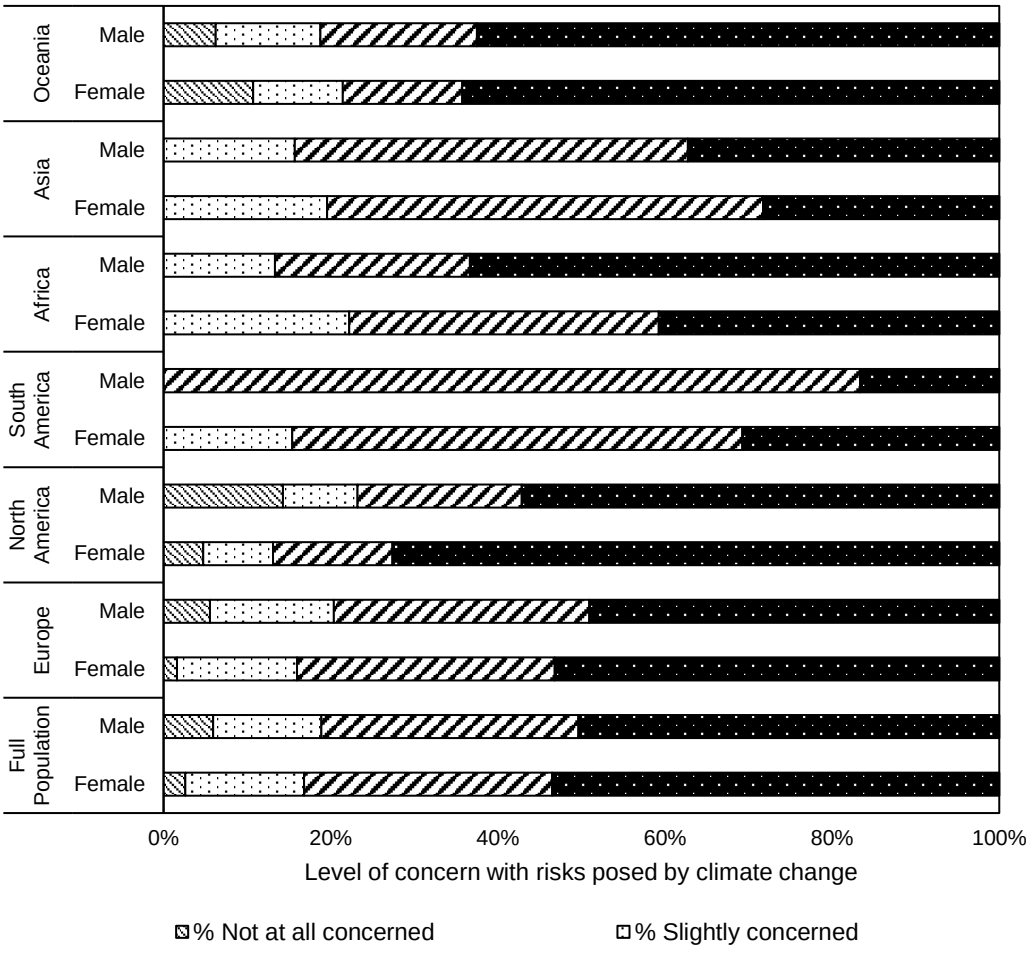


Figure 2b: Graph showing the difference in the response to Question 2 (Appendix A) between Female and Male Respondents for the Full Population and regional responses.

Whilst gender bias has been shown to not influence respondent levels of self-certification on conceptual understanding of climate change, or the level of concern with the risks posed by climate change across the Full Population, variation does exist at a regional level, especially within the North America, South America and Africa populations. This variation may be attributed to the low response numbers for these groups indicating low levels of concern with the risks posed by climate change as when the Full Population of respondents are assessed, limited variation exists in the population.

5.1.2 Respondent age distribution

Table 2 provides a breakdown of respondent age for the Full Population as well by region. Respondents were provided with the following age classifications: 18-24, 25-34, 35-44, 55-64, 65 and over, and prefer not to say. The response numbers for prefer not to say have been removed from this testing in the assessment of age on the response population.

Table 2: Table showing the total number of responses and the weighting of the population on the basis of Nationality and Age. Full Population (n=666), Europe (n=301), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=43).

Region	18 - 24	25 - 34	35 - 44	44 - 54	55 - 64	65 and over
Full Population	348	145	51	56	38	28
Europe	189	60	18	20	10	4
North America	50	12	16	24	20	20
South America	6	12	0	1	1	0
Africa	25	22	6	2	1	1
Asia	56	30	8	3	1	1
Oceania	21	7	3	5	5	2

The Full Population of responses was significantly skewed towards the respondents under the age of 35. The age groups 18-24 and 25-34 made up 495 of the 669 respondents accounting for 74% of the total response population. This significant skew in respondents towards the under 35 age groups is reflected in all other response groups other than the responses for North America. Whilst North American respondents comprised 44% of the

under 35 age group, there was a range from 11-17% in the response percentage for the 35-44, 44-54, 55-64 and 65 and over response groups.

Given the limited response numbers for the regional populations the effects of respondent age on the responses were assessed for the Full Population of responses only. This was completed in two ways so as to address the risk. The first was through the analysis of the division between age and the response to Question 1: *Do you believe you understand the difference between Weather and Climate?* (Appendix A). The second was the breakdown of responses to Question 8: *How concerned if at all are you about climate change, sometimes referred to as 'global warming'?* (Appendix A). Please refer to Figures 3a and 3b below for the outcome of this analysis.

Based on the testing completed in Figure 3a no significant variation between age groups in response to Question 1 was noted apart in the 55-64 age group which had 10% more of the response group stating that they did not understand the concepts of weather and climate compared with the rest of the population whose range was 5%.

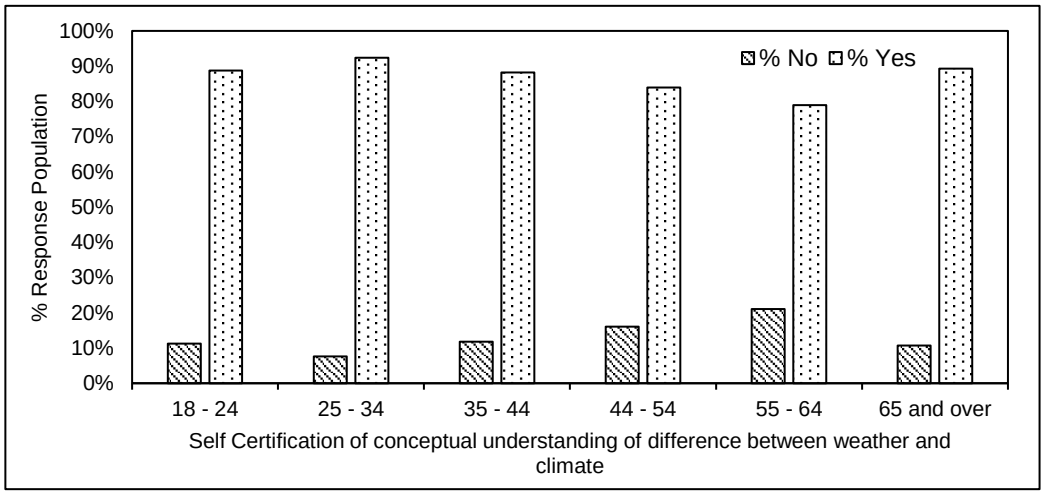


Figure 3a: Graph showing the difference in the response to Question 1 with age for respondents based on the Full Population of responses.

The Age bias towards the under 35 respondents presented in the Full Population had no significant impact on the responses provided when viewed across the Full Population of responses for Question 1.

When the effects of Age bias are considered in the assessment of respondent concern with climate change it was noted that for the majority of testing groups no significant variation existed when compared with the Full Population (Figure 3b). Both the response populations for ‘Not at all Concerned’ and ‘Slightly Concerned’ were found to not vary significantly with age. The only significant variation from the other age groups was for ‘Moderately concerned’ and ‘Extremely concerned’ levels. In both cases the 55-64 and 65 and over groups showed significantly lower levels of extreme concern (-7% and -16%) and higher levels of moderate concern (+7% & +16%) when compared with the Full Population.

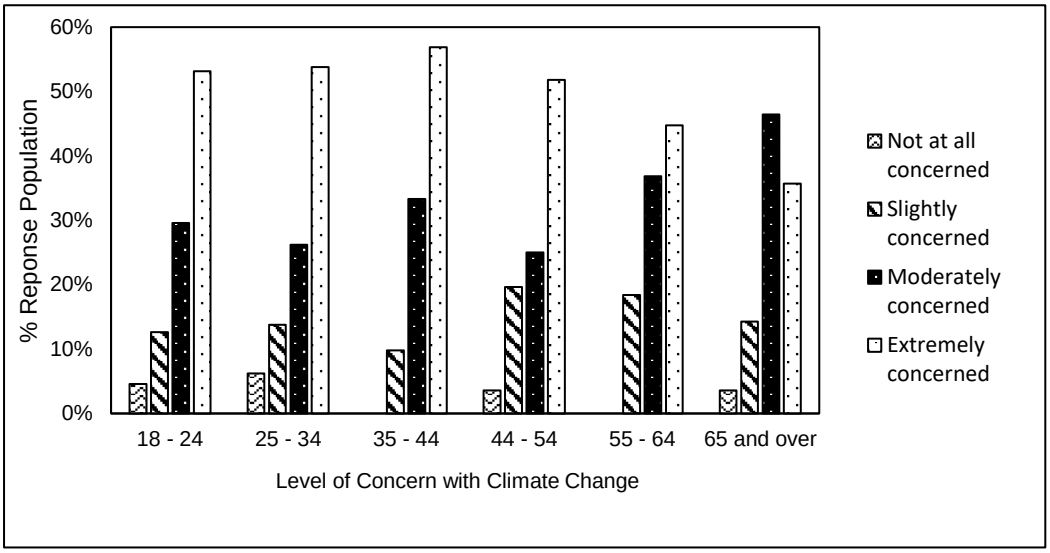


Figure 3b: Graph showing the difference in the response to Question 2 with Age for the Full Population of responses.

5.1.3 Behaviour decision hypothesis effect

The Behaviour Decision Hypothesis (BDH) has been demonstrated to impact on an individual's approach to responding to risk based questionnaires (Viscusi & Zeckhauser, 2005) as discussed in section 4.5. Testing was completed to assess the effect of BDH on the population. Please refer to Figure 4 for evidence of the responses to Question 12: *Globally, estimate the current number of deaths, illnesses and injuries caused by global warming*. No significant variation exists regionally, except for the South American and African populations. The South American population responded with a lower number of deaths being predicted, while conversely, African responses predicted higher numbers of deaths as a result of climate change. Given the lower response numbers compared with other response groups the significance of these variations is reduced and it can be concluded that the variations are not a result of the effects of the Behavioural Decision Hypothesis.

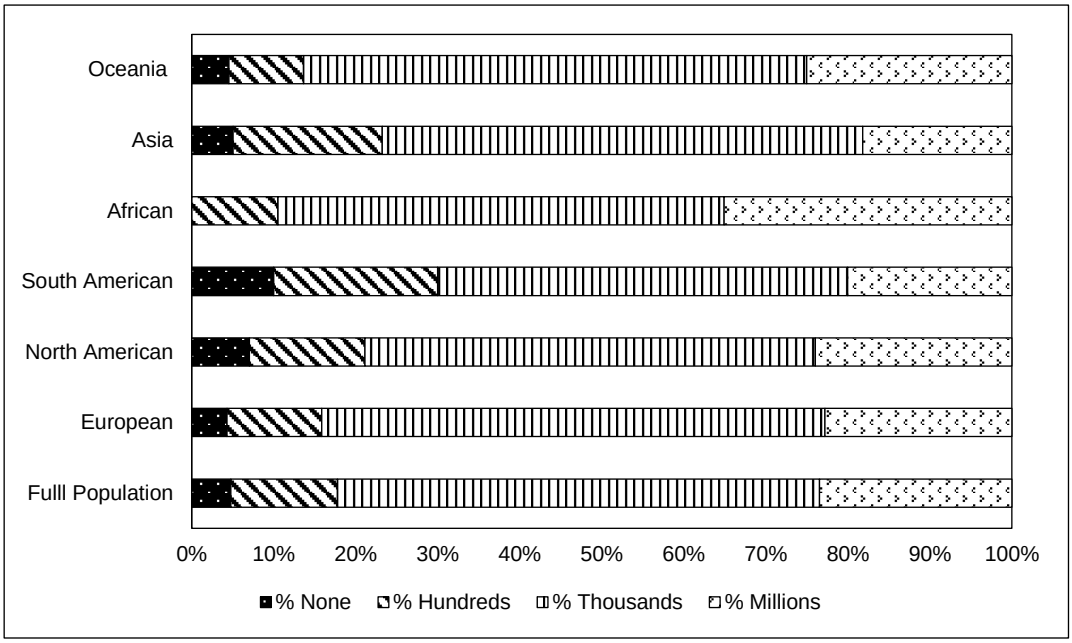


Figure 4: Graph showing the difference in the response to Question 12 for the Full Population (n=669), European (n=303), North American (n=142), South American (n=20), African (n=57), Asian (n=99) and Oceania (n=44) response populations.

When age is considered for the Full Populations are considered in response to the Question 12 (Table 3) it was shown that there was no significant variation between the Full Population and individual age groups caused by BDH. The only variation in the responses from the mean were for groups 55-

64 (+10%) and 65 and over (+12%) both predicting Millions of deaths. When compared with the groups' weighting towards a moderate level of concern with Climate Change it can be concluded that the variation is not a result of the effects of the Behavioural Decision Hypothesis.

Table 3: Table showing the difference in the responses to Question 12 for the Full Population (n=666), scaled with age.

Estimates of number of deaths	18 - 24	25 - 34	35 - 44	44 - 54	55 - 64	65 and over
None	4%	3%	10%	5%	8%	7%
Hundreds	15%	13%	14%	13%	8%	0%
Thousands	59%	61%	57%	55%	50%	57%
Millions	22%	23%	20%	27%	34%	36%

5.2 Conceptual Understanding of Weather and Climate

5.2.1 Self-certification of conceptual understanding

Self-certification levels on respondent understanding of the difference between weather and climate did not vary significantly with gender or age (Figure 2a, Figure 3a). When the population is considered in full 12 % (n=77) of the total response population (n=669) stated they did not understand the difference between Weather and Climate (Table 4). Regional responses for Europe, Africa, Asia and Oceania all correlated strongly with the responses of the Full Population. South America showed the lowest self-understanding of the concepts of weather and climate. By contrast, North American responses displayed the highest level of agreement they understand the difference between weather and climate with only 4% of respondents (n=6) stating they were unable to distinguish between weather and climate.

Table 4: Table showing the variation in responses to Question 1: *Do you believe you understand the difference between Weather and Climate?* (Appendix A) amongst the Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44) respondent populations.

Region	% No	% Yes
Full Population	12%	88%
Europe	14%	86%
North America	4%	96%
South America	20%	80%
Africa	16%	84%
Asia	10%	90%
Oceania	11%	89%

5.2.2 Conceptual understanding of weather and climate based on questionnaire responses

Responses to questions 2.1-2.7 (Appendix A) were scored and results averaged across the populations for each region (Table 5) to assess the average correct level of conceptual understanding of weather and climate. Please refer to Table 5 for the questions and correct responses. Definitions of weather and climate were based on those outlined in 2.1. Given the social effect of climate responses to 2.2 and 2.3 accepted the response ‘both weather and climate’ respectively as respondents demonstrated a suitable level of understanding of the concept. Following review of responses Question 2.4 was omitted from the testing population due to the significant number of ‘unsure’ responses provided.

Table 5: Table showing the questions and anticipated response to each question as well as the % correct score for each question for the Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44) respondent populations.

		% Correct Response Numbers						
Statement	Correct Response	Full Population	Europe	North America	South America	Africa	Asia	Oceania
2.1 - There was a heatwave last summer	Weather	60%	64%	68%	40%	58%	41%	61%
2.2 - For the last 4 years the least amount of rain has occurred during Autumn	Weather, both weather & climate	44%	47%	53%	45%	21%	36%	45%
2.3 - We are predicting temperatures will be greater than normal this Autumn	Climate, both weather & climate	64%	65%	62%	60%	51%	70%	68%
2.5 - Scientists say it will be 3 degrees Celsius warmer in 80 years	Climate	86%	92%	85%	80%	81%	72%	95%
2.6 - In the future there will be an Ice Age	Weather	66%	64%	65%	75%	65%	70%	80%
2.7 - The Arctic is warmer in the summer than it was 100 years ago	Climate	87%	92%	85%	85%	84%	76%	89%
Average % Correct		68%	71%	70%	64%	60%	61%	73%

Across the Full Population of responses an average of 68% of respondents responded correctly across all questions. The highest volume of correct responses were to questions 2.5 and 2.7. This trend was corroborated across all response groups. The statement with the lowest number of correct responses was 2.2 (44%). This was reflected by all regional response groups other than South America. South America respondents displayed the lowest level of agreement with statement 2.1. It was noted across all responses, the response groups of Europe, North America and Oceania either correlated with or performed better than the global average. By contrast response groups from South America, Africa and Asia correlated with or performed worse than the global average.

Table 6 provides evidence of the weighting of correct responses between questions classified as relating to weather (2.1, 2.2, & 2.6), or climate (2.3,

2.5 & 2.7). It was noted all response populations produced the same relationship with all testing groups demonstrating a greater understanding of climate when compared with responses to questions relating to weather. All regional response populations correlated strongly with the Full Population's knowledge gap between correct weather and climate responses. It was noted that the North American population was the only anomalous result with a significantly lower level of correlation with the Full Population.

Table 6: Table showing the average weighting of % correct responses to questions on Weather (2.1, 2.2, & 2.6) and Climate (2.3, 2.5 & 2.7). The table displays results for the Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44)

Region	Average % Correct Weather Questions	Average % Correct Climate Questions	Category with best understanding	Difference between % Correct
Full Population	57%	79%	Climate	22%
Europe	58%	83%	Climate	25%
North America	62%	77%	Climate	15%
South America	53%	75%	Climate	22%
Africa	48%	72%	Climate	24%
Asia	49%	72%	Climate	23%
Oceania	62%	84%	Climate	22%

When responses for weather were considered in isolation Africa, Asia and South America performed less well than the Full Population. All other response groups performed better than the Full Population of responses. When responses to statements around climate were considered it was noted all response groups performed better than for weather. The lowest average correct response groups were Africa and Asia with 72%, and North and South America also performed worse than the full population. Only the respondent groups for Europe and Oceania outperformed the global average.

5.2.3 Effects of age on conceptual understanding of the differences between weather and climate

Variation in responses for the Full Population of responses based on age were assessed to identify any variation present in the testing population and the results displayed in Tables 7 and 8 below. Table 7 provides the % correct

responses for each question for all age groups. It was noted that whilst variations do exist within responses there was no significant variation in responses when compared with the population as a whole for statements 2.5, 2.6, or 2.7.

The greatest variation from the Full Population in Table 5 was found in statement 2.1 with 35-44 (+13%), 55-64 (+14%), and 65 and over (+22%) groups returning response percentages significantly greater than the Full Population, and 25-34 providing 12% lower correct responses than the global average. Whilst variation exists in 2.2 it is limited to 55-64 group (+14%) and 45-54 group (+8%). For statement 2.3 only 25-34 (-9%) and 65 and over (-14%) vary from the full population in Table 5. It was observed that groups 18-24 and 45-54 do not vary significantly in response across all statements.

Table 7: Table showing the responses to questions 2.1 – 2.7 scales with Age for the Full Population (n=669). Groups 18-24 (n= 348), 25-34 (n= 145), 35-44 (n= 51), 45-54 (n= 56), 55-64 (n= 38), and 65 and over (n= 28) were assessed.

Statement reference	18 - 24	25 - 34	35 - 44	45-54	55 - 64	65 and over
2.1 - There was a heatwave last summer	59%	48%	73%	66%	74%	82%
2.2 - For the last 4 years the least amount of rain has occurred during Autumn	43%	42%	45%	52%	58%	46%
2.3 - We are predicting temperatures will be greater than normal this Autumn	68%	55%	63%	66%	68%	50%
2.5 - Scientists say it will be 3 degrees Celsius warmer in 80 years	86%	80%	92%	93%	92%	89%
2.6 - In the future there will be an Ice Age	67%	66%	65%	64%	71%	68%
2.7 - The Arctic is warmer in the summer than it was 100 years ago	89%	83%	86%	88%	84%	89%
Average % Correct	69%	62%	71%	72%	75%	71%

Table 8: Table showing the average weighting of % correct responses to questions on Weather (2.1, 2.2, & 2.6) and Climate (2.3, 2.5 & 2.7). The table displays results for the Full Population (n=669) and groups: 18-24 (n= 348), 25-34 (n= 145), 35-44 (n= 51), 45-54 (n= 56), 55-64 (n= 38), and 65 and over (n= 28) were assessed.

Age Group	Average % Correct Weather Questions	Average % Correct Climate Questions	Category with Better understanding	Difference between % Correct
18 - 24	56%	81%	Climate	25%
25 - 34	52%	73%	Climate	21%
35 - 44	61%	80%	Climate	20%
45-54	61%	82%	Climate	21%
55 - 64	68%	82%	Climate	14%
65 and over	65%	76%	Climate	11%

Table 8 provides evidence of the of the weighting of correct responses between questions classified as relating to weather (2.1, 2.2, & 2.6) or climate (2.3, 2.5 & 2.7) or climate for the Full Population of respondents scales with age. It was noted that no significant variation in response existed between the average % correct responses for each age when compared with the Full Population in Table 6. The only significant variations from the Full Population related to the average % correct response for questions on Weather, in respect of the 55-64 (+11%) and 65 and over (+8%)groups.

5.3 Level of Concern about the Risks associated with Climate Change

Figure 5 displays the variation in the response levels relating to the level of concern with climate change between the full population of respondents and the regional responses. The full population of responses was most heavily weighted towards the 'extremely concerned' (52.2%). By contrast only 4.2% of the Full Population responded as being 'not at all concerned' about climate change. It was noted 43.6% of the population indicated intermediate levels of concern (either 'slightly concerned', or 'moderately concerned').

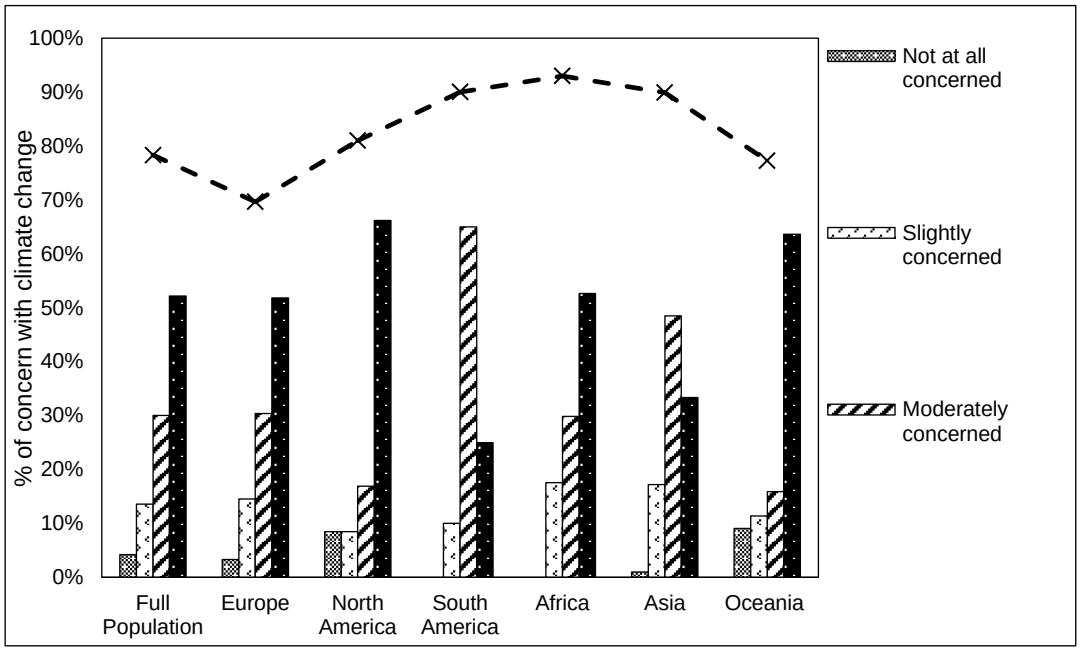


Figure 5: Graph showing variation in the response to Question 8 (Appendix A) assessing the variation in the level of concern with climate change with the Full Population of respondents as well as regionally. The graph also displays the response populations to Question 6 (Appendix A). Responses are plotted as a line graph to display respondent agreement with whether respondents have noticed changes to the seasons, wildlife, temperature or rainfall in the area where they live.

The European and African response populations correlate most strongly with the Full Population of responses across all the response groups. It was noted that all the response groups correlate with the Full Population for the low levels of concern with climate change risk ('not at all concerned' and 'slightly concerned'). North America and Oceania demonstrated the highest level of extreme concern, with South America and Asia responding with the lowest level of extreme concern. Both these response groups returned the highest level of moderate concern across the response group.

Figure 5 also provided assessment of the numbers of respondents within each population who have noticed changes to the seasons, wildlife, temperature or rainfall in the area where they live. Across the Full Population of respondents 78% stated they had observed changes to their local environment. The response populations for Oceania and North America were both found to correlate strongly with the Full Population. The response groups for South America, Africa and Asia had the highest portion of the populations who had noticed changes to their local environment. The European response group provided the lowest level of agreement with 70% of respondents stating they had noticed changes to their local environment.

5.3.1 Risks associated with climate change

Respondent perceptions of the risks posed by climate change were captured in Question 4 (Appendix A), “What are the 3 main risks associated with climate change” which was answered in free text form to allow for the broadest range of responses. These were then reviewed and coded based on their nature to enable effective analysis across the whole response population. Submitted responses such as ‘rising sea levels’, ‘ocean level rise’, and ‘rising seas’ all were coded to the risk category of ‘Sea Level Rise’. By accounting for variation in the responses it was possible to assess the key risks identified across all populations.

Table 9 displays the top 10 responses to question 4 across the full population of responses (n=699), and the European (n=260), North American (n=142), South American (n=20), African (n=57), Asian (n=99) and Oceania (n=44) populations. Based on a review of all regional responses it was noted that across all populations little variation existed with Sea Level Rise, Rising Temperatures and Extreme Weather Events being the most prevalent. Only South America and Asia (Flooding), and Oceania (Drought) had any variation in the top 3 risks associated with climate change.

Outside of the top 3 risks some limited regional variation is present. The North American population identified Famine as a risk over a Loss in Biodiversity, Africa and Asia both responded with Disease over Habitat Loss, and Oceania responded with Crop Failure over Melting Ice Caps.

It was also observed that across all response populations Unsure was present in the top 10 risks posed by climate change, with the South American population being the highest at number 5.

Table 9: Table showing the top 10 risks associated with climate change across the full response population. This top 10 were then also assessed for all response groups to assess regional variation in perceptions of the key risk associated with climate change. The table displays results for the Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44)

#	Full Population	Europe	North America	South America	Africa	Asia	Oceania
1	Sea Level Rise	Sea Level Rise	Sea Level Rise	Extreme weather events	Sea Level Rise	Sea Level Rise	Sea Level Rise
2	Rising Temperatures	Rising Temperatures	Rising Temperatures	Flooding	Rising Temperatures	Rising Temperatures	Drought
3	Extreme weather events	Extreme weather events	Extreme weather events	Sea Level Rise	Flooding	Extreme weather events	Extreme weather events
4	Flooding	Loss of biodiversity	Flooding	Rising Temperatures	Extinction	Flooding	Rising Temperatures
5	Drought	Drought	Extinction	Unsure	Melting Ice Caps	Loss of biodiversity	Loss of biodiversity
6	Extinction	Flooding	Melting Ice Caps	Crop Failure	Loss of biodiversity	Extinction	Unsure
7	Loss of biodiversity	Extinction	Drought	Melting Ice Caps	Disease	Drought	Habitat loss
8	Unsure	Unsure	Habitat loss	Extinction	Extreme weather events	Disease	Flooding
9	Melting Ice Caps	Habitat loss	Unsure	Loss of biodiversity	Drought	Melting Ice Caps	Extinction
10	Habitat loss	Melting Ice Caps	Famine	Drought	Unsure	Unsure	Crop Failure

5.4 Media Influence

5.4.1 Frequency of searching for information on climate change

Frequency of searching for information on climate change was captured through a self-assessment with Question 16: *'How frequently do you search for information on climate change / global warming?'* (Appendix A). The results of the full population, Europe, North America, South America, Africa, Asia and Oceania populations are displayed in Figure 6a.

Across the Full Population of respondents the most popular search frequency for information on climate change was 'Less than once per month' (32%). This was corroborated with all other response populations other than Oceania which returned 'Monthly' as the most common search frequency across the response population.

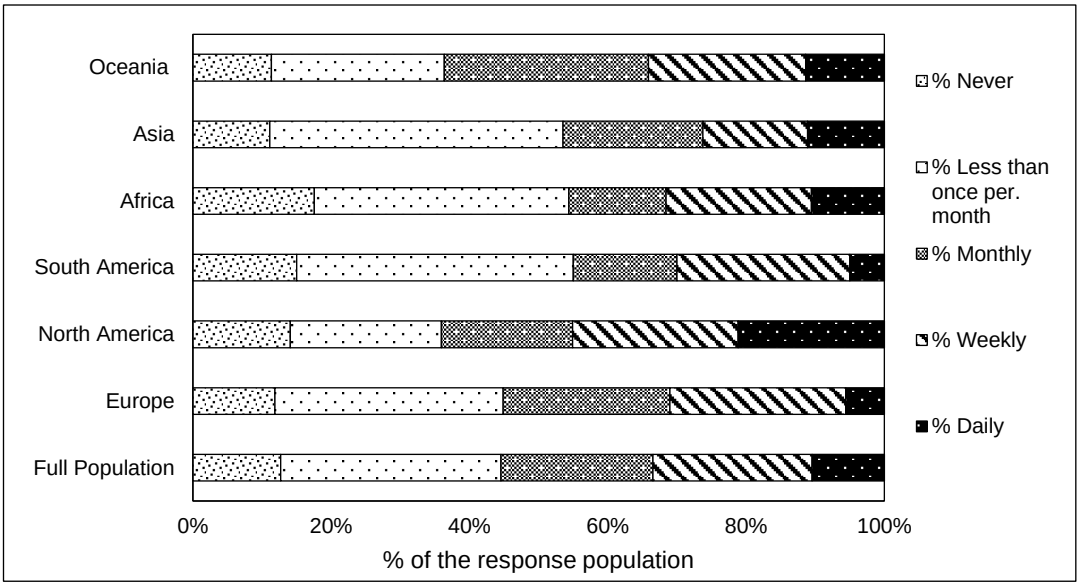


Figure 6a: Graph showing variation in the Frequency of searching for information on climate change for the Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44) response populations.

The European population correlates most strongly with the full population of responses on the search frequency. It was noted that there was no significant variation across all response groups for those who never search for information on climate change. This trend ~~is~~ was also matched with the 'Weekly' and 'Daily' responses and both categories only had one group which varied from the full population**:** Asia (15% 'Weekly') and North America (21% 'Daily').

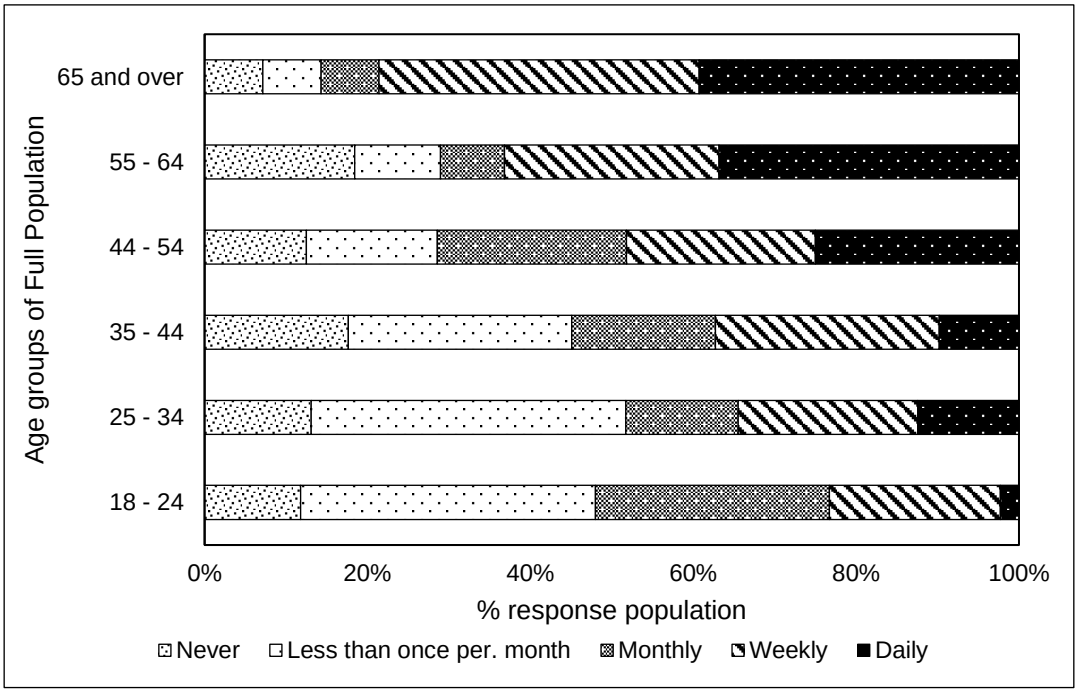


Figure 6b: Graph showing variation in the Frequency of searching for information on climate change for the Full Population (n=669) scaled with age. Groups 18-24 (n= 348), 25-34 (n= 145), 35-44 (n= 51), 45-54 (n= 56), 55-64 (n= 38), and 65 and over (n= 28) were assessed.

Figure 6b presents the results of a comparison of Search Frequency with Age for the Full Population of respondents. The results indicate significant variation between the frequency of searching for information on climate change and Age. The results show more frequent searches for information on climate change in the 44 – 65 and over group which are between 15% and 29% higher in proportion of the population than when the population is considered as a whole.

Other than the 65 and over demographic responses correlated with the Full Population in Table 6a for 2 search frequencies: 'Never' (4% maximum variation) and 'Weekly' (4% maximum variation). The most variation existed

in the ‘Less than once per month’ (+9%, -23%), Monthly’ (-23%) and ‘Daily’ (+29%, -8%) populations.

5.4.2 Source of information on climate change

The sources used to access information on climate change were assessed across the full population of respondents, and at a regional level for the response populations. Please refer to Table 10 for details of the media source types for the Full Population, and American and British populations as a proportion of each media source.

Respondents were given 10 sources of media, and the option of responding ‘Other’ in order to provide answers across the media spectrum through Question 14 (Appendix A). Respondents were asked to select the sources they most commonly used to find information on climate change. When the Full Population of responses were assessed (Table 10) Social Media was identified as the key source of information on climate change (22%). News websites and Television were found to be the next most common source (17% and 15% respectively) with Scientific Journals and Newspapers each accounting for over 10% of the response population. This trend was corroborated across all response populations. The only exceptions were in the Africa response group which highlighted that 11% of respondents gathered information on climate change from YouTube, and conversely, Oceania, where television was not used as a major source of information on climate change with only 8% of respondents stating they gathered information via this source.

Table 10: Responses to Question 14: '*Select the 3 main media sources where you most commonly come across stories on climate change'* for the Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44) response populations.

	% Response Population						
Media Source	Full Population	Europe	North America	South America	Africa	Asia	Oceania
Social Media	22%	20%	23%	22%	23%	22%	23%
News Websites	17%	18%	16%	15%	15%	15%	20%
Television	15%	16%	14%	18%	15%	15%	8%
Scientific Journals	13%	14%	13%	15%	11%	10%	15%
Newspapers	11%	10%	7%	13%	10%	15%	14%
Word of Mouth	5%	6%	5%	5%	6%	4%	4%
YouTube	5%	4%	4%	3%	11%	8%	5%
Radio	4%	4%	5%	0%	2%	2%	5%
Magazines	4%	3%	5%	5%	3%	4%	2%
Blogs	4%	4%	4%	3%	2%	3%	4%
Other	2%	1%	3%	0%	2%	1%	1%

5.4.3 New vs old media

The influence of new media as a source of public information has been well documented in literature (2.3.4). Respondents' use of new and old media sources to gather information on climate change has been assessed based on responses to Question 14 (Appendix A) which are documented in Table 9 above. New media has been classified as the following response categories**:** news websites, YouTube, social media and blogs. Old media has been classified as; newspapers, television, radio, magazines and scientific journals. Both word of mouth and other responses have been classified as other in Figures 7 and 8.

Figure 7 provides a breakdown of the variation in Media Type compared for the Full Population as well as across the regional response populations. It was noted that there was a limited variation in the full population responses corroborated with the majority of the response populations. Only the African population had a variation of over 10% with 51% of the response population relying on new media sources.

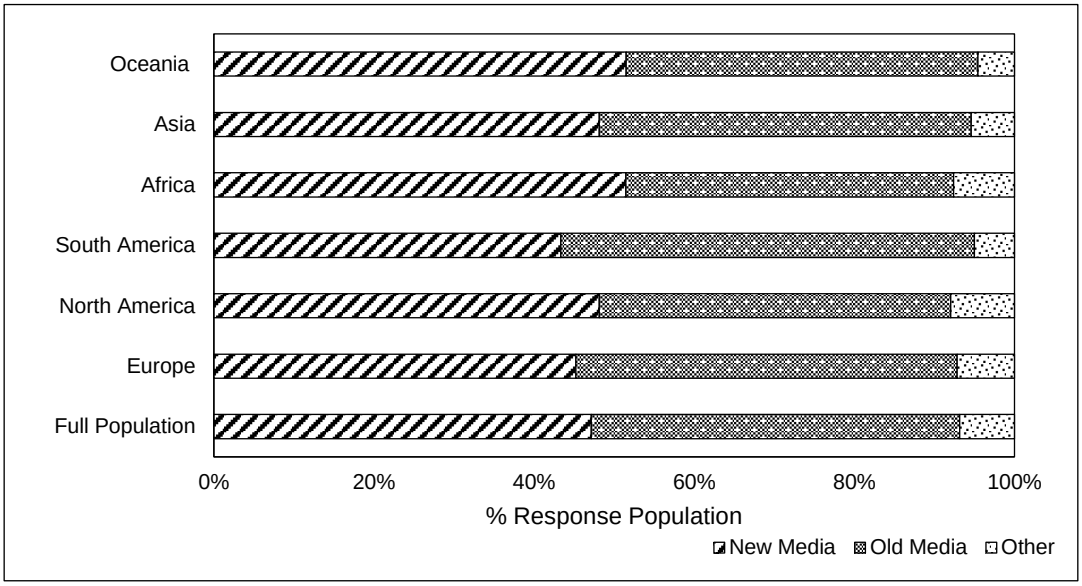


Figure 7: Graph showing variation responses on Media Type used to search for information on Climate change compared for the Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44) response populations.

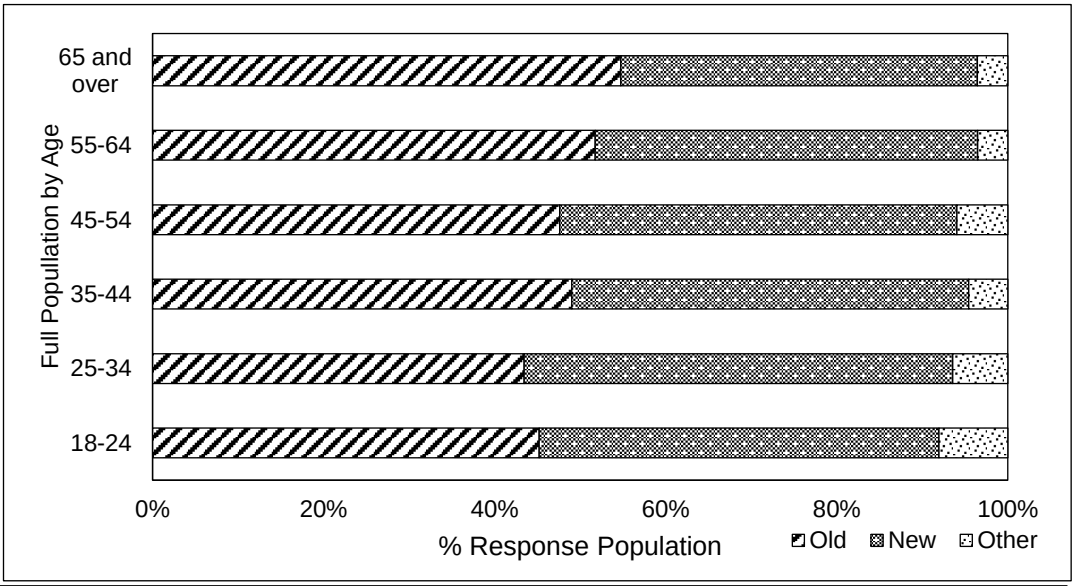


Figure 8: Graph showing variation in the Full Population data scaled with age to assess the variation between Old and New Media on location for sourcing information on climate change. Full Population (n=669) scaled with age. Groups 18-24 (n= 348), 25-34 (n= 145), 35-44 (n= 51), 45-54 (n= 56), 55-64 (n= 38), and 65 and over (n= 28).

The variation in the Full Population with media type with age was also assessed (Figure 8). Little variation was shown to exist between the responses at each age group when compared with the Full Population. Only the 65 and over age category varied significantly as this group was shown to utilise Old Media sources (+8.7%) when compared with the Full Population. It was also shown to use fewer New Media sources (-6.0%) and less 'Other' sources of information compared with the Full Population.

A greater degree of variation exists in the variation between 'Old' and 'New' media. 65 and over (13.1%), 55-64 (7.1%), and 25-34 (6.7%) had the most significant levels of variation in the populations when compared to the variation which existed across the population as a whole (1%).

5.4.4 Media outlet used for searching for information on climate change

The relationship between the level of understanding of the difference between weather and climate and the media outlet used to receive the majority of information on climate change were assessed through the survey by requesting respondents list the outlets they gathered the majority of information on climate change from through a free text field. Responses were coded as can be viewed in Figure 9 to remove duplicates and identify the key outlets relied upon by the respondent population for information on climate change.

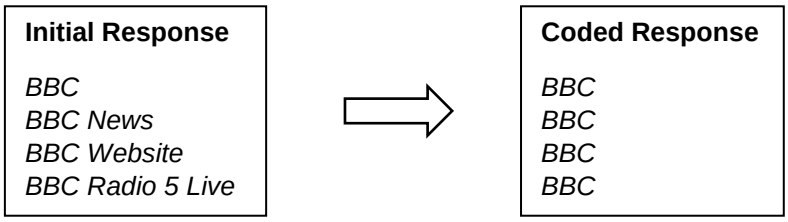


Figure 9: Flow chart showing the coding used to identify key media outlets.

The top 10 media outlets were identified for each of the response populations. Please refer to Table 11 below.

Table 11: Responses to Question 15: '*From what outlets do you get the majority of your information on climate change?'* for the Full Population (n=1093) and the Europe (n=514), North America (n=263), South America (n=35), Africa (n=72), Asia (n=133) and Oceania (n=70) response populations.

Media Outlet Ranking	Full Population	European	North American	South American	African	Asia	Oceania
1	Facebook	BBC	Facebook	Facebook	Facebook	Facebook	Facebook
2	BBC	Facebook	BBC	BBC	BBC	BBC	BBC
3	Guardian	Guardian	New York Times	National Geographic	YouTube	National Geographic	ABC
4	New York Times	Twitter	NPR	El Pais	National Geographic	CNN	Guardian
5	National Geographic	National Geographic	CNN	NPR	Twitter	Huffington Post	New Scientist
6	Twitter	Nature	Twitter	Twitter	CNN	Times	Word of Mouth
7	YouTube	New Scientist	Huffington Post	Huffington Post	Guardian	YouTube	IPCC
8	Huffington Post	Economist	YouTube	Reddit	Huffington Post	Twitter	Sydney Morning Herald
9	CNN	Independent	Washington Post	NASA	Al Jazeera	Guardian	The Age
10	NPR	Huffington Post	Guardian	Times	Instagram	Instagram	CNN

Tables 11 and 12 show that across all response populations Facebook and the BBC were found to be the most common media outlets used to access information on climate change. The BBC was only the most prominent group with European respondents**,** with the remaining response categories citing Facebook as the main source of information used to learn about climate change. Both outlets**,** across all response groups, accounted for around 50%

of all sources of information used to gather information on climate change. Only North America (32.3%) and Oceania (40.0%) did not corroborate this trend.

The third most popular outlet was found to vary regionally and was divided between traditional regional media outlets (Guardian, New York Times, and ABC News) and new media companies (YouTube and National Geographic). Across all regions these outlets accounted for an average of 7.1% of the population. In respect of all other outlets, only the North American response population had an additional outlet which was used by over 5% of the population to learn about climate change (NPR).

Table 12: Responses to Question 15: '*From what outlets do you get the majority of your information on climate change?'* for the Full Population (n=1093) and the Europe (n=514), North America (n=263), South America (n=35), Africa (n=72), Asia (n=133) and Oceania (n=70) response populations. Responses are ranked as percentages of responses and compared with the Top 20 responses across the Full Population of responses to assess the global influence of media outlets across response populations.

		% Response Population						
#	Media Outlet	Full Population	Europe	North America	South America	Africa	Asia	Oceania
1	Facebook	25.6%	20.6%	21.7%	40.0%	45.8%	36.8%	27.1%
2	BBC	22.0%	31.7%	10.6%	11.4%	13.9%	19.5%	12.9%
3	Guardian	5.0%	8.4%	1.5%	0.0%	2.8%	2.3%	4.3%
4	New York Times	2.4%	0.4%	8.7%	0.0%	0.0%	0.8%	0.0%
5	National Geographic	2.3%	1.9%	1.5%	5.7%	2.8%	5.3%	0.0%
6	Twitter	2.1%	2.1%	2.3%	2.9%	2.8%	2.3%	0.0%
7	YouTube	1.9%	1.2%	1.9%	0.0%	8.3%	2.3%	1.4%
8	Huffington Post	1.8%	1.4%	2.3%	2.9%	1.4%	3.0%	1.4%
9	CNN	1.6%	0.2%	3.8%	0.0%	2.8%	3.0%	1.4%
10	NPR	1.6%	0.0%	5.7%	2.9%	0.0%	0.0%	1.4%
11	New Scientist	1.4%	1.9%	0.8%	0.0%	0.0%	0.0%	4.3%
12	Nature	1.4%	1.9%	1.1%	0.0%	0.0%	0.8%	0.0%
13	Instagram	1.2%	1.0%	1.1%	0.0%	1.4%	2.3%	1.4%
14	Times	1.2%	1.2%	0.8%	2.9%	0.0%	3.0%	0.0%
15	Word of Mouth	1.0%	1.2%	0.8%	2.9%	0.0%	0.0%	2.9%
16	Economist	0.9%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%
17	Independent	0.9%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%
18	Reddit	0.8%	0.8%	1.1%	2.9%	0.0%	0.0%	1.4%
19	ABC	0.7%	0.0%	0.4%	2.9%	0.0%	0.0%	8.6%
20	Google	0.7%	0.8%	0.4%	0.0%	0.0%	2.3%	0.0%
Other Sources		23.3%	19.5%	33.5%	22.9%	18.1%	16.5%	31.4%

5.5 Climate Change Perception Matrix

Perceptions of climate change were scored and assessed based on levels of concern captured in Question 8: *"How concerned if at all are you about climate change, sometimes referred to as Global Warming?"*(Appendix A). Responses assessed regionally (Figure 10) and based on respondent level of concern with the risks posed by climate change (Figure 11).

Based on the populations of respondents within these 4 risk categories responses to questions 8, 9, 10 and 16 (Appendix A) were compared both regionally (Figure 10) and across 4 risk classifications (Figure 11). Across the Full Population of responses the results were coded based on risk level identified with 'No Risk' responses selecting 'Not at all concerned' (n=28), 'Low Risk' selecting 'Slightly Concerned' (n=91), Moderate Risk responding 'Moderately Concerned' (n=201) and Significant Risk responding 'Extremely Concerned' (n=349).

Given the ordinal nature of the data the median was taken across each risk category to produce the risk score for each grouping. Please refer to Appendix C, Table 1 for the response scores for each question in each of the four risk categories and regional variation in response. Due to the low population of responses across the 'No Risk' and 'Low Risk' classifications at a regional level testing was limited to the Full Population only when assessing the effects of level of concern on responses in order to reduce the impact of sample size bias on the results. Testing was performed on the Full Population (n=669) of responses and median scores for the regional populations: Europe (n=303), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44). These responses where plotted graphically to present the variation in perceptions on the risks associated with climate change across the 4 risk classifications. See Figure 10 for regional populations and Figure 11 for the level of concern with climate change across the full population.

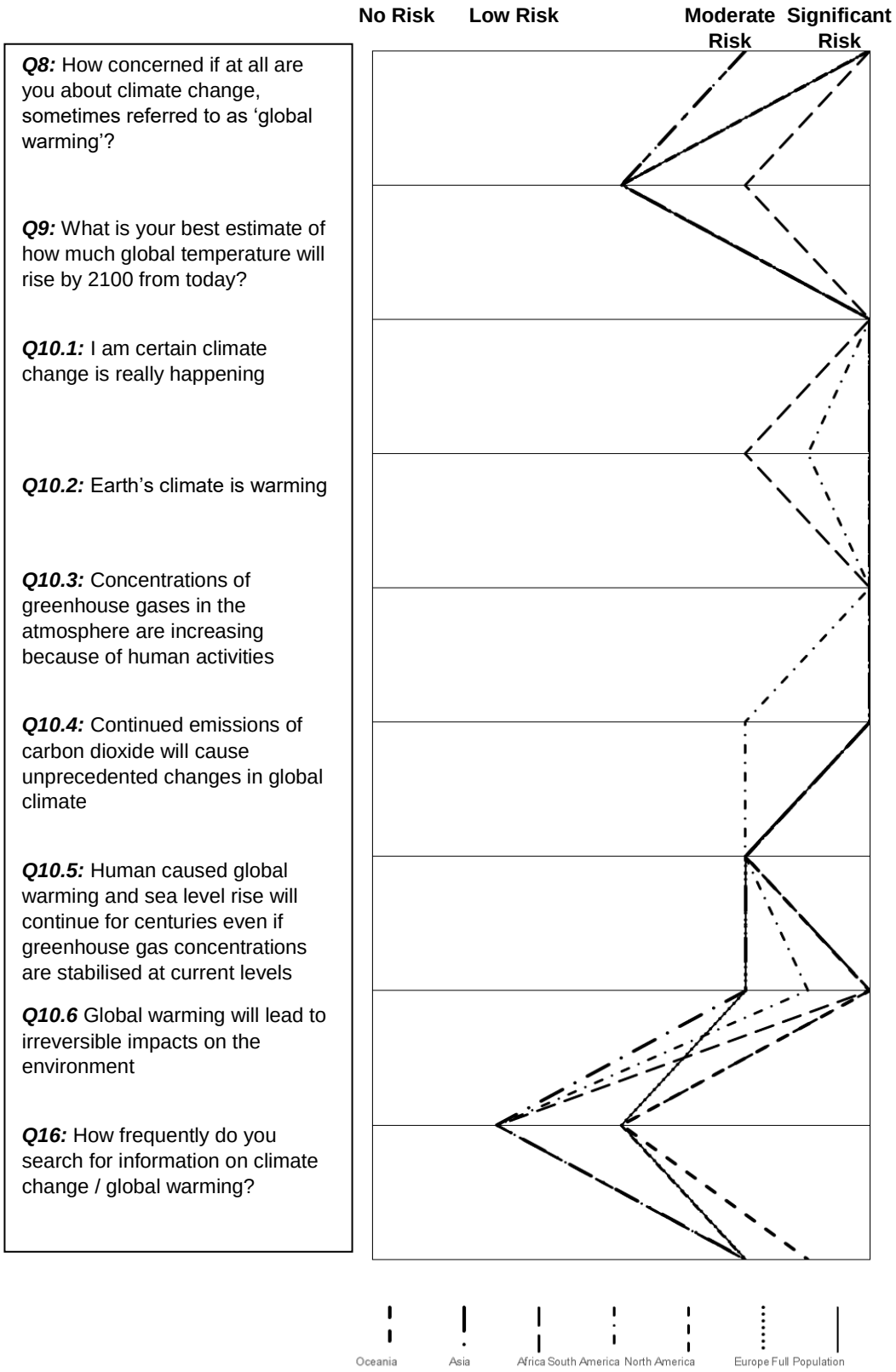


Figure 10: Graph showing variation in median perceptions of climate change risk across the regional response populations. Levels of concern captured in Question 8: *"How concerned if at all are you about climate change, sometimes referred to as Global Warming?"* (Appendix A). Responses were coded based on the median risk rating for each response population. Full Population (n=669) and the Europe (n=260), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44) response populations.

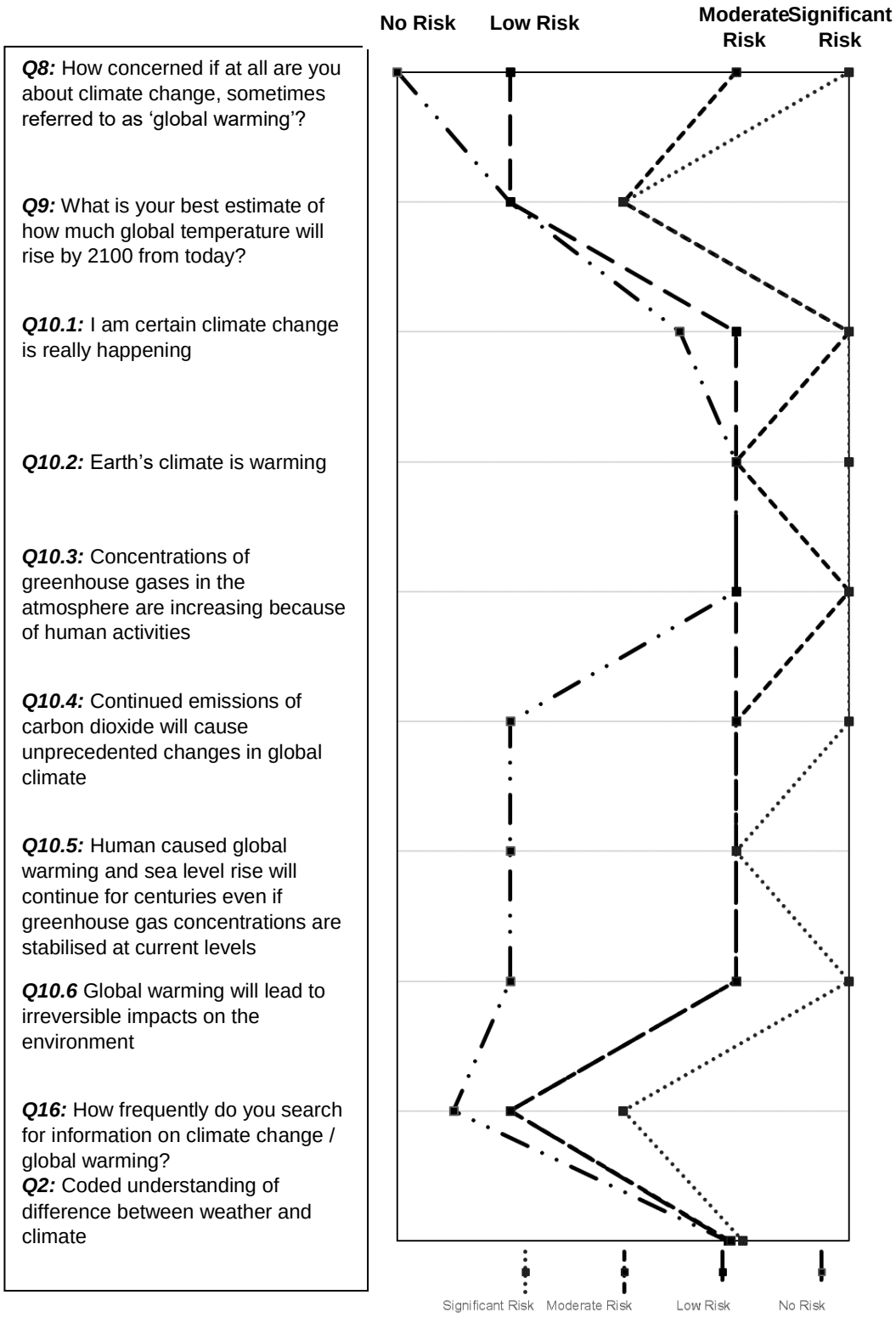


Figure 11: Graph showing variation in median perceptions of climate change risk across 4 risk ratings for the Full Population (n=669). Levels of concern captured in Question 8: *"How concerned if at all are you about climate change, sometimes referred to as Global Warming?"*(Appendix A). Responses were coded based on risk level identified with 'No Risk' responses selecting 'Not at all concerned' (n=28), 'Low Risk selecting 'Slightly Concerned' (n=91), Moderate Risk responding 'Moderately Concerned' (n=201) and Significant Risk responding 'Extremely Concerned' (n=349).

Results across the Full Population demonstrate a strong correlation between the levels of concern shown about climate change and perceptions of the risks associated with it. It was noted all response populations (Figure 10) and concern groups (Figure 11) correlated with each other based on median levels of agreement with perceptions of the risks associated with climate change. It was noted the 'Significant', 'Moderate' and 'Low' risk classifications did not vary significantly for questions 9, 10.1 - 10.6 with a maximum range between the 3 risk classification groups. The level of concern with the risks posed by climate change across the full and regional populations and correlated with both Significant and Moderate Risk classifications (Figure 11). This trend was corroborated with responses to Question 9. Respondent predictions of the projected increase in temperatures by 2100 were found to correlate strongly with the Significant and Moderate Risk categorises. Only African respondents were found to predict higher levels of warming.

Whilst the level of agreement was high across the response populations with all groups scoring between Moderate (4) and Significant (5) in agreement level with statements around risks posed by climate change (10.1 – 10.6) some variation does exist. The Full Population of responses, European, North American, Asian and Oceania response groups all scored the same in response to questions 10.1 – 10.5. Both South American and African respondents produced lower levels of agreement with the statements when compared with the rest of the response population. The highest level of agreement for all responses was identified as being in response to Questions 10.1: I am certain climate change is really happening, 10.2: Earth's climate is warming, and 10.3 Concentrations of greenhouse gases in the atmosphere are increasing because of human activities for all Risk Groups. It was noted that all groups other than 'No Risk' indicated a high level of risk in response to 10.4: Continued emissions of carbon dioxide will cause unprecedented changes in global climate.

The long term effects of climate change were assessed in questions 9, 10.5 and 10.6. Across the majority of the response populations (Figure 10) respondents indicated lower levels of agreement with the statements when

compared with statements around climate change science and the short term impacts of climate change (10.1 – 10.4). Across levels of concern (Figure 11) it was observed both Low Risk and No Risk groups displayed a lower level of risk perception for long term statements when compared with short term questions relating to concern with climate change. This trend is also partially observed for Moderate and Significant Risk groups which both correlate in response for questions 9 and 10.5. This correlation is not observed in responses to question 10.6.

Respondent's engagement with climate change was captured through Question 16, 'How frequently do you search for information on climate change'. It was noted the Full Population, European, North American and Oceania response groups all searched more frequently for information on climate change when compared with South American, African and Asian respondents. Across the Concern Groups (Figure 11) it was observed that the Low Risk and Moderate Risk ratings correlated with responses from South American, African and Asian response populations and Significant Risk populations correlated with the Full Population, European, North American and Oceania populations. The No Risk response population was the only group to be assessed as demonstrating a lower search frequency scoring 0.5 less than the Low and Moderate risk groups.

This variation was shown to have no impact on the score for the level of conceptual understanding of the risks posed by climate change across all respondent groups (Figures 10 and Figure 11). It was observed that only respondents from Oceania scored higher in the level of conceptual understanding across all groups compared with all other response groups.

5.5.1 Psychological distance of climate change

The psychological distance associated between the respondents identifying changes to their local environment (Question 6) and the level of concern displayed with the risks posed by climate change (Question 8). Figure 12 displays this relationship across the full response population.

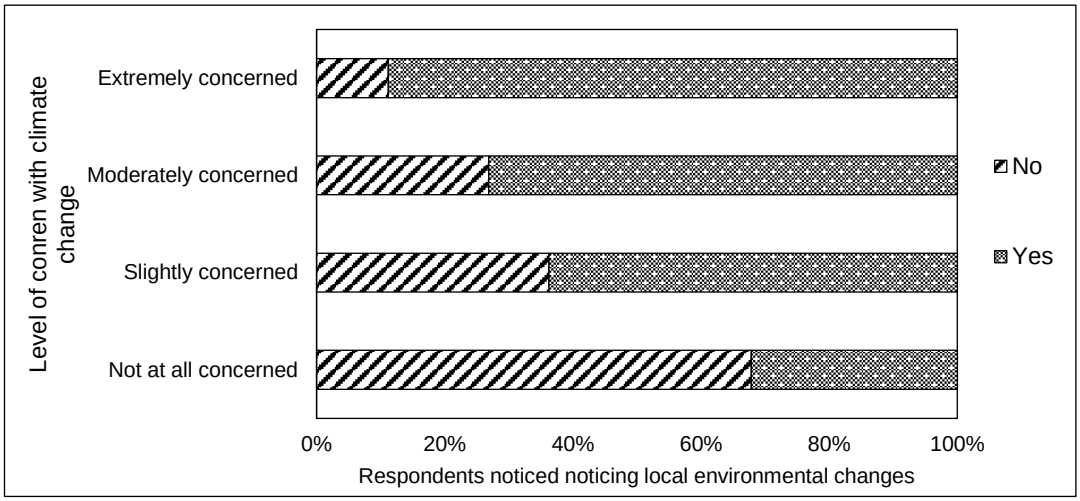


Figure 12: Relationship between respondent level of concern with climate change (Question 8 – Appendix A) and whether respondents had noticed environmental changes to their local environment.

It was noted that a strong linear relationship exists between level of concern with the risks posed by climate change and respondents who noticed changes to their local environment. 88.8% of respondents who were ranked as Extremely Concerned about climate change noticed changes to their local environment compared to 11.2% of respondents who had not and had registered Not at all Concerned about the risks posed by climate change. This relationship is reflected across both the moderate and slightly concerned response groups.

5.6 Influence of conceptual understanding of weather & climate on climate change understanding

Average correct responses for respondent understanding of the differences between weather and climate (Question 2.1 – 2.7: Appendix A) assessed in Section 5.2.2 were evaluated at a respondent level and coded based on average correct response. These scores were then classified as falling into one of the following 5 classifications: Very Low (<20% correct), Low (20%-40%), Moderate (40%-60%), High (60%-80%), and Very High (80-100%).

Table 13 below details the breakdown of respondents within these classifications across the Full Population, and regionally. It was observed that the majority of respondents displayed a Very High or High level of understanding of the concepts of Weather and Climate based on the above classifications. It was also observed there was little variation in the response populations at a regional level. Both the European and North American populations strongly correlated with the full population across all levels of understanding. Responses for both Oceania (86.4%) and Europe (78.5%) produced the highest levels of understanding across the High and Very High categories. Conversely, South America was the only group to produce more than 10% of respondents who had a Very Low level of conceptual understanding. When both the Very Low and Low classifications were reviewed together over 20% of both South American and African respondents fell into this category.

Table 13: Variation in response classification scores for the Full Population (n=669), and the Europe (n=303), North America (n=142), South America (n=20), Africa (n=57), Asia (n=99) and Oceania (n=44) response populations.

Region	Very Low	Low	Moderate	High	Very High
Full Population	3.0%	5.2%	17.6%	36.6%	37.5%
Europe	0.7%	3.6%	17.2%	38.6%	39.9%
North America	2.8%	3.5%	19.0%	31.0%	43.7%
South America	15.0%	5.0%	5.0%	40.0%	35.0%
Africa	7.0%	14.0%	19.3%	33.3%	26.3%
Asia	6.1%	9.1%	22.2%	40.4%	22.2%
Oceania	0.0%	2.3%	11.4%	36.4%	50.0%

To maximise the effectiveness of the insights into the influence conceptual understanding weather and climate has on levels of concern with climate change, risks associated with climate change and of the respondent use of media to learn about climate change testing was only completed on the Full Population. This was due to the low number of respondents returning Very Low, Low and Moderate levels of conceptual understanding of weather and climate (Appendix B, Table 4) in order to reduce error caused by low response numbers only the Full Population of respondents.

5.6.1 Perceptions of climate change

The relationship between respondent conceptual understanding of the difference between weather and climate and perceptions of climate change were assessed through comparison with key questions identified during testing. The following questions were selected for testing:

- **Question 8:** *How concerned if at all are you about climate change, sometimes referred to as 'global warming'?*
- **Question 5:** *The effects of climate change will depend on where you live. Do you believe by 2100 your local area will be better or worse off because of the effects of climate change?*
- **Question 6:** *In the area where you live have you noticed changes to the seasons, wildlife, temperature or rainfall?*
- **Question 10.1:** *I am certain climate change is really happening.*
- **Question 11.1:** *I am prepared to greatly reduce my energy use to help tackle climate change.*

Questions were selected to assess the effects of conceptual understanding of the difference between weather and climate and three key testing areas relating to climate. The first was with perceptions of the risk posed by climate change (Questions 8 & 10.1). The second was the physiological distance associated with climate change (Question 5 & Question 6). Finally, responses to Question 11.1 assesses the willingness of respondents to make changes to their lifestyle in response to climate change. Please refer to Figures 13a – 13e for evidence of the relationship between these key attributes and respondent understanding of the difference between weather

and climate. The results are displayed as a 100% cumulative stacked bar chart to allow comparison between the different groups.

The responses to questions 8 and 10.1 are assessed in Figures 13a and 13b. It was noted that the responses to both questions 8 and 10.1 were weighted towards agreement / concern with climate change as an issue across all levels of understanding of the differences between weather and climate. Little variation existed between level of understanding and level of concern about climate change. The only anomalous group in the population was the ‘Low’ level of understanding. This group produced the highest levels of ‘Not at all concerned’ and ‘Slightly concerned’ responses and a percentage of ‘Extremely concerned’ responses which was 5.4% lower than the next lowest response. However, when the statement ‘I am certain climate change is really happening’ (Figure 13b) was considered the relationship in Figure 13a shown by the ‘Low’ level understanding group was not reflected in the results with 97.2% of respondents at this level of understanding of climate change stating that they either ‘Agreed’ or ‘Strongly Agreed’ with the statement, the highest level of agreement across each of the 5 levels of understanding. It was noted that respondents with a Very Low level of understanding of the difference between weather and climate indicated the lowest level of agreement with the Statement 10.1 with only 85.0% of respondents stating they agreed or strongly agreed.

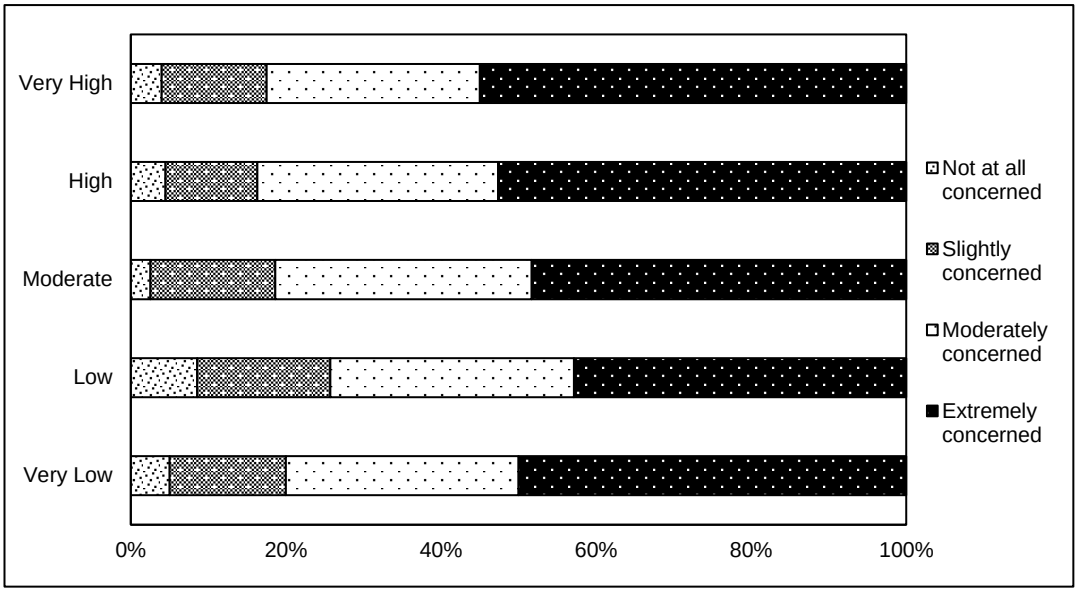


Figure 13a: Graph showing responses to Question 8: How concerned if at all are you about climate change, sometimes referred to as 'global warming'? Full Population (n=669).

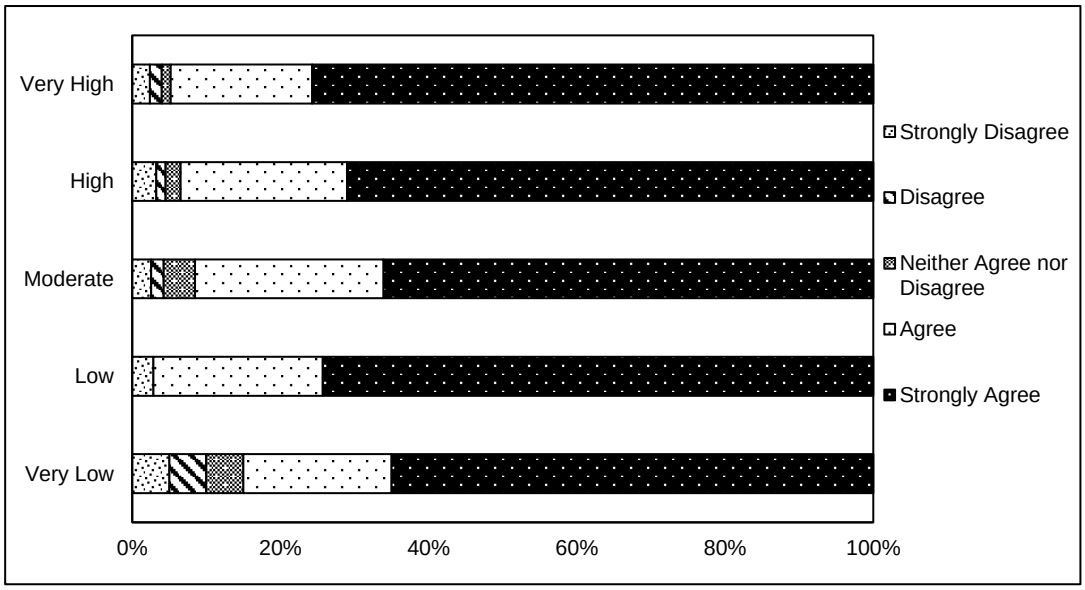


Figure 13b: Graph showing responses to Question 10.1: I am certain climate change is really happening. Full Population (n=669).

It was observed that respondents believed their local area would be 'worse off' by 2100 as a result of the effects of climate change (Figure 13c). All levels of understanding of the difference between weather and climate responded between 80% and 90% with a range of 8.3%. The Very Low level of understanding group produced the highest proportion of 'Worse off' results (90.0%) and respondents with a Very High level of understanding produced the lowest level of understanding (81.7%). The results indicate no significant

relationship exists between respondent level of understanding of the difference between weather and climate and the impact climate change will have on their local area.

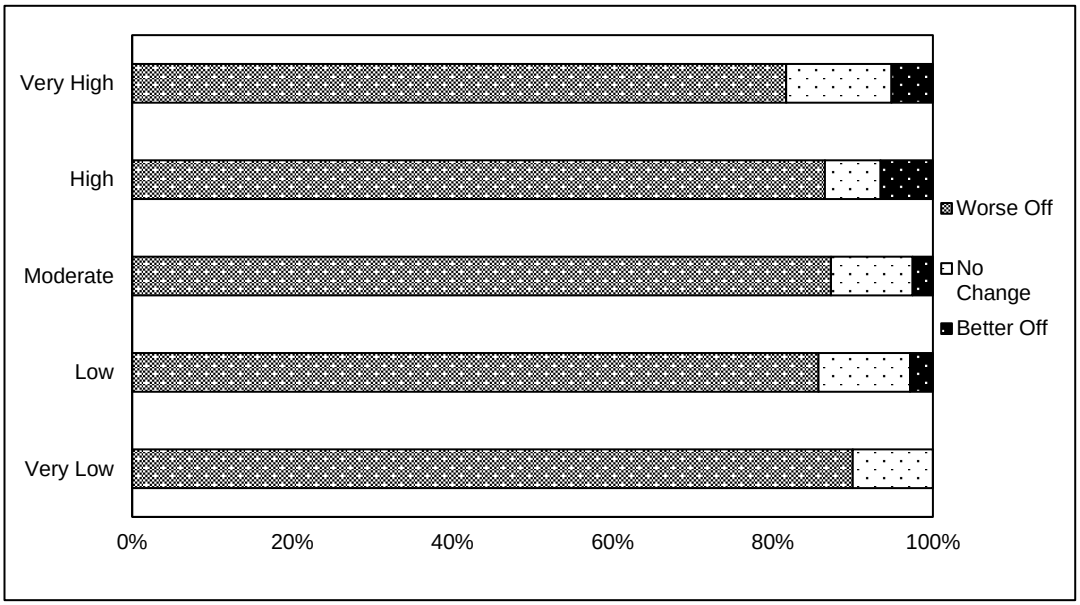


Figure 13c: Graph showing responses to Question 5. The effects of climate change will depend on where you live. Do you believe by 2100 your local area will be better or worse off because of the effects of climate change? Full Population (n=669).

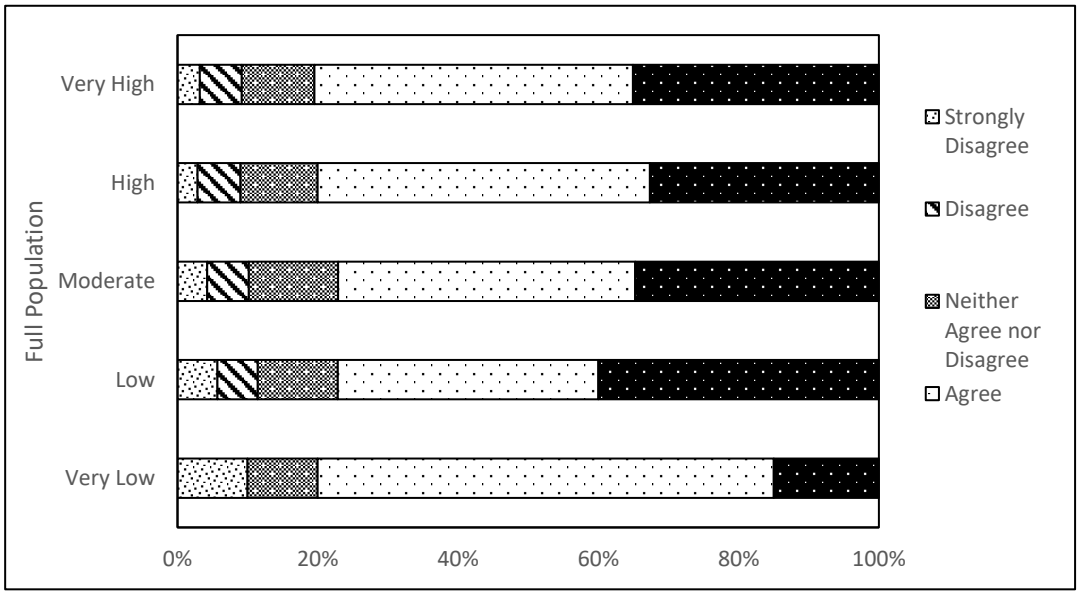


Figure 13d: Graph showing responses to Question 11.1. I am prepared to greatly reduce my energy use to help tackle climate change. Full Population (n=669).

Respondent willingness to greatly reduce their energy consumption to help tackle climate change was shown to be to have a relationship with the level of understanding of the difference between weather and climate (Figure 13d). It was observed that the respondents with a 'Very Low' understanding of the difference between weather and climate responded 'Strongly Agree' with only 15% of the total response population (n=20). It was noted this was an average of 20.6% lower than 4 other levels of response. The population also displayed the highest proportion of 'Strongly Disagree' responses (10.0%) compared with an average of 4.0% across the remaining 4 levels of understanding. However, when the responses are considered as joint between the levels of disagreement (Strongly Disagree & Disagree) and agreement (Strongly Agree and Agree) the relationship does not exist. 10% of the response population responded with levels of disagreement against an average for the 4 remaining categories of 9.95%. The level of agreement across both categories was found to be 80%. This also correlated strongly with the remaining classifications which averaged 78.7% agreement. It is likely the variation in the 'Very Low' respondent grouping was a result of the limited sample size present for this level of understanding.

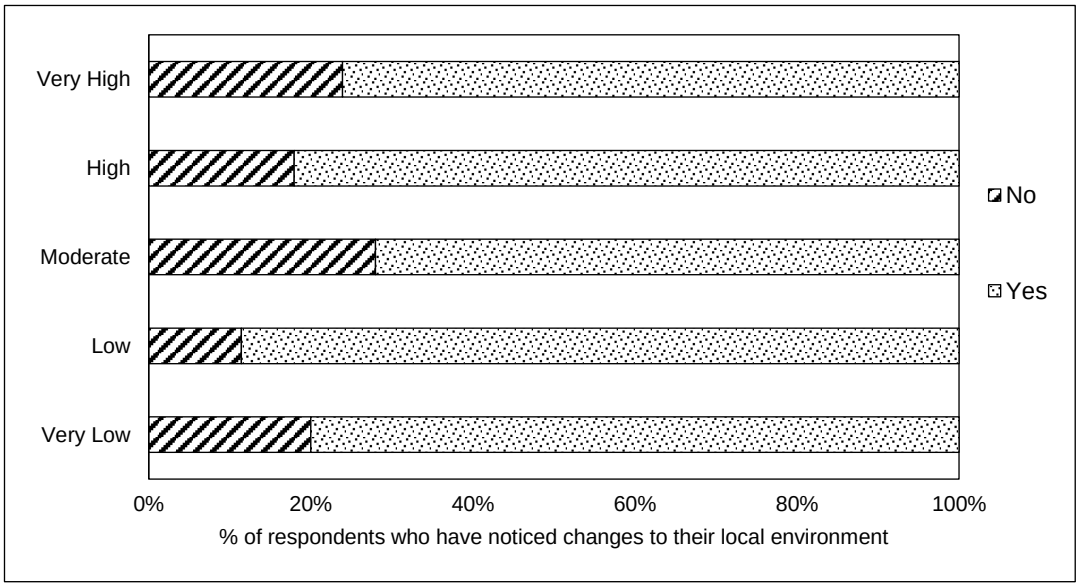


Figure 13e: Graph showing responses to Question 6: 'In the area where you live have you noticed changes to the seasons, wildlife, temperature or rainfall?' scaled against the respondent level of conceptual understanding of weather and climate across the Full Population (n=669).

When the level of conceptual understanding of weather and climate and number of respondents noticing changes to their local environment were assessed it was shown that no significant relationship existed with limited variation being observed across the 5 levels of understanding (Figure 13e).

5.6.2 Regression analysis

Given the ordinal nature of the data captured in the survey it was only possible to employ a regression analysis for the two composite Likert Scales formulated as part of the study (Appendix A). The level of conceptual understanding of weather and climate were captured through Questions 2.1 – 2.7 and perceptions of the climate change risk were assessed through responses to questions 10.1-10.6. Responses to questions 2.1-2.7 were first coded as either being correct or incorrect before being averaged across the total response population to produce a final score detailing the respondent level of conceptual understanding of weather and climate. Responses to questions 10.1-10.6 were coded between 1 and 5 with 1 being Strongly Disagree and 5 being Strongly Agree. These scores were then averaged across the questions to produce an average agreement level.

To assess the significance of the relationship between the level of conceptual understanding of weather and climate and perceptions of climate change a one-way repeated measure analysis of variance (ANOVA) was conducted to evaluate a null hypothesis that there is no significant correlation between level of understanding of the differences between weather and climate and perceptions of risks posed by climate change. The results of the analysis are detailed in Table 14 below.

Table 14: One-way ANOVA completed between level of understanding of the difference between weather and climate and the perceptions of climate change.

Regression Statistics	
Multiple R	0.05989787
R Square	0.003587755
Adjusted R Square	0.002093883
Standard Error	1.014523198
Observations	669

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.471914828	2.471915	2.401649	0.121681749
Residual	667	686.5146323	1.029257		
Total	668	688.9865471			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.661662992	0.224664713	16.29834	1.61E-50	3.220527769	4.102798	3.220528	4.102798
Average Climate Change Perception Rating	0.079253859	0.05114058	1.549725	0.121682	-0.021162049	0.17967	-0.02116	0.17967

The results show there is not a significant relationship between levels of understanding of the difference between weather and climate and respondent perceptions of climate at the p<.05 level for the three conditions [F (1,667) = 2.401649 p = 0.121682].

5.6.3 Effect on perceptions of risks posed by climate change

Perceptions of the risks posed by climate change were captured in free text response format in Question 8. These were assessed across the Full Population as well as regionally (5.3.1). The level of respondent conceptual understanding of weather and climate was compared with the top 10 risks identified with climate change (Table 15).

Table 15: Table showing the top 10 risks most common risks associated with climate change for the Full Population (n=669) scaled with respondent level of conceptual understanding of weather and climate.

	Level of conceptual understanding of weather and climate				
#	Very Low	Low	Moderate	High	Very High
1	Sea Level Rise	Drought	Sea Level Rise	Sea Level Rise	Sea Level Rise
2	Rising Temperatures	Sea Level Rise	Extreme weather events	Rising Temperatures	Rising Temperatures
3	Loss of biodiversity	Extreme weather events	Rising Temperatures	Extreme weather events	Extreme weather events
4	Extreme weather events	Flooding	Extinction	Flooding	Drought
5	Melting Ice Caps	Rising Temperatures	Drought	Extinction	Flooding
6	Flooding	Famine	Flooding	Loss of biodiversity	Extinction
7	Mass migration	Disease	unsure	unsure	Melting Ice Caps
8	Water Scarcity	Loss of biodiversity	Melting Ice Caps	Drought	Loss of biodiversity
9	unsure	Melting Ice Caps	Loss of biodiversity	Melting Ice Caps	habitat loss
10	Famine	habitat loss	habitat loss	habitat loss	unsure

It was observed that across respondents with a Moderate, High and Very High level of conceptual understanding the responses corroborated with the results of the Full Population when considered in isolation. However, whilst respondents who demonstrated a Very Low and Low level of conceptual understanding produced the same top 5 responses as the Full Population responses 6 – 10 varied. Respondents with a Very Low level of conceptual understanding ranked risks posed by Mass Migration, Water Scarcity and Famine in the top 10. Respondents with a Low level of conceptual understanding included Famine and Disease in the response population.

5.6.4 Frequency of searching of information on climate change

Variation in the level of conceptual understanding of the difference between weather and climate was compared with the frequency of searching for information on climate change to assess if any correlation existed between the groups. Testing was completed across the Full Population (Figure 14).

Whilst some variation exists between understanding groups within the Full Population it is not sufficiently significant to indicate a relationship exists between level of understanding of the difference between weather and climate and the frequency of searching for information on climate change.

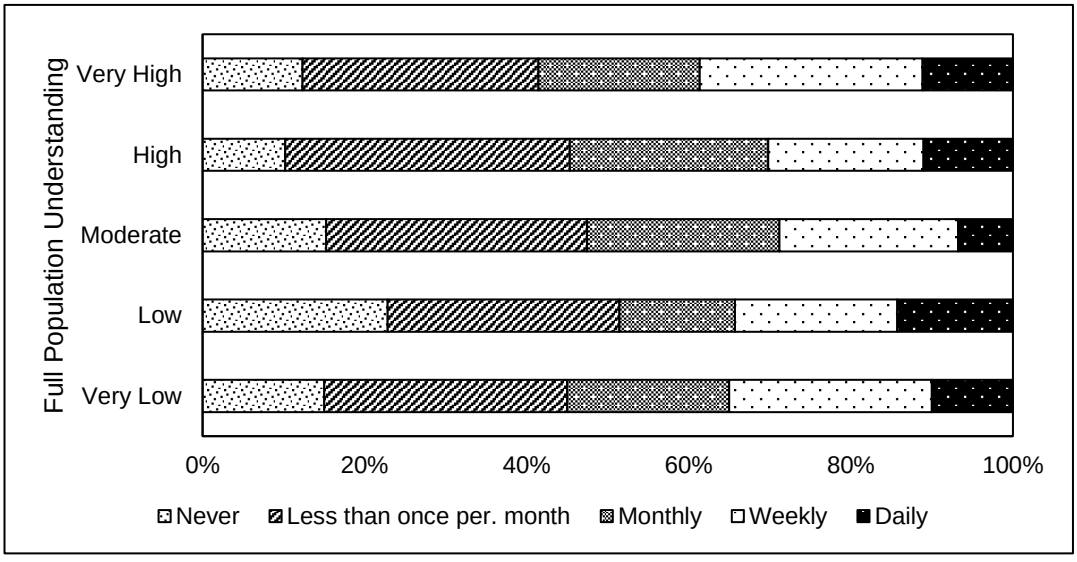


Figure 14: Relationship between Conceptual understanding of the difference between Weather and Climate and interest in seeking out information on climate change based on the Full Population of respondents (n=669).

5.6.5 Media source for searching for information on climate change

The relationship between the level of understanding of the difference between weather and climate and the media source used to search for information on climate change was assessed and documented (Table 16). It was noted that across the 11 media sources there was very little variation with the level of understanding on the differences between weather and climate. It was only Television which demonstrated a level of variation between the response groups. Respondents scoring Very Low and Low relied on the source for 25.0% and 22.9% respectively of their information on climate change. This was in contrast with Moderate, High and Very High scoring respondents who averaged 14.1% across the full population.

Table 16: Relationship between Conceptual understanding of the difference between Weather and Climate and the media source used to search for information on climate change.

	Coded average question numbers correct				
Media Source	Very Low	Low	Moderate	High	Very High
Social Media	25.0%	21.0%	24.0%	20.8%	21.6%
News Websites	11.7%	14.3%	16.1%	15.8%	18.3%
YouTube	6.7%	1.9%	7.6%	5.0%	4.5%
blogs	1.7%	1.0%	2.8%	4.1%	3.9%
Television	25.0%	22.9%	15.3%	14.8%	12.1%
Scientific Journals	10.0%	10.5%	9.3%	13.7%	15.0%
Newspapers	8.3%	16.2%	12.1%	10.6%	9.7%
Radio	5.0%	0.0%	3.7%	4.5%	4.0%
Magazines	5.0%	1.0%	2.3%	4.1%	4.0%
Word of Mouth	1.7%	8.6%	4.8%	5.3%	5.2%
Other	0.0%	2.9%	2.0%	1.2%	1.7%

5.6.6 Old vs new media source comparison for searching for information on climate change

The relationship between understanding of the difference between weather and climate and the respondent division between the Old and New media source was assessed (Table 17). A correlation was observed between respondents with a Low and Very Low level of understanding as they used Old Media sources more than respondents scoring Moderate, High and Very High. However, the relationship was not significant upon investigation.

Table 17: Relationship between understanding of the difference between Weather and Climate and the division between Old and New media for searching for information on climate change.

	Coded average question numbers correct				
Media Type	Very Low	Low	Moderate	High	Very High
New Media	45.0%	38.1%	50.6%	45.7%	48.3%
Old Media	53.3%	50.5%	42.7%	47.8%	44.8%
Other	1.7%	11.4%	6.8%	6.5%	6.9%

5.6.7 Media outlet used for searching for information on climate change

The top 20 media outlets were identified for the full population and are listed in Table 18 below. It was observed that across all response groups 2 outlets, Facebook and the BBC, were by far the most prominent. Both groups made up at least 59% of the total response population across all levels of understanding of the differences between weather and climate.

Table 18: Relationship between understanding of the difference between weather and climate and the media outlet used to search for information on climate change.

		Coded average question numbers correct				
Media Outlet	Total responses	Very Low	Low	Moderate	High	Very High
Facebook	280	54.2%	53.1%	33.3%	30.1%	33.3%
BBC	241	29.2%	25.0%	28.2%	29.5%	28.8%
Guardian	58	0.0%	0.0%	7.1%	8.2%	6.9%
National Geographic	25	0.0%	3.1%	3.8%	3.1%	2.6%
New York Times	25	0.0%	0.0%	2.6%	2.8%	3.9%
Twitter	23	0.0%	3.1%	3.2%	3.4%	2.0%
YouTube	22	4.2%	3.1%	3.8%	1.9%	2.6%
Huffington Post	20	0.0%	0.0%	3.2%	2.8%	2.0%
CNN	18	0.0%	0.0%	3.8%	1.3%	2.6%
Nature	15	4.2%	0.0%	0.6%	2.2%	2.0%
New Scientist	15	4.2%	0.0%	0.0%	2.2%	2.3%
NPR	14	4.2%	0.0%	0.6%	1.6%	2.3%
Instagram	13	0.0%	3.1%	1.3%	0.9%	2.3%
Times	13	0.0%	6.3%	0.6%	1.9%	1.3%
Word of Mouth	11	0.0%	3.1%	3.2%	0.9%	0.7%
Economist	10	0.0%	0.0%	1.3%	1.9%	0.7%
Independent	10	0.0%	0.0%	1.3%	1.6%	1.0%
ABC	8	0.0%	0.0%	0.6%	1.6%	0.7%
Google	8	0.0%	0.0%	0.6%	0.9%	1.3%
Reddit	8	0.0%	0.0%	0.6%	1.3%	1.0%

The Guardian and Times were the only outlets other than Facebook and the BBC to produce responses greater than 5%. However, it was noted that the Very Low population did not have an outlet greater than 5% coverage other than Facebook and the BBC.

It was observed that respondents scoring either Very Low or Low in their understanding of the difference between weather and climate gathered more than 50% of their information on climate change from Facebook. This was compared with an average of 32.2% of information on climate change being gathered from Facebook for respondents scored Moderate, High and Very High.

It was also noted that the reliance on the BBC for information on climate change did not vary significantly with the level of understanding on the difference between weather and climate between the populations with a range of 4.5% between all 5 levels of understanding.

5.6.8 Media influence on perceptions of climate change

Responses to respondent level of concern with climate change (Question 8) were compared with the responses to how frequently respondents searched for information on climate change in the media (Question 16). The results demonstrated a high degree of variation existed amongst the response populations and the frequency of searching for information on climate change. Across the Full Population of respondents the most popular search frequency was 'Less than once per month' with 30% of the population. The results demonstrated a high degree of variation between search frequency and the level of concern demonstrated with climate change and a strong linear relationship was found to exist between levels of concern with climate change and frequency of searching for information on climate change (Figure 15).

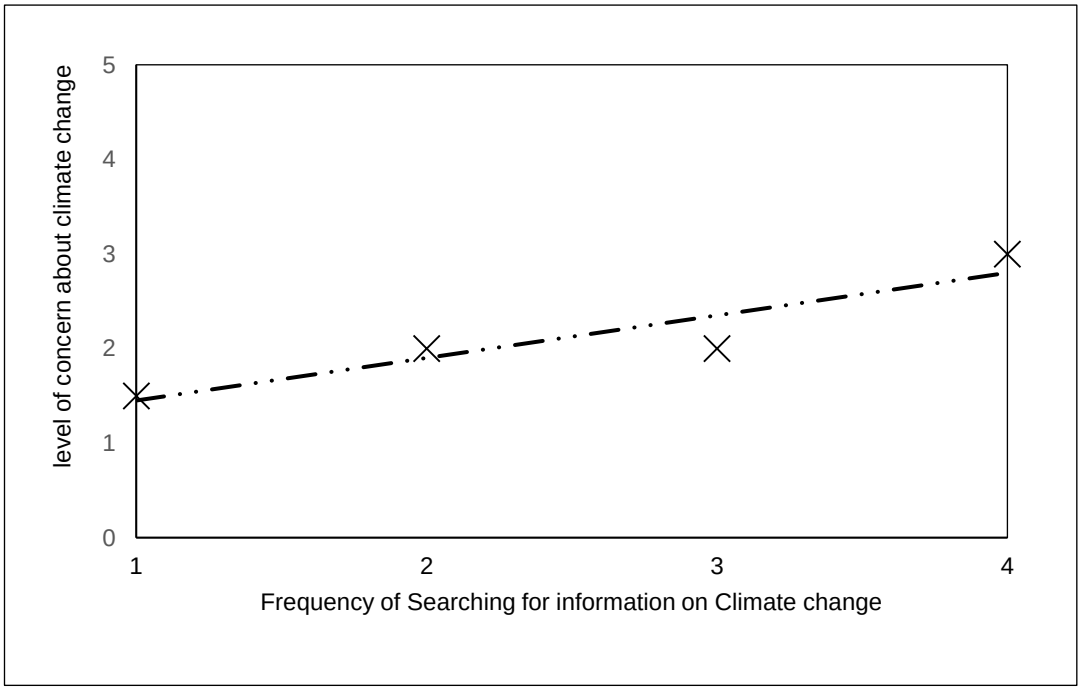


Figure 15: Graph showing the relationship between frequency of searching for information on climate change and level of concern demonstrated with climate change.

On the basis of this relationship a regression was performed to assess the significance of this analysis. A one-way repeated measure analysis of variance (ANOVA) was conducted to evaluate a null hypothesis that there is no significant correlation between level of concern with climate change and frequency of searching for information on climate change. The results of the analysis are listed in Table 19 overleaf.

It was found that a significant relationship existed between the frequency of searching for information on climate change and the level of concern shown for the issue at the p<.05 level for the three conditions [F 1, 667) = 27.82969, p = 1.7929 E-07].

Table 19: One-way ANOVA completed between level of concern with climate change and the frequency of searching for information on climate change.

Regression Statistics	
Multiple R	0.200131292
R Square	0.040052534
Adjusted R Square	0.038613332
Standard Error	0.752587759
Observations	669

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	15.76241	15.76241	27.82969	1.7929E-07
Residual	667	377.781	0.566388		
Total	668	393.5434			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.723936283	0.080919	58.37872	2.5E-264	4.56505004	4.882823	4.56505	4.882823
16. How frequently do you search for information on climate change / global warming?	-0.127137424	0.0241	-5.27539	1.79E-07	-0.17445866	-0.07982	-0.17446	-0.07982

6 Discussion

The results of the study show that an overwhelming majority of respondents believed they have a high level of conceptual understanding of the differences between weather and climate. This is corroborated across all response populations with South American respondents demonstrating the lowest levels of conceptual understanding of weather and climate (80%) compared to the Full Population of 88% while North American respondents had the highest level of confidence with 96% agreement.

However, when the level of understanding was compared with the responses to Questions 2.1 – 2.7 (Appendix A) a significant knowledge gap was observed across all response populations. The only questions to correlate with the predicted level of understanding were in response to Questions 2.5 ‘Scientists say it will be 3 degrees Celsius warmer in 80 years’ and 2.6 ‘The Arctic is warmer in the summer than it was 100 years ago’ (Table 7). A comparison of the results in Table 4 and Table 5 show the average gap between the perceived and actual levels of conceptual understanding of weather and climate across the Full Population of respondents was 20% with the Asian respondent population demonstrating the greatest level of variation with an average knowledge gap of 29% across the Likert Scale responses. Across all populations two levels of understanding were found to exist. The Full Population corroborated with the European, North American, and Oceania populations with an average correct response of ~70% (Table 5). African, South American and Asian response groups demonstrated a lower level of conceptual understanding with respondent average correct score being ~62% correct (Table 5). This trend corroborated with the predicted levels of understanding for African and South American respondents which showed lower levels of predicted understanding.

When age was considered results showed that no significant variation existed when considered as an average across all responses. However, when questions were split between the percentage of correct responses to questions relating to weather and climate the older age groups (55-64 & 65 and over) demonstrated a higher level of conceptual understanding of

weather and displayed a lower level of variation between percentage correct responses than the younger age groups which reflected the responses in the full population (Table 8).

These results confirm the findings of Bodstrum et al. (1994) who examined public understanding of climate change and its influences on perceptions of risks posed by climate change and identified that a knowledge gap existed between perceived and understood levels. The results of this research show that across the population, a knowledge gap between perceived levels of understanding of the concepts of deep time (namely the difference between weather and climate) and actual understanding still exists over 20 years later.

When levels of conceptual understanding of climate and weather (order dealt with in the paragraph) were considered separately a significantly more polarised relationship is demonstrated to exist between perceived and actual levels of conceptual understanding.

When questions relating to climate were considered in isolation (Table 6) it was observed that the knowledge gap reduced significantly. Across all response populations no group scored lower than 72% average correct responses. When the Full Population was considered the gap between perceived and actual understanding decreased to 9% (Table 4 and Table 6), with the greatest difference of 18% observed in the Asian population.

By contrast, when conceptual understanding of weather was considered a significantly greater knowledge gap was observed with no response group scoring greater than 62% average correct responses (Table 6) and the African and Asian response groups both scored less than 50% correct. The average knowledge gap was found to be 31% (Table 4 and Table 6) across the Full Population, with the greatest differences observed in the Asian (41%), African (36%) and North American (34%) response groups.

The results endorse the knowledge gap effect, as previously observed in research into public understanding of weather and climate (Spence et al. 2011; Leiserowitz et al. 2012; Egan & Mullin 2010). Whilst the levels of understanding of climate are generally well understood the results of this study demonstrate a significant gap in the conceptual understanding of

weather and demonstrate the scientific and meteorological definitions of weather are misunderstood by the lay public as previous literature has indicated (2.1).

The nature of the responses indicated that the respondent tendency to attribute meteorological events to climate rather than weather. This was captured most strongly by the responses to Question 2.2 ‘For the last 4 years the least amount of rain has occurred during autumn’. The responses to this question in Table 5 demonstrated the lowest level of understanding with the Full Population scoring 44% correct. North America had the highest correct score of 53% and Africa the lowest at 21%. This demonstrated a clear gap in the social meaning of climate. Whilst the meteorological definition of climate is constructed over of period of 15 to 30 years its social meaning has been influenced by lay public perceptions of climate to establish a ‘normal climate’.

These findings corroborate research that public constructs of climate can be over a short time period outside of the scientific norms (Moore et al., 2019; Marlon et al., 2019). The research demonstrated public perceptions and relationship with climate is more complex than interpreting meteorological measurements. Perceptions of what constitutes a climate event is influenced by the public drawing inferences about changes taking place in the broader climate from perceived changes in their own local weather patterns (Goebbert et al. 2012). Weather is something that can be experienced, climate by contrast is a statistical construct that individuals can observe only indirectly (2.1). Unusually hot summers and milder winters, prolonged periods of drought, or unusually frequent flooding appear to provide local weather ‘‘signals’’ the public have seeped into public perceptions of climate and into the descriptions of climate change (Hamilton & Keim, 2009; Shwom et al. 2008). This has contributed to the respondents weighting in response towards climate.

6.2 Level of Concern with Climate Change

6.2.1 Concern with risks posed by climate change

This research concurs with the findings of a large body of existing literature that global levels of concern with climate change are high. (Lorenzoni & Pidgeon, 2006; Brulle et al. 2012; Scruggs & Benegal, 2012; Gifford, 2011). This study identified that 82% of the Full Population of respondents demonstrated either Extreme or Moderate levels of concern with climate change (Figure 5). This was closely mirrored by the European and African response populations which did not vary significantly from this trend.

Figure 3b showed that when age was considered there no significant variation between the different groups when compared with the Full Population. The responses of all the age groups to the Not at all concerned and slightly concerned were found to not vary significantly. The only significant variation from the full population was for the Moderate and Extreme levels of concern. Both age groups 55 – 64, and 65 and over, displayed lower levels of extreme concern (-7% and -16%) and higher levels of moderate concern (+7% & +16%) when compared with the Full Population (Figure 3b and Figure 5). This weighting in concern level towards increased levels of Moderate concern was reflected in the South American and Asian response population (Figure 5).

Whilst response populations all indicate they are concerned about the risks posed by climate change (Figure 5) a persistent minority of respondents were either ‘not at all concerned’ or only ‘slightly concerned’ with the issue in most populations. Across all response groups other than South American, responses ranged for these two categories between 17% and 20% of the population of respondents. By contrast, only 10% of the South American response group indicated low levels of concern with climate change. However, it was noted that this group comprised 20 respondents, reducing the significance of this exception. These results corroborate previous studies (Leal Filho et al., 2019; Wang & Kim, 2018) which indicated a small but persistent minority exists globally who perceive the risks posed by climate change do not exist.

Both the North American and Oceania populations demonstrated the greatest degree of polarity in responses. The populations displayed the greatest percentage of 'Extremely concerned' (66% and 64%) and 'Not at all concerned' (8% and 9%) responses. This reflected the polarity which has come to be widely identified, especially within the response populations (Dunlap and York, 2008). The responses demonstrate climate change continues to be a deeply polarising issue with the public becoming increasingly entrenched in perceptions of the level of risk associated with climate change.

6.2.2 Level of concern and perceptions of climate change

Respondent perceptions of the risks posed by climate change were found not to vary significantly between response populations with respondents indicating a high level of concern with the risks posed by climate change.

Respondent predictions of the level global temperature will rise by 2100 were found to fall within the 3-5 degrees Celsius range other than African responses which selected 5-10 degrees (Figure 10 & Figure 11). The survey was completed in the summer of 2017 and despite significant media attention with the issue following the COP21 Paris Climate Summit and the subsequent Paris Climate Change Agreement no response population believed that the long term goal of limiting warming to 2 degrees Celsius is achievable. This view was borne out when respondent levels of concern with the risks associated with climate change were reviewed. Only No Risk and Low Risk respondent populations predicted lower levels of warming with both selecting the 1-3 degrees Celsius population, correlating with the COP21 targets.

There were significant levels of agreement across all populations and concern levels when responses to 10.1 – 10.3 were considered. These questions related to perceptions of the consensus that climate change is really happening and is a result of human activities. These results showed that a high level of consensus exists amongst all respondent groups that climate change is really happening and is being caused by human actions. These results challenge previous research (Capstick & Pidgeon, 2014) which

found respondents with low levels of concern about climate change are also likely to exhibit high degrees of scepticism over the scientific consensus of the anthropogenic causes of climate change.

The most significant variation in respondent perceptions of climate change were to questions relating to the long term impacts of climate change. In response to questions 10.4-10.6 (Figure 11) respondents indicating there was No Risk associated with climate change were found to have very low levels of agreements with the statements. By contrast, Low, Moderate and Significant respondent groups were found to correlate with each other demonstrating higher levels of agreement with the statements indicting the severity of the long term effects associated with climate change. These findings confirm previous studies which identified that a persistent minority exists with No concern for climate change (Leal Filho et al., 2019; Wang & Kim, 2018). However, this minority of respondents demonstrated agreement with statements around the human causes of climate change and the Earth's climate is warming. This group's only significant variation from the other response categories was in the belief that the long term impacts of climate change are not severe. These findings endorse work which shows the public are known to dramatically underestimate how long drivers, such as CO2, remain in the atmosphere and continue to change the climate (Steratore, 2019).

When the key risks respondents associated with climate change were assessed (5.3.1) Table 9 identified that the three key risks were Sea Level Rise, Rising Temperatures and Extreme Weather Events. The only variation in this response was in the South American and African populations which included Flooding and Oceania which included drought over rising temperatures. When the results are extrapolated to include the top ten risks associated with climate change there are very low levels of variation across all response groups. This demonstrated that**,** on a global scale**,** the key risks associated with climate change are understood and that the key risks associated with climate change have been broadcast consistently.

However, it was noted that in all respondent populations Unsure ranked in the ten most common responses. This showed that despite evidence of consensus on the key risks associated with climate change a significant portion of respondents globally were unsure of what these risks are. In order to assess the impact**,** the respondent level of concern with the risks associated with climate change were compared with the risks respondents provided (Appendix C, Table 2). It was noted that Sea Level Rise was the most frequent response across all levels of concern. There was little variation in responses between the Extremely Concerned, Moderately Concerned, and Slightly Concerned response groups. Only the Slightly Concerned and Not at all Concerned groups identified Melting Ice Caps as one of the five most common risks. The most significant variation in responses was in the Not at all Concerned group. These respondents were the only group to include human risks (Mass Migration) and Unsure in the five most common responses. It indicated that an understanding of the risks associated with climate change is important in order to increase levels of concern with climate change amongst respondents who believe there is no risk associated with climate change. The results corroborate Bergquist & Warshaw (2019) finding that more work is needed on knowledge of the increasing global temperatures in order to achieve a public consensus about the threat posed by climate change.

For individuals who perceive there to be no risk associated with climate change the causality of this view is around the long term impacts associated with climate change, and a lack of understanding of the risks posed by climate change rather than scepticism of scientific consensus of the science of climate change, or the anthropogenic causes of the warming.

6.2.3 Psychological distance of climate change

When the psychological distance of climate change was assessed the results of the study correlated with previous findings that perceived climate change related events such as flooding, or increased hurricane frequency or severity have been found to influence the physiological distance of climate change. Individuals who experience environmental issues first hand have been

shown to demonstrate significantly higher concern with climate change (Albright & Crow, 2019; Demski et al., 2017 Spence et al., 2011; Zahran et al., 2006). The results across the full population of respondents (Figure 12) extend previous research and demonstrate that respondents who have noticed changes to their local environment are significantly more likely to demonstrate higher levels of concern with the risks posed by climate change.

However, when responses are considered by region (Figure 5) it was noted that the response groups for South America, Africa and Asia had the highest portion of the populations who had noticed changes to their local environment. The European response group provided the lowest level of agreement with 70% of respondents stating they had noticed changes to their local environment. This did not correlate with levels of concern across the full population of respondents as both South American and African respondents registered higher moderate**,** rather than extreme, levels of concern with climate change.

These results indicate the effects of experiencing changes to local environment is significant in influencing levels of concern with climate change. However, when considered across a full population the results are weakened. The results suggest that regional variation in levels of concern with climate change are influenced by other factors.

6.3 Media influence on Perceptions of Climate Change

The importance of understanding public interaction with climate change is essential as the media have been shown to play a key role in framing climate change. The effects are complex and dynamic and there is no straight forward relationship between information campaigns and behaviour change (Anderson, 2009; Dunwoody 2007; Stamm et al. 2000).

The results of this study demonstrate that a high degree of variation existed within all response populations in the frequency of searching for information on climate change. Across the Full Population of respondents the most popular search frequency for information on climate change was 'Less than once per month' (Figure 6a) with 32% of the population. This was corroborated with all other response populations other than Oceania which ranked a Monthly frequency highest. When considering the levels of concern with climate change and frequency of searching for information on climate change, a significant relationship was identified as respondents who demonstrated higher levels of concern with the risk associated with climate change searched for information on climate change more frequently. These results affirmed the belief that respondent engagement with media on climate change is correlated significantly with the level of concern with climate change.

The results highlighted the importance of new media, namely social media as the key source of information respondents used to learn about climate change. The findings also corroborated previous research which demonstrated the importance of the new media in engaging the public with climate change (O'Neill & Boykoff, 2011; Schäfer, 2012; Dietz & Stern, 2008). However, whilst social media was identified as the key source of information used to gather information on climate change across all response population News Websites and Television were found to be the next most common sources used to gather information on climate change. This highlighted that whilst social media has emerged as a key tool for communicating and interacting with climate change as an issue**,** the public still rely on traditional media outlets to complement this understanding. As a result when new and

traditional media outlets were compared there was very little variation in respondent use of either source more than the other.

When the media outlet which respondents relied on most heavily to gather information on climate change was analysed, the importance of social media on influencing perceptions of climate change was evident, with 25.6% of all respondents stating they relied on Facebook as a key source of information to learn about climate change. This trend was similar across all response populations (Table 12) (Appendix C, Table 3). The results corroborate previous work which identified that social media would and continues to transform the way in which people interact with news stories and issues such as climate change globally (Segerberg & Bennett, 2011; Boykoff, 2007 & Carvalho, 2010; Auer et al. 2014).

The BBC was the only other outlet to be used by more than 10% of all respondents across all regions. Below this**,** media outlets such as the New York Times, Guardian newspaper, ABC News, NPR and CNN were all used by respondents to gather information on climate change. These varied regionally with respondents from each region relying on the most popular outlets in their own countries. However, in addition to news outlets South American and Asian respondents also relied on National Geographic to learn about climate change**,** with African respondents also relying on YouTube rather than the traditional media outlets.

When these results were scaled with the level of concern respondents displayed with the issue of climate change it was found that across the five most popular media outlets there was little variation when compared to the Full Population of respondents with Facebook, the BBC and the Guardian newspaper being the most popular outlets followed by regional news outlets. However, it was noted that key difference between the respondents who were not at all concerned with the risks posed by climate change comparted to the other response categories**,** was that CNN was the fourth most common outlet to be used to learn about climate change. The responses suggest that the coverage of the issue by this channel may have had an influence in framing the low levels of concern with climate change. This finding

challenges the results of Feldman et al. (2012) who found that compared with Fox News and MSNBC**,** CNN's coverage of climate change was not sceptical with the overwhelming majority of commentary on the issue being in agreement.

6.4 Conceptual understanding of Weather and Climate on Perceptions of Climate Change

Research has previously identified causality between perceptions of local weather and the understanding of the concept of deep time and the differences between weather and climate and perceptions of climate change (Lombardi & Sinatra, 2012; Goebbert et al. 2012; Joireman et al. 2010; Egan & Mullin 2010; Hamilton & Keim 2009; Li et al. 2011; Schwartz 2012). However, the results of this study challenges these conclusions.

When levels of conceptual understanding of weather and climate and responses to key questions selected to assess perceptions of climate change were assessed, across (Figure 13a – 13d). The lack of correlation was enforced through the assessment of the relationship between the levels of understanding of the risks posed by climate change and perceptions of the risks posed by climate change. The results of the ANOVA analysis portrayed no relationship existed with the population when the two attributes were assessed (5.6.2).

It was shown that the level of conceptual understanding of weather and climate had no impact on the perceived psychological distance associated with climate. Questions 5: '*The effects of climate change will depend on where you live. Do you believe by 2100 your local area will be better or worse off because of the effects of climate change?'* (Figure 13c) and Question 6: *'In the area where you live have you noticed changes to the seasons, wildlife, temperature or rainfall?*' (Figure 13e) was designed to identify any relationship between the level of conceptual understanding of weather and climate and the effects of the physiological distance of climate change discussed in Section 2.2.4. Responses demonstrate no relationship exists with all respondents, regardless of the level of understanding of the difference between weather and climate portray similar response beliefs that

their local environment will be worse off as a result of climate change. The results also demonstrate that no variation exists between respondents noticing changes to their local environment and improved levels of conceptual understanding of weather or climate.

The results do highlight variations in levels of conceptual understanding of weather and climate and key risks associated with climate change identified by respondents. It was found that respondents demonstrating a Moderate, High and Very High level of conceptual understanding identified the same key risks associated with climate change as when the response population was considered in full. However, whilst respondents demonstrating Low and Very Low levels of conceptual understanding correlated with responses for the five most commonly stated risks they also identified risks such as Famine, Disease, and Mass Migration which were unique to these groups. These results correlate with the key risks respondents who stated that were not concerned at all about the risks posed by climate change. Both groups were the only ones to identify Mass Migration as a key risk associated with climate change.

The results of this study refute the findings of previous studies into the influence of conceptual understanding of weather and climate on perceptions of climate change. In the 5 years between the publication of Lombardi and Sinatra's findings (Lombardi & Sinatra, 2012), public understanding of climate change has improved with a consensus on the anthropogenic causes of climate change and that earth's climate is warming. However, variation in levels of concern with climate change are not shown to be influenced by levels of conceptual understanding of weather and climate.

6.5 Influence of Media on Conceptual Understanding of Weather and Climate

This study was the first to examine the relationship between public interaction with the media and their conceptual understanding of the differences between weather and climate despite significant research assessing the media's influence on perceptions of climate change.

Results highlighted that no significant variation existed in the respondent population between search frequencies for information on climate change and the level of conceptual understanding of weather and climate. It can be concluded that no relationship exists between search frequency and level of understanding of the differences between weather and climate.

When the influence of media source was assessed (Table 16) it was noted that whilst there was no significant variation in response populations**,** respondents demonstrating Very Low and Low levels of conceptual understanding obtained 25.0% and 22.9% of their information on climate change from Television compared to an average score of 14.1% of information across respondents demonstrating a Moderate, High and Very High level of conceptual understanding. This was reflected in the relationship between level of understanding and reliance on either traditional or new media outlets for information on climate change. Across both Very Low and Low populations respondents demonstrated a higher use of new media compared with traditional outlets (Table 17).

When the media outlets used to gather information on climate change were compared with the levels of conceptual understanding a significant relationship was identified (Table 18) as two media outlets, Facebook and the BBC, dominated the response population. Respondents with a Very Low or Low level of conceptual understanding of the differences between weather and climate were found to have significantly higher levels of reliance on Facebook for information on climate change with an average of 53.7% of both groups information originating from this source. This was in contrast to

respondents demonstrating Moderate, High and Very High levels of understanding which had an average for the use of Facebook as a source of information on climate change of 32.2%.

This relationship highlights the risks associated with using social media as a primary source of information on an issue. These risks have been widely documented in connection with climate change and politics (O'Neill & Boykoff, 2011). However their association with levels of conceptual understanding of weather and climate has not been previously demonstrated. Fake news has been shown to influence public perceptions of key issues (Shu et al. 2018; Allcott & Gentzkow, 2017; Lazer et al. 2018; Polletta & Callahan, 2019). The spreading of fake news on social media may be divided into 2 key categories: Malicious accounts used for propaganda, and the Echo Chamber Effect (McGrew et al. 2017, Marchi, 2012). It is the latter which is considered here as being the most influential in the level of understanding given the low level of variation between conceptual understanding of weather and climate and variations in levels of concern with climate change.

Social media has democratised the distribution of media with the information seeking and consumption process changing from a mediated channel (Del Vicario et al. 2016). Consumers are selectively exposed to certain kinds of news because of the way social media news appears on their homepage. The platforms amplify the psychological challenges to dispelling fake news. On Facebook users have been found to only follow like-minded people and thus receive news that promotes their favoured existing narratives (Quattrociocchi et al. 2016). Therefore, users on social media tend to form groups containing like-minded people where they then polarize their opinions, resulting in an echo chamber effect. The echo chamber effect facilitates the process of distribution of fake, incorrect or misleading content. It is this effect which can lead to users not understanding the difference between weather and climate, given the lack of exposure to the issue from other traditional sources of information. Van der Linden et al.'s (2017) study demonstrated that it was possible to inoculate against misinformation by

communicating strongly and consistently on the fact there is a consensus on the risks posed by climate change. This is something that is required to be undertaken to clarify the meanings of both climate and weather so as to improve conceptual understanding of weather and climate amongst these populations.

6.6 Limitations

Whilst the study has been successful in addressing the aims of the research it was noted that a number of limitations exist which must be considered and addressed as they may influence the significance of the conclusions of this research.

In addition it must be considered how the responses were gathered. The use of an online survey distributed through Facebook has in-built bias to the respondent group which is unavoidable. The distribution method may have resulted in a significant weighting of reliance on key outlets for sources of information on climate change which resulted in the finding that Facebook was the key outlet used to gather information on climate change. Whilst this study has been unable to account for this possible population bias in this study future research should include additional, offline samples to further investigate the relationship and confirm its significance.

Whilst is was possible to complete analysis at a regional level for all continents it was noted that the populations are heavily weighted towards Western respondents for both Europe (n=303), and North America (n=142). As a result of this bias this study has not been as successful in addressing the gap which exists in research into perceptions of climate change between the West and the rest of the world. However, the study is able to provide an initial insight into how levels of conceptual understanding of weather and climate and perceptions of climate change vary across all continents.

Given the limited nature of the respondents across all levels of conceptual understanding of weather and climate and perceptions of change risk it was only possible to perform testing of this relationship across the full population.

Future research would benefit from building a significantly greater volume of responses to allow for a range of levels of understanding to be constructed so as to assess the significance of this relationship at a regional as well as at a global level. The study was completed in June and July 2017. It would be interesting to assess how the relationships observed in this research have evolved in the two years following the conclusion of the data collected for this research.

7 Conclusions

This study extends previous work into at understanding levels of conceptual understanding of weather and climate and how this level of understanding influences respondent risk perceptions associated with global climate change. An online survey was distributed globally for the first time and used to measure respondents' levels of understanding on the concepts of weather and climate, their perceptions of the risks associated with climate change.

The results highlight that a significant knowledge gap exists between levels of perceived and actual conceptual understanding of concepts of weather and climate. Understanding of weather was shown to be lowest across all populations assessed as part of the study with African, Asian and South American respondents all demonstrating the lowest levels of conceptual understanding of weather and climate. It was also observed that the gap was significantly larger when weather was considered separately with respondents demonstrating a low level of understanding of weather compared with the scientific definition. However, the results suggest little variation existed between respondent understanding of weather and climate and their perceptions of climate change. This is in contrast to previous literature which has demonstrated a link between levels of conceptual understanding and perceptions of the risks posed by climate change.

The study did establish a relationship exists between the respondents scoring 'Very Low' or 'Low' in levels of understanding of weather and climate and gathering the majority (+50%) of information on climate change from Facebook. The result suggests the importance of clear communication online

to educate the public on the difference between weather and climate is key to improve levels of understanding of the concepts.

This research corroborates the findings of a large body of existing literature that global levels of concern with climate change are high. (Lorenzoni & Pidgeon, 2006; Brulle et al. 2012; Scruggs & Benegal, 2012; Gifford, 2011). Around 80% of respondents demonstrated around either High or Moderate levels of concern with the risks posed by climate change. The research also corroborate previous studies (Leal Filho et al., 2019; Wang & Kim, 2018) in demonstrating that across all regions a small but persistent minority of individuals exist globally who perceive that the risks posed by climate change do not exist. However, this minority of respondents demonstrated agreement with statements around the human causes of climate change and that the Earth's climate is warming. This group's only significant variation from the other response categories was in the belief the long term impacts of climate change are not severe.

When the psychological distance of climate change was considered across the results it was shown that the effects of experiencing changes to local environment has a significant influence on levels of concern with climate change.

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Appendices

Appendix A: Final Questionnaire Design
Appendix B: Breakdown of demographics for respondent populations
Appendix C: How Levels of Concern about climate change influence perceptions

Appendix A: Final Questionnaire Design

The following screenshots detail the questionnaire design used in this study. The questionnaire is divided into 7 pages of questions covering the following areas;

Page 1: Understanding of the Concepts of Weather and Climate
Page 2: Perceptions of risks posed by climate change
Page 3: Levels of concern with climate change
Page 4: Assessing Psychological Distance of Climate Change and BDH.
Page 5: Media influence on Climate Change
Page 6: Demographics

Page 1: Understanding of the Concepts of Weather and Climate

Do you believe you understand the difference between Weather and Climate?

- ○ Yes
- ○ No

This part of the survey uses a table of questions, view as separate questions instead?

Read the following statements. Decide if the statement best fits into the category of weather, climate, both or unsure and select the appropriate box.

	Weather	Climate	Both Weather & Climate	Unsure
There was a heat wave last summer	☐	☐	☐	☐
For the last 4 years, the least rainfall occurred during Autumn	☐	☐	☐	☐
We are predicting that temperatures will be greater than normal this autumn	☐	☐	☐	☐
Monsoon rains will probably begin in June	☐	☐	☐	☐
Scientists say it will be 3 degrees Celsius warmer in 80 years time	☐	☐	☐	☐
In the future there will be an Ice Age	☐	☐	☐	☐
The Arctic is warmer in the summer than it was 100 years ago	☐	☐	☐	☐

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Page 2: Perceptions of risks posed by climate change

What are the 3 greatest threats currently facing the planet?

What are the 3 main risks associated with climate change?

The effects of climate change will depend on where you live. Do you believe that by 2100 your local area will be better or worse off because of the effects of climate change?

- Worse Off
- No Change
- Better Off

What is your best estimate of how much global temperature will rise by 2100 from today?

- Less than 1 degree
- Between 1 and 3 degrees
- Between 3 and 5 degrees
- Between 5 10 degrees
- 11 degrees or more

Page 3: Levels of concern with climate change

How concerned, if at all, are you about climate change, sometimes referred to as 'global warming'?

- not at all concerned
- Slightly concerned
- Moderately concerned
- Extremely concerned

This part of the survey uses a table of questions, view as separate questions instead?

Read the following statements. Decide to what extent you agree with them and select the appropriate box.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I am certain climate change is really happening					
Earth's climate is warming					
Concentrations of greenhouse gases in the atmosphere are increasing because of human activities					
Continued emissions of carbon dioxide will cause unprecedented changes in global climate					
Human caused global warming and sea level rise will continue for centuries even if greenhouse gas concentrations are stabilised at current levels					
Global warming will lead to irreversible impacts on the environment					

This part of the survey uses a table of questions, view as separate questions instead?

Consider the following statements. Rank your agreement from Strongly disagree, to Strongly agree.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am prepared to greatly reduce my energy use to help tackle climate change.					
Environmental policies do me harm					

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Page 4: Assessing Psychological Distance of Climate Change and BDH.

In the area where you live have you noticed changes to the seasons, wildlife, temperature or rainfall?

- Yes
- No

In the area where you live. How much of a risk does Global Warming pose to your current standard of living? Rank your answers from Low, to High risk.

- Low risk
- Moderate risk
- Considerable risk
- High risk

Globally, how much of a risk does Global Warming pose to the standard of living? Rank your answers from Low, to High risk.

- Low risk
- Moderate risk
- Considerable risk
- High risk

Globally, estimate the current number of deaths, illnesses and injuries caused by global warming

- None
- Hundreds
- Thousands
- Millions

Globally by 2100, estimate the number of deaths, illnesses and injuries caused by global warming.

- None
- Hundreds
- Thousands
- Millions

Page 5: Media influence on Climate Change

Select the 3 main sources where you most commonly come across stories on climate change.

Please select exactly 3 answer(s).

- Newspapers
- Television
- News Websites
- Radio
- Youtube
- Social Media
- Magazines
- Scientific Journals
- Blogs
- Word of Mouth
- Other

If you selected Other, please specify:

From what outlets do you get the majority of your information on climate change? (BBC, Facebook, Huffington Post, Times etc..)

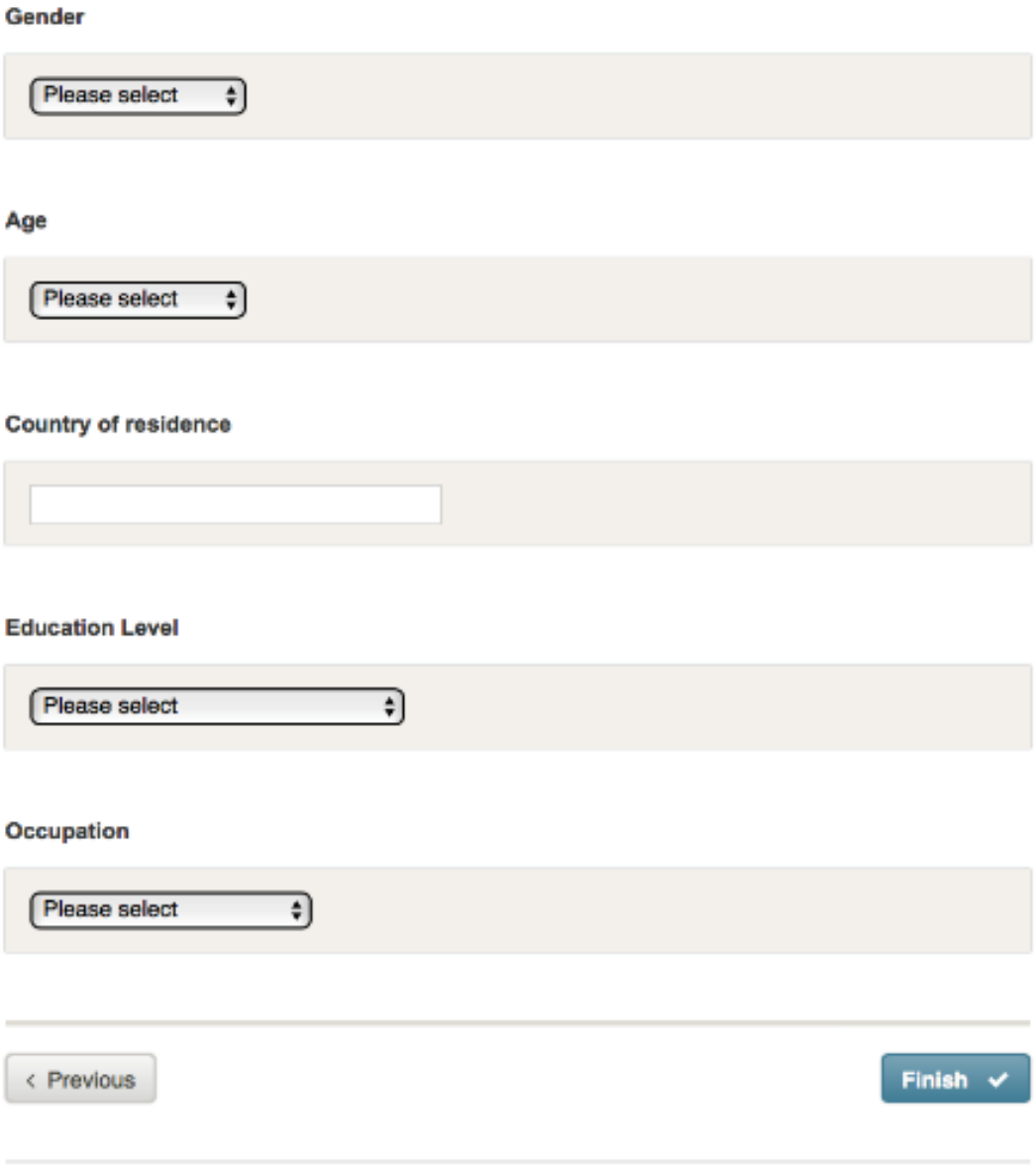
How frequently do you search for information on climate change / global warming?

- Daily
- Weekly
- Monthly
- Less than once per. month
- Never

Do you follow people of social media with the intention of learning about Climate Change?

- Yes
- No

Page 6: Demographics



Appendix B: Demographic Breakdown for Respondent Population

Table 1: Breakdown of total number of respondents from each Nationality

#	Nationality	Response Frequency
1	Algerian	1
2	American	132
3	Australian	43
4	Austrian	1
5	Brazilian	7
6	British	215
7	Bulgarian	1
8	Cambodian	1
9	Canadian	10
10	Chilean	1
11	Chinese	8
12	Colombian	1
13	Costa Rican	1
14	Croatian	1
15	Danish	2
16	Dutch	23
17	Ecuadorian	2
18	Egyptian	1
19	Ethiopian	4
20	Fijian	1
21	Finish	1
22	French	8
23	German	10
24	Greek	7
25	Honduras	1
26	Indian	34
27	Indonesian	7
28	Iranian	1
29	Iraqi	3
30	Irish	10
31	Italian	5
32	Japanese	1
33	Kenyan	1
34	Latvian	2
35	Lebanese	1
36	Lithuania	1
37	Luxembourg	1
38	Malawian	3
39	Malaysian	34
40	Maldives	1
41	Mexican	4
42	Namibian	1
43	Nepalese	2

44	Nigerian	4
45	Norwegian	1
46	Pakistani	4
47	Portuguese	4
48	Prefer not to say	4
49	Puerto Rican	1
50	Romanian	1
51	Singaporean	1
52	Slovakian	2
53	Slovenian	1
54	South African	37
55	Spanish	5
56	St. Lucian	1
57	Sudanese	1
58	Swedish	1
59	Taiwanese	1
60	Trinidadian	1
61	Vietnamese	1
62	Zimbabwean	3
Total Responses		**669**

Table 2: Breakdown of total number of respondents by Nationality and Gender

Region	Gender	No	Yes	Total Population
Full Population	Female	49	338	387
	Male	26	244	270
Europe	Female	27	161	188
	Male	16	92	108
North America	Female	5	79	84
	Male	0	56	56
South America	Female	3	10	13
	Male	1	5	6
Africa	Female	6	21	27
	Male	3	27	30
Asia	Female	4	42	46
	Male	5	46	51
Oceania	Female	4	24	28
	Male	1	15	16

Table 3: Breakdown of total number of respondents by Nationality and Age

Region	18 - 24	25 - 34	35 - 44	44 - 54	55 - 64	65 and over	Prefer not to say	Totals
Full Population	348	145	51	56	38	28	3	669
Europe	189	60	18	20	10	4	2	303
North America	50	12	16	24	20	20	0	142
South America	6	12	0	1	1	0	0	20
Africa	25	22	6	2	1	1	0	57
Asia	56	30	8	3	1	1	0	99
Oceania	21	7	3	5	5	2	1	44

Table 4: Breakdown of respondent level of concern with climate change (Question 8, Appendix A) and nationality.

Region	Gender	Not at all concerned	Slightly concerned	Moderately concerned	Extremely concerned	Total
Full Population	Female	10	55	115	207	387
	Male	16	35	83	136	270
Europe	Female	3	27	58	100	188
	Male	6	16	33	53	108
North America	Female	4	7	12	61	84
	Male	8	5	11	32	56
South America	Female	0	2	7	4	13
	Male	0		5	1	6
Africa	Female	0	6	10	11	27
	Male	0	4	7	19	30
Asia	Female	0	9	24	13	46
	Male	0	8	24	19	51
Oceania	Female	3	3	4	18	28
	Male	1	2	3	10	16

Appendix C: How Levels of Concern about climate change influence perceptions

Table 1: Questions and average scores relating to Figure 9 for Full Population scaled with Risk Classification Level

Question	*No Risk*	*Low Risk*	*Moderate Risk*	*Significant Risk*	*Full Population*	*Europe*	*North America*	*South America*	*Africa*	*Asia*	*Oceania*
8. How concerned if at all are you about climate change, sometimes referred to as 'global warming'?	1	2	4	5	5	5	5	4	5	4	5
9. What is your best estimate of how much global temperature will rise by 2100 from today?	2	2	3	3	3	3	3	3	4	3	3
10.1. I am certain climate change is really happening	3.5	4	5	5	5	5	5	5	5	5	5
10.2. Earth's climate is warming	4	4	4	5	5	5	5	4.5	4	5	5
10.3. Concentrations of greenhouse gases in the atmosphere are increasing because of human activities	4	4	5	5	5	5	5	5	5	5	5
10.4. Continued emissions of carbon dioxide will cause unprecedented changes in global climate	2	4	4	5	5	5	5	4	5	5	5
10.5. Human caused global warming and sea level rise will continue for centuries even if greenhouse gas concentrations are	2	4	4	4	4	4	4	4	4	4	4

stabilised at current levels											
10.6. Global warming will lead to irreversible impacts on the environment	2	4	4	5	4	4	5	4.5	5	4	5
16. How frequently do you search for information on climate change / global warming? (Scale reversed)	1.5	2	2	3	3	3	3	2	2	2	3
Coded understanding of difference between weather and climate	4	4	4	4	4	4	4	4	4	4	4.5

Table 2: Key risks respondents associated with climate change aligned with levels of concern with the risks posed by climate change (Question 8, Appendix A).

#	Not at all concerned	Slightly concerned	Moderately concerned	Extremely concerned
1	Sea Level Rise	Sea Level Rise	Sea Level Rise	Sea Level Rise
2	Melting Ice Caps	Rising Temperatures	Extreme weather events	Rising Temperatures
3	Drought	Flooding	Rising Temperatures	Extreme weather events
4	Mass migration	Extreme weather events	Flooding	Drought
5	unsure	Melting Ice Caps	Loss of biodiversity	Flooding

Table 3: Media Outlets used by respondents compared with levels of concern with climate change.

#	Not at all concerned	Slightly concerned	Moderately concerned	Extremely concerned	Full Population
1	Facebook	Facebook	Facebook	Facebook	Facebook
2	BBC	BBC	BBC	BBC	BBC
3	Guardian	New York Times	Guardian	Guardian	Guardian
4	CNN	Guardian	YouTube	National Geographic	New York Times
5	National Geographic	National Geographic	New Scientist	New York Times	National Geographic