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Staying over-optimistic about the future:

uncovering attentional biases to climate change messages.

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Abstract

There is considerable concern that the public are not getting the message about climate change. One possible explanation is 'optimism bias', where individuals overestimate the likelihood of positive events happening to them and underestimate the likelihood of negative events. Evidence from behavioural neuroscience suggest that this bias is underpinned by selective information processing, specifically through a reduced level of neural coding of undesirable information, and an unconscious tendency for optimists to avoid fixating negative information. Here we test how this bias in attention could relate to the processing of climate change messages. Using eye tracking, we found that level of dispositional optimism affected visual fixations on climate change messages. Optimists spent less time (overall dwell time) attending to any arguments about climate changes (either 'for' or 'against') with substantially

shorter individual fixations on aspects of arguments *for* climate change, i.e. those that reflect the scientific consensus but are bad news. We also found that when asked to summarise what they had read, non-optimists were more likely to frame their recall in terms of the arguments 'for' climate change; optimists were significantly more likely to frame it in terms of a debate between two opposing positions. Those highest in dispositional optimism seemeed to have the strongest and most pronounced level of optimism bias when it came to estimating the probability of being personally affected by climate change. We discuss the importance of overcoming this cognitive bias to develop more effective strategies for communicating about climate change.

Introduction

The scientific evidence for climate change, its causes and consequences, is overwhelming. The Intergovernmental Panel on Climate Change (IPCC) has carefully reviewed the evidence around climate change in a succession of reports and its conclusions are that they are 'now 95 percent certain that humans are the *main cause* of current global warming.' (IPCC 2015: v; italics added). The extreme seriousness of this threat and its global effects has been detailed by the IPCC in a series of reports (IPCC 2014; 2015). They conclude that a rise in global temperature will have 'severe and widespread impacts on… substantial species extinctions, large risks to global and regional food security…growing food or working outdoors' as well as producing more extreme fluctuations in weather, including droughts, flooding and storms (IPCC, 2014, p.14). However, although the role of human activity in its causation is both 'clear and growing' (IPCC 2015: v), evidence for large-scale behavioural adaptation is unfortunately absent (see Beattie 2010; Marshall 2015).

There has been scientific evidence for the role of human activity in producing increased greenhouse gas emissions and climate change for a significant period. Indeed, as far back as 1896 the Swedish chemist Svante Arrhenius calculated the possible effects of doubling the amount of carbon dioxide on global temperatures. In 1965, President Lyndon B. Johnson's Scientific Advisory Council warned that the constant increase in atmospheric carbon dioxide could 'modify the heat balance of the atmosphere' (see also Marshall 2015: 63). In the U.K., the Stern Review (conducted by Sir Nicholas Stern the former chief economist of the World Bank) concluded over a decade ago that 'climate change presents very serious global risks, and it demands an urgent global response.' (Stern Review, 2006, p.i). Stern's conclusion was that 'Climate change threatens the basic elements of life for people around the world – access to water, food production, health, and use of land and the environment' (2006, p. iii). Stern also made it clear that it is extremely probable that human activity and particularly patterns of consumption and energy use, driven by consumer demand for higher standards of living, are significant factors in the rise of global CO_2 emissions, and therefore a major driver of climate change. He argued that 'Emissions have been, and continue to be, driven by economic growth' (2006, p.xi), a view subsequently supported by a number of IPCC reports.

Strong, indeed incontrovertible, evidence has been available for some time, so why has this urgent global response still not occurred? Indeed, why is there currently no suggestion that this 'global response' is even on the horizon? Policies to limit greenhouse gases emissions and engage sustainable development, combined with individual reduction in the use of fossil fuels would all significantly help to reduce greenhouse gas emissions and prevent further global warming (IPCC 2015). Indeed, the IPCC (2015) have argued that we could *limit* the effects of climate change by

changing our individual and collective behaviour and by taking action now. We could use public transport rather than private vehicles (Wall, Devine-Wright and Mill 2007), increase recycling (Elgaaied 2012) or alter our patterns of choice as consumers to approach a more carbon-neutral purchasing pattern (Walker and King 2008). Consumer choice of low carbon products would then influence the production process with further significant effects on greenhouse gases (Beattie 2010). There are many things that we could do, and there has been significant local change but nothing like the 'global response' that Stern said was required to ameliorate the further deleterious effects of climate change (Power, Beattie and McGuire in press).

This inaction by consumers is clearly manifest in a very revealing statistic reported by a leading multinational, Unilever, in their 'Sustainable Living Plan'. They outline how they aim to halve the greenhouse gas impact of their products across the lifecycle by 2020 (2013: 16). To achieve this goal, they reduced greenhouse gas emissions from their manufacturing chain and deforestation. They opted for more environmentally friendly sourcing of raw materials, doubled their use of renewable energy, and produced concentrated liquids and powders. They reduced greenhouse gas emissions from transport and from refrigeration. They also restricted employee travel. The result of all of these initiatives was that their 'greenhouse gas footprint impact per consumer….***increased*** by around 5% since 2010' (2013: 16). They concluded: 'We have made good progress in those areas under our control but…the big challenges are those areas not under our direct control like…..***consumer behaviour'*** (2013:16). It would seem that consumers are not 'getting the message' - they are not opting for the low carbon alternatives in the way envisaged, they are not reducing the length of their showers (to reduce energy and water consumption), and they are not breaking their high carbon habits. The question is why.

This failure on the part of the public to alter their behaviour is perhaps even more puzzling given that The Department of the Environment, Food and Rural Affairs in the U.K. (DEFRA) have repeatedly argued that 'Many people are willing to do a bit more to limit their environmental impact, yet people have a much lower level of understanding about what they can do and what would make a difference' (DEFRA 2007). The Unilever campaign was, of course, designed to help in this regard by making more sustainable products readily available. There have been a number of other government-backed campaigns in the U.K. designed to persuade us to change our behaviour as consumers – to turn off lights when not in use, to recycle, to buy alternative products with lower carbon footprint, to travel by car less and take fewer long-haul flights etc. (see, for example, Act on CO_2 2010; World Wildlife Fund 2008). These are all relatively clearly defined actions, which could make a significant difference if enough people did them, but the results generally have been very disappointing (Beattie 2010). Take, for example, the issue of low carbon alternatives and consumer choice. Tesco, the U.K. based retailer, introduced carbon labelling to guide consumers towards the more environmentally friendly alternative in 2007, aiming to include carbon labels on all of its 70,000 own-brand products. Terry Leahy, CEO of Tesco at that time said 'The green movement must become a mass movement in green consumption' and to achieve this goal, Leahy argued 'we must empower everyone – not just the enlightened or the affluent' (Leahy 2007). The results, however, in terms of actual sales were not as anticipated. Indeed, Tesco dropped this plan in 2012 because they argued other supermarkets had not joined them in this enterprise, and they also said that the accurate calculation of carbon footprint for products was both slower and far more expensive than they had originally anticipated. However, another major issue was that when products were labelled in this way,

consumers were not using them to guide their actual choice of the low carbon alternatives. In a controlled experimental situation, Beattie (2012) reported that people paid very little attention to the carbon labels, especially on the products with the higher carbon footprint – the 'bad news products'. Using eye tracking to monitor individual gaze fixations on products with carbon footprint labels every forty milliseconds, Beattie, McGuire and Sale (2010) reported that in less than 7% of all cases did participants fixate first on either the carbon-footprint icon or the accompanying carbon-footprint information, as opposed to brand information, price, energy use, details of product etc. These latter features were all much more salient to individuals (see McGuire and Beattie 2016). Thus, consumers in the UK were not responding in the way anticipated by both government and major retailers, after numerous government-led campaigns and significant publicity and media coverage about the issue.

Of course, from a psychological perspective there are a range of possible theoretical reasons why this might be the case. For example, the public might not have the right attitude to climate change after all, contrary to what DEFRA and others hypothesised (Beattie 2010; Beattie and Sale 2009, 2011). Consumers might be leaving it to others to change their behaviour (Beattie and McGuire 2014). Consumer habits might be too ingrained and too difficult to break easily (Ulph and Southerton 2014). Consumers in rich Western countries might assume that they are safe and that it is only poorer countries that will be affected, at least in the first instance (a view bolstered by the evidence in the Stern Review, p.vii). We will consider this so-called 'optimism bias' in more detail below. The public generally might not be inclined to look that far into the future to imagine possible effects (Beattie 2010). They might be confused by the whole climate change 'debate', and the contrary arguments that

humans have only a limited (or no) role in the rise of global temperatures. It has, however, been pointed out that some of those who have been most vociferous in raising objections to the scientific evidence may have a particular (financial) stake in the matter; this includes the oil lobby (see Oreskes and Conway 2010).

Optimism and cognitive processing

However, there is a more basic hypothesis to explain this lack of action on the part of the public. What happens if people do not 'see' the arguments for climate change in the first place? What happens if selective perception is at work here? The arguments about climate change are, after all, very pessimistic – in Stern's words 'it threatens the basic elements of life for people around the world'. These are worse than pessimistic, they are cataclysmic, and the available scientific evidence makes this more compelling and therefore even more depressing. Information about climate change has been reproduced endlessly in newspapers, television and film, which can influence people's attitudes and cognitions when *they are viewed* (Beattie, McGuire and Sale 2011). However, what happens if people avoid seeing them? What happens if people attend instead to arguments *against* climate change? These, by definition, do present a much rosier picture of both the present and of the future ('there is actually significant doubt about anthropogenic climate change and your current lifestyle is totally acceptable').

So what does affect whether we see the arguments for climate change or not? This question could be critical for understanding the effectiveness of any forms of communication about climate change. There is evidence from a number of other domains, including health, well-being, relationships and enrepreneurial success

(Isaacowitz 2006; Seligman 2002) to suggest that some people do have a bias in the processing of, and the reasoning about, positive and negative information, and that this bias links to one major *individual* difference, namely 'dispositional optimism'. Dispositional optimism 'refers to generalized outcome expectancies that good things, rather than bad things, will happen; pessimism refers to the tendency to expect negative outcomes in the future' (Taylor 1998). Seligman (2002) has argued that optimists and pessimists differ in terms of a number of basic psychological features, including attributional style. Attributional style refers to consistent patterns in our automatic thinking when we try to understand the causes of various events. Seligman maintains that this is a primitive aspect of psychological functioning as we try to understand why things have occurred. It is a core part of making sense of, and giving meaning to, our social worlds. He has argued that 'Optimistic people explain *good* events in terms of permanent causes such as traits and abilities. Pessimists name transient causes, such as moods and effort' (emphasis added) (Seligman 2002: 89). Optimists, on the other hand, explain *bad* events in terms of transient features, pessimists explain bad events in terms of more enduring causes. In other words, if something goes well (say passing an examination), optimists assume that the cause is long lasting and they will attribute it (in terms of their automatic thinking) to something to do with themselves (their underlying characteristics or ability – 'I am clever'). They will assume that it will be there in the future ('permanent') and affect many aspects of their lives ('pervasive'); after all our innate ability is fairly enduring. If something goes badly, optimists will assume that the cause is transient; they will attribute it to something that will pass ('I was tired'; 'the exam was too hard'). They will assume that it will not be there in the future ('temporary') and be limited to specific aspects of their life ('specific'). Pessimists, on the other hand, make quite

different attributions for success and failure. If something goes well, pessimists attribute this to transient causes ('I passed the exam but I got lucky'; 'it was easy' etc.); however, failures are ascribed to permanent causes ('I failed the exam because I am stupid').

Attributional reasoning, according to Seligman (2002) and others, underpins our everyday social life. It is sense-making in action and leads to crucial expectations about the future. It has a major effect on both our mental and physical health (Seligman 2002) - optimists live significantly longer than pessimists, and are much less likely to die from cardiac arrest (Scheier et al. 1989); it also increases the survival time after a diagnosis of cancer (Schulz et al. 1996). Optimism does this by reducing stress and anxiety about the future, and optimists consequently have better immune functioning (Segerstrom, Taylor, Kemeny and Fahey 1998). It has been argued that optimism was selected for during evolution (Mosing, Zietsch, Shekar, Wright and Martin 2009).

However, there may be another psychological factor that also distinguishes optimists and pessimists. Attributional style is reasoning about the causes of events (the 'why') but what about the perception of any such events in the first place (the 'what'). Could this also distinguish optimists and pessimists? Isaacowitz (2006) has argued that dispositional optimism does affect basic perceptual processes with optimists quite literally look on the bright side of life. He used an eye-tracking procedure to investigate this, tracking individual gaze fixations, when participants looked variously at images of skin cancer, line drawings with the same shape as the cancer images, and neutral faces. He selected images of skin cancer because they are clearly 'negative' images, being both unpleasant and graphic. He found that young adults high in dispositional optimism fixated less on these skin-cancer images than

their less optimistic peers (Isaacowitz 2006: 68). In other words, Isaacowitz claims that adult gaze preferences 'towards positive and away from negative images suggest that gaze patterns may reflect an underlying motivation to regulate emotions and to feel good.' (Isaacowitz 2006: 69). Luo and Isaacowitz (2007) also reported negative (but non-significant) relationships between dispositional optimism and eye-gaze to both negative and neutral text about skin cancer. The negative correlation suggests that optimists may read information about a negative topic more quickly than do pessimists. Other research has shown that individual differences in mood are indeed associated with attentional bias to certain stimuli. Individuals suffering from anxiety or depression have attentional biases toward negative information (Bradley, Moog and Lee 1997; Mathews and MacLeod 2002). Attentional bias to certain affective stimuli appears to be motivated by the need to self-regulate emotion, or maintain one's positive mood state (Wegener 1994). Attention away from negative images may help individuals prolong their positive mood. Participants who are instructed to regulate their emotions (Xing and Isaacowitz 2006) or trained to self-regulate emotions by attending to positive stimuli (Wadlinger 2008) also showed an attentional bias by looking less at negative stimuli.

Therefore, according to Isaacowitz (2006) and Seligman (2002) optimists have distinct cognitive 'strategies', involving both attributional reasoning and attentional bias, for staying optimistic. At the level of the individual this might be a very good thing (Harker and Keltner 2001), and as a consequence, strategies for becoming and remaining optmistic have been trained on a very large scale through both cognitive behavioural therapy (CBT) and the self-help industry (see Beattie 2011). However, what may be good for the individual, may be less good for society as a whole. Ehrenreich (2009) has argued that high levels of optimism (either dispositional or

learned) have 'undermined preparedness' to deal with real threats, including 9/11, the economic bubble bursting, world terrorism etc. 'The truth is that Americans had been working hard for decades to school themselves in the techniques of positive thinking, and these included the reflexive capacity for dismissing disturbing news' (Ehrenreich, 2009:10). The economic crisis, she argues, is a case in point ('imagining an invulnerable nation and an ever-booming economy - there was simply no ability or inclination to imagine the worst' (Ehrenreich 2009:11). Ehrenreich has argued that the problem was that 'professional optimists dominated the world of economic commentary' (Ehrenreich 2009:181) and that some people who had managed to anticipate the forthcoming economic disaster 'had been under pressure over the years to improve their attitude' (Ehrenreich 2009: 181). Shiller (2000) had also warned that 'wishful thinking on the part of investors …blinds us to the truth of our situation.' This is the downside of optimism, the fact that people may not notice those warning signs that are available and that a focus on the negative is actually an important aspect of human survival.

One very significant question is whether optimists may be missing some of the crucial signs of *climate change* because they are avoiding seeing them. There is some evidence for this. Optimism bias has been found for climate change in that individuals perceive climate change to be less of a risk to themselves, but the utmost risk to the environment (Costa-Font, Mossialos and Rudisill 2009). Attentional bias has been found to extend to the self-selection of information. One survey found that having positive or negative emotions about climate change was differentially related to information-seeking and avoidance behaviours (Yang and Kahlor 2012). People who felt excited, hopeful and happy about climate change were more likely to avoid or ignore information about climate change. Positive emotions about climate change

were not related to behavioural intentions to seek out information about climate change. In contrast, individuals who reported feeling concerned, worried and anxious about climate change were less likely to avoid information about climate change, and more likely seek out such information (Yang and Kahlor 2012). Beattie et al (2010) had found that experimental participants do fixate on the carbon footprint of specific products like low energy light bulbs, where, of course, the information about carbon footprint is positive, rather than on the carbon footprint of products where the information is going to be obviously higher (like detergent).

However, there is one counter study here. Beattie and McGuire (2011) did not find any evidence of an attentional bias in optimists away from negative iconic images of climate change, when these were presented on a computer screen alongside positive images of nature and images of neutral objects. Indeed, the negative images of climate change were fixated more by optimists than by pessimists. However, these iconic images of climate change may have differed in a number of ways to the alternative images as well as just on the positive-negative dimension. The iconic images of climate change (e.g. polar bears on ice floes, Manhattan under water, deserts, a tsunami crashing against a tropical shore) (Beattie and McGuire 2011: 245) might have conjured up images of challenge and adventure rather than just straightforward negative affect. One might recall that the image used to advertise the Hollywood movie 'The Day after Tomorrow' (2004) depicting New York in the wake of climate change was the Statue of Liberty barely visible through the changed landscape. This iconic image of climate change was used to promote an adventure movie. Furthermore, there is an argument that optimism is a valuable psychological state because in common with other positive emotions it acts to '*broaden* individuals' momentary thought-action repertoires, prompting them to pursue a wider range of

thoughts and actions than is typical' (Fredrickson and Branigan 2005). Optimists in this previous study could have been focussing on the 'challenging' iconic images of climate change because they are interested in more divergent action against it. Such negative images may represent a challenge rather than just merely representing 'bad news' like the images of skin cancer.

Furthermore, iconic images of climate change are just one type of 'communication' about this global phenomenon and we clearly need to recognise that despite their clear 'iconicity', such images have complex psychological and emotional effects on us (Barthes 1957). Iconic representations, be they in the form of everyday gestural communications or codified and recognisable photos, are also likely to be subject to multiple *individual* interpretations at both the conscious and unconscious levels (Beattie and Shovelton 1999a,b; Beattie 2016). One important question (amongst many) is how would level of dispositional optimism relate to attentional focus to more substantive climate change messages**?** Would it affect what people attend to, and even how they remember these messages? This is the focus of the current research.

Optimism bias and its antecedents

But there is another important consideration here. How might dispositional optimism affect so-called *optimism bias*, which has been reported frequently in the psychological literature, and may be particularly relevant to climate change? The potential relationship between dispositional optimism and optimism bias is an extremely important issue (especially given that we have been training people using CBT to become more optimistic) that is relatively under-explored in the literature (many use the terms 'optimism' and 'optimistic bias' more or less interchangeably

without proper evidence). Optimism bias is extremely important because it is so rife. Many of us (estimated at around 80%) apparently suffer from some form of optimism bias (Sharot 2012) – believing that our marriages will work (Baker and Emery 1993), our start-up businesses will succeed (Bracha and Brown 2012), and that we will have a long and fulfilling life compared to everyone else (Weinstein 1980). This sort of unrealistic optimism (after all, we all cannot be better than the average) would seem to be pervasive, affecting not just our personal relationships but also our attitudes to finance, work and health. For example, adolescent smokers are two and a half times more likely than non-smokers to doubt that they would ever die from smoking even if they smoked for thirty of forty years; adult smokers are three times more likely to believe this (Arnett 2000).

Optimism bias has been found across a range of environmental issues (Gifford et al. 2009), as well as in estimates of the risk of health damage from specific environmental hazards, like water pollution (Pahl, Harris, Todd and Rutter 2005), and with climate change (Gifford 2011). A large 18-nation survey demonstrated that individuals believe that across a number of environmental issues they are safer than others living elsewhere ('spatial bias') and that they are safer than future generations ('temporal bias') (Gifford et al. 2009). Indeed, optimism bias is one of the most consistent cognitive biases documented in both psychology and behavioural economics. Could it help explain why the public generally seem less concerned about climate change than they should be, and why they are not doing enough to ameliorate the effects of climate change? In addition, is level of dispositional optimism a contributory factor here?

The public do know about climate change and report some knowledge of the factors behind it. Thus, the British Social Attitudes survey (2012) in the U.K.

revealed that 76% of people 'believe climate change is happening and that humans are, at least partly, responsible.' However, research in the U.S. has shown that knowledge does not necessarily equate to actual concern (Kellstedt, Zahran and Vedlitz 2008). So could an increased understanding of the mechanisms that sustain optimism help us consider new ways of reaching this clearly over-optimistic public?

Optimism bias appears to be associated with specific cognitive biases in processing relevant information. One study in behavioural neuroscience used Functional Magnetic Resonance Imaging (FMRI) to measure brain activity as participants estimated their probability of experiencing a range of negative life events, including things like Alzheimer's and burglary (Sharot, Kom and Dolan 2011). After each individual trial, participants were presented with the average probability of that event occurring to someone like him or herself. How did this new information affect their estimate of it happening to them? The researchers found that their participants were significantly more likely to change their estimate *only* if the new information was better than they had originally anticipated. This bias was reflected in their FMRI data in that optimism was related to a reduced level of neural coding of more negative than anticipated information about the future in the critical region of the frontal cortex (right inferior prefrontal gyrus). They also found that those participants highest in dispositional optimism were significantly worse at tracking this new *negative* information in this region, compared to those who were lower in dispositional optimism. In other words, optimism bias derives partly from a failure to learn systematically from new undesirable information and this bias is most pronounced with those highest in dispositional optimism.

However, as we have already discussed there may well be other biases associated with how optimists process relevant information about the world in

addition to the *learning bias* identified by Sharot and her colleagues (in other words other biases which could affect 'perception' as well as 'learning'). Isaacowitz's (2006) research clearly demonstrates this. Similarly, the emotional Stroop task, where participants have to name the ink colours of a list of words varying in emotional valence (and ignore the meanings of the words), reveals that highly optimistic individuals have an unconscious, automatic attentional bias to positive stimuli than negative stimuli (Segerstrom 2001). They show maximum interference to positive stimuli resulting in longer latencies to respond in the Stroop task (Segerstrom 2001). Pessimists, on the other hand, have an attentional bias for negative stimuli (Segerstrom 2001). Optimists may end up with a rosier picture of the world because of this automatic biased pattern of visual attention.

Optimism may be highly advantageous for the individual, as we have discussed. Belief in a positive future also encourages individuals (in *some* domains, particularly those that they have some control over) to behave in ways that can actually contribute to this positive future, thus becoming a self-fulfilling prophecy (Sharot 2011). However, although underestimating future negative life events can reduce stress and add to our longevity, sometimes negative events really do need to be considered. Hence, optimism bias can have very significant deleterious consequences particularly regarding the discounting of serious risk. If we underestimate the risks of something like smoking, we may be much less likely to try to change our behaviour and stop smoking, and less likely to engage in basic preventative behaviours and avoid it in the first place**.**

Rationale for the present study

Optimism bias could be particularly relevant to issues to do with climate change. If we underestimate the probability of the negative effects of climate change happening to *us*, we may be much less likely to engage in mitigation behaviour, or sacrifice many of the things we currently value (foreign holidays, big cars, and high carbon lifestyles) to reduce the risks associated with climate change (Bracha and Brown 2008). But how might we gain insights into cognitive biases in the area of climate change? We cannot present participants with the actual *outcome* data (as was done in the Sharot study) to see how they update their own estimates in the light of this because the catastrophic consequences of climate change are still largely in the future. However, could the research on biased patterns of attention provide us with any new insights here? Does the evidence of differential focus on positive images by optimists in the Isaacowitz study have any relevance for how individuals attend to more serious substantive messages about climate change, as opposed to just drawings and images? We have been bombarded with information by high profile and credible organisations like the IPCC, governments and NGOs, but are there cognitive biases in how this information is being attended to and do any such biases connect to underlying dispositiona optimism? Here we conduct two studies. Study 1 examines the relationship between level of dispositional optimism and the processing of climate change messages. Study 2 examines the relationship between level of dispositional optimism and the extent of optimism bias.

In Study 1, we employ an eye-tracker to record eye movement behaviour to reveal online visual and cognitive processing when participants are presented with climate change messages. It has long been established that eye movement behaviour can be linked to cognitive processing in a range of tasks (e.g., Buswell 1922; Just and Carpenter 1976; Rayner 1978, 1998;Yarbus 1967), and we know more about eye

movements involved in reading than in any other cognitive task (for a review, see Rayner 2009). On average, we read around 330 words per minute (Rayner, Well, Pollatsek, and Bertera 1982), and to achieve this large amount of information processing we rapidly move our eyes forward through the text between 3-5 times per second (Rayner, Pollatsek, Ashby, and Clifton 2012). Our eye movement behaviour largely consists of the actual eye movements (also known as saccades) and the periods in which are eyes are not moving, but are relatively fixated in position. Research shows that very little information is processed during saccades (known as 'saccadic suppression', Matin 1974), and that instead it is during fixations that visual and cognitive processing takes place, such as word identification and semantic processing. Evidence of this processing can also be seen in the durations of each fixation. The average fixation duration is approximately 200-250ms, but there are numerous factors that can influence fixation duration (Just and Carpenter 1980). One of the strongest contributors to fixation duration is the familiarity of a word (i.e., word frequency). Rare words are fixated longer, whereas more familiar words are fixated for a shorter duration, or sometimes skipped altogether. Word length also affects fixation duration and the likelihood of word skipping, with longer words being associated with increased fixation durations and are less likely to be skipped compared to shorter words. In addition, as one would expect, it is generally the case that the more difficult the text, the slower the reading rate. However, on a more fine-grained level, increased difficulty of the text can also lead to longer fixation durations, smaller saccades, and an increase in regressive saccades (Scheier et al. 2012).

Extensive research on eye movement behaviour (cf. Rayner et al. 2012) suggests that although reading is largely a case of processing information word-by-word, there is more to reading than just identifying a word and moving on to the next

word. Words need to be comprehended within their context of the sentences, and the reader needs to extract the meaning out of successive sentences and parse these sentences together to process the discourse of the text. To understand the discourse of the text may require the reader to draw on knowledge about the topic and to understand what the text is trying to convey. For example, the reader will need to establish what the text is trying to describe or suggest, and judge whether they believes the claims that the text may make. Taken together, discourse comprehension is an *active* process in which the reader's individual prior knowledge, perspective on the situation, moods, attitudes and intentions may influence how the message of the text is perceived (see, for example, Bower 1978). In Study 1, we investigate experimentally whether dispositional optimism affects patterns of fixation. Optimists manage to maintain a positive focus in life, the question that we pose here is whether this is partly attributable to *reduced* processing of negative information driven by a desire to maintain a positive outlook? Could this help explain the apparent failure of many climate change communications?

Study 1:

Method

Participants

Participants were a sample of university staff and students from the North West of England. They received £6 for taking part. Ethical approval was obtained from the University Human Research Ethics Committee (UREC). We recruited 45 participants (65.2% female) for the study. Basic demographic information, including whether they were a member of an environmental group was collected. The mean age was 29.9 (range 18-63 years). The age, gender and environmental membership of our

participants, as well as their familiarity with the topics of the climate change articles were all noted. There were no significant differences between optimists and non-optimists on any of these variables. Three participants were unable to have their eye movements tracked and excluded from this study. Participants were randomly assigned to a recall or no recall condition.

Materials

The materials consisted of a practice text (about asthma) and three articles about (1) climate change in general, (2) climate change and its relation to flooding in the UK, (3) climate change and its consequences for food scarcity and violent conflict. Texts of all four articles can be found in the Supplementary Material.

Each climate change article contained 3 arguments for climate change ('for') and 3 arguments against climate change ('against'). 'For' arguments were that climate change is real, human activity is the cause of both climate change generally and flooding in the UK, and predictions that climate change will cause food scarcity and conflict. 'Against' arguments were that climate change is not occurring or is exaggerated, that it is not caused by human activity, that flooding in the UK is not caused by climate change, and that there is no link between climate and food scarcity and conflict. All arguments were drawn from print and electronic media (e.g. *The Guardian, BBC News website* etc.) and online blogs. 'For' arguments came from news articles summarizing the findings detailed in the IPCC 2014 report about climate change. 'For' and 'against' arguments were edited such that they were of similar word count and frequency. There were no significant differences on average word frequency, word count or word length between 'for' and 'against' arguments within each article, as well as the average of all 'for' and 'against' arguments for all articles. The three articles were of similar length (mean of 388 words; range: 363-405).

Measures

The independent variable, the 10-item Life Orientation Test - Revised (LOT-R) was used to measure dispositional optimism and we divided our participants (using a median split) into optimists (LOT-R score 16.55, SD = 2.37, range 17-22) and non-optimists (LOT-R score 10.45, SD = 2.65, range 3-14). Familiarity with the topic of article was assessed with a single item measure: 'How familiar are you with the topic described in the text you just read?' on a 5-point scale (1 = 'I have never heard about this topic before'; 5 = 'I am very familiar with this topic') (Kaakinen and Hyönä 2005).

Three dependent variables were used to assess attention: fixation count (number of individual eye gaze fixations), average fixation duration and dwell time, the total duration of all fixations within an AOI (an overall measure of reading time). The text of 'for' and 'against' arguments were grouped into Areas of Interest (AOI).

Procedure

Eye movements were captured with an Eyelink 1000 (SR Research) desktop eye-tracker. The sampling rate was 1000hz. Articles were presented on a 19" CRT (150Hz), with a resolution 800x600. Participants were seated 57cm in front of the eye tracker with a chin-rest to observe the stimulus material on a computer monitor. The eye-tracker infrared camera determines the participant's point of gaze on the screen. Viewing was binocular, but only one eye was recorded.

The eye-tracking experiment began with a standard 9-point calibration procedure, which was repeated after reading each article. Only calibrations with an

average calibration error < 0.5° were accepted. All texts were presented in Arial font with identical font size (16), line spacing (1.5), and left-justification, as this was the default settings for text reading in the Eyelink 1000. Due to the font size and word limit restrictions of 150 words per page, text from each article was displayed over three 'pages' or screens. For the three climate change articles, each 'page' contained one 'for' and one 'against' argument. Presentation of 'for' and 'against' paragraphs differed by article. 'Against' arguments were the first paragraph on the screen for the 'General climate change' article. For the 'Flooding' and 'Food Scarcity and Conflict' climate change articles 'for' arguments were the first paragraph on the screen. To start reading, participants looked at a fixation point in the top-left corner of the screen and pressed the spacebar. The fixation page was replaced with the first page of an article. After they had finished reading the first page, participants pressed the spacebar to proceed to the fixation point page. This procedure was repeated to read the second and third pages of text. The spacebar presses started recording of the eye-tracker. Participants read the practice article to familiarize themselves with the procedure. After the calibration was repeated, participants then read the three climate change articles. Presentation of climate change article were randomized. After reading each article in the recall condition participants were asked to verbally recall what they had just read to the experimenter (Kaakinen and Hyönä 2005; Kretzschmar et al. 2013).

Results

Rationale for statistical analyses

Normality was assessed prior to analysis within the optimist and non-optimist groups. Within each group, the Kolmogorov-Smirnov (K-S) test was non-significant for all 6 eye movement outcome variables indicating normal distribution. The assumption of homogeneity of variance was met in all 2*2 factorial ANOVA analyses.

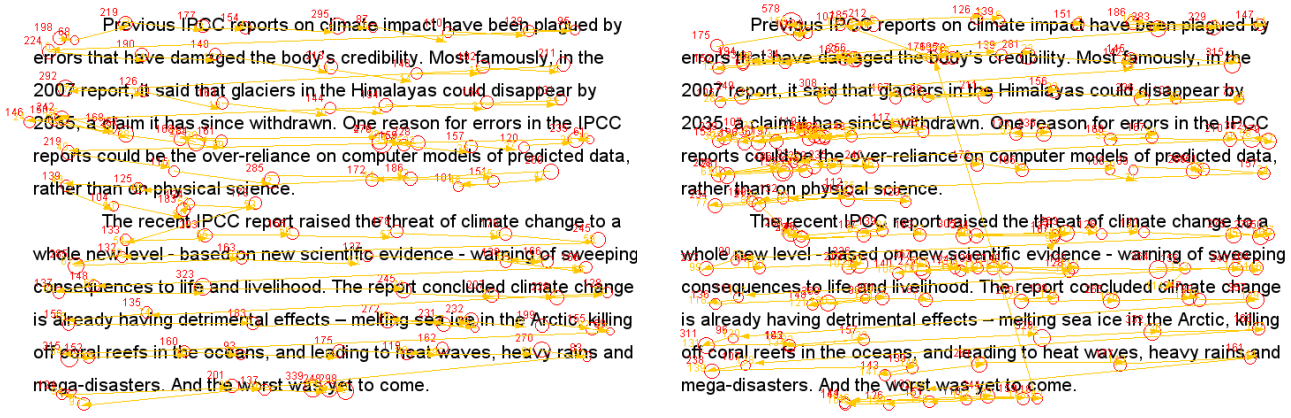
Analysis of the number of 'for' and 'against' arguments recalled was conducted for the recall condition only (n = 20). A median split with ties to the mean was conducted for this subsample; ten recall participants were in each group. Normality was assessed within each group with the K-S test. The number of 'for' arguments recalled by optimists was not normally distributed, $D(10) = .278$, $p = .03$. Recall of 'for' arguments for both groups, as well as recall of 'against' arguments for non-optimists were non-significant, indicating normal distribution. Consequently, independent samples *t*-test were conducted for recall of 'for' arguments and a Mann-Whitney-U test conducted for recall of 'against' arguments between optimists and non-optimists.

Content analysis was used to analyse the transcripts of recall participants. Analyses of recall transcripts were scored for the number of 'for' and 'against' propositions correctly recalled as well as more detailed analyses on how the recalled gist information was framed (Bransford and Franks 1972).

Eye tracking

The individual scan paths of two participants (an optimist and a non-optimist) are displayed below as they read arguments both 'against' and 'for' climate change (Fig. 1). In this scan path, circles represent individual fixations on words, with larger circles representing longer fixation durations. Lines between circles represent saccadic eye movement behaviour. The text of the 'for' and 'against' arguments were

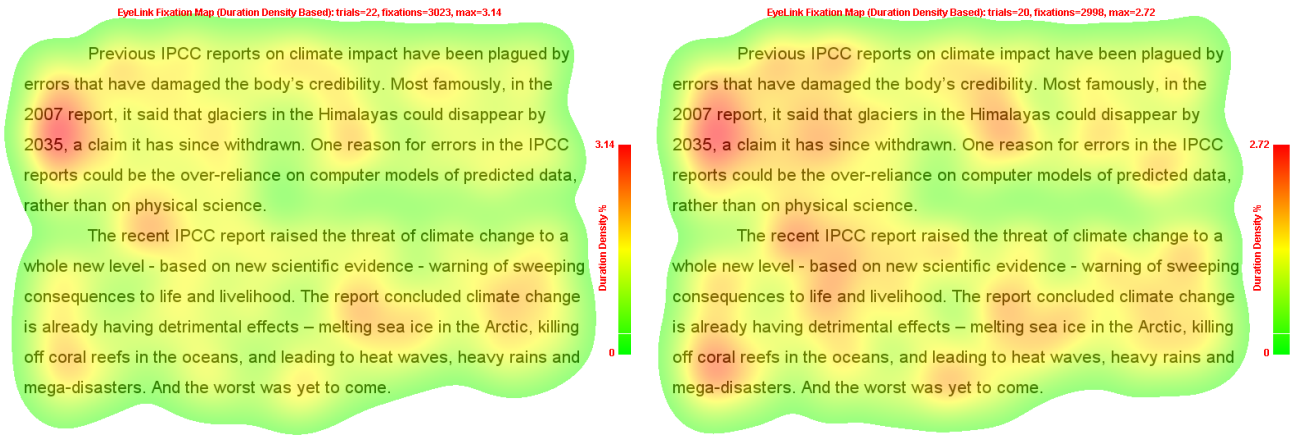
grouped into Areas of Interest (AOI). We measured fixation count, fixation duration and dwell times to 'for' arguments; and to 'against' arguments for both optimists and non-optimists (see Fig. 2).



a) optimist **b) non-optimist**

Figure 1: An individual scan path of a) an optimist and b) a non-optimist, as they read one argument 'against' climate change (first paragraph) and one argument 'for' climate change (second paragraph).

Figure 2 displays hotspot analysis of eye gaze fixations of the group of optimists and non-optimists reading arguments 'against' or 'for' climate change. In this figure, greater intensity represents longer dwell times at fixated locations.



a) optimists **b) non-optimists**

Figure 2: A hotspot analysis of eye gaze fixations of a group of optimists and non-optimists reading one argument against climate change (first paragraph) and one argument for climate change (second paragraph) .

We found no significant correlation between level of dispositional optimism and the number of fixations to either 'for' or 'against' arguments (see Table 1). However, there was a significant correlation between optimism and average fixation duration to 'for' arguments only (r = -.*327*, $p < 0.05$). Optimism level was also significantly negatively correlated with average dwell time to both 'for' (r = -.369, p <0.05) and 'against' arguments (r = -.347, $p < 0.05$). In other words, higher levels of dispositional optimism are associated with less time spent attending to the content of the climate change articles irrespective of argument ('for' or 'against'), and shorter

periods of time fixating on aspects of the arguments 'for' climate change (the bad news sections of the articles). See Tables 1 and 2.

Table 1:, *Means and correlation coefficients for fixation count, fixation duration and overall dwell time* – arguments ***for*** climate change

	Optimists Mean	**Non-optimists Mean**	**Correlation optimism level/gaze measures**
Fixation count	69.2	74.9	-0.220
Fixation duration (ms)	194.2	212.7	-0.327*
Overall dwell time (s)	13.3	15.9	-0.369*

Note. 0 = Pessimists, 1 = Optimists. * = $p < .05$

Table 2: *Means and correlation coefficients for fixation count, fixation duration and overall dwell time* – arguments ***against*** climate change

	Optimists Mean	**Non-optimists Mean**	**Correlation optimism level/gaze measures**
Fixation count	67.7	74.2	-0.253
Fixation duration (ms)	198.2	211.7	-0.232
Overall dwell time (s)	13.3	15.9	-0.347*

Note. 0 = Pessimists, 1 = Optimists. * = $p < .05$

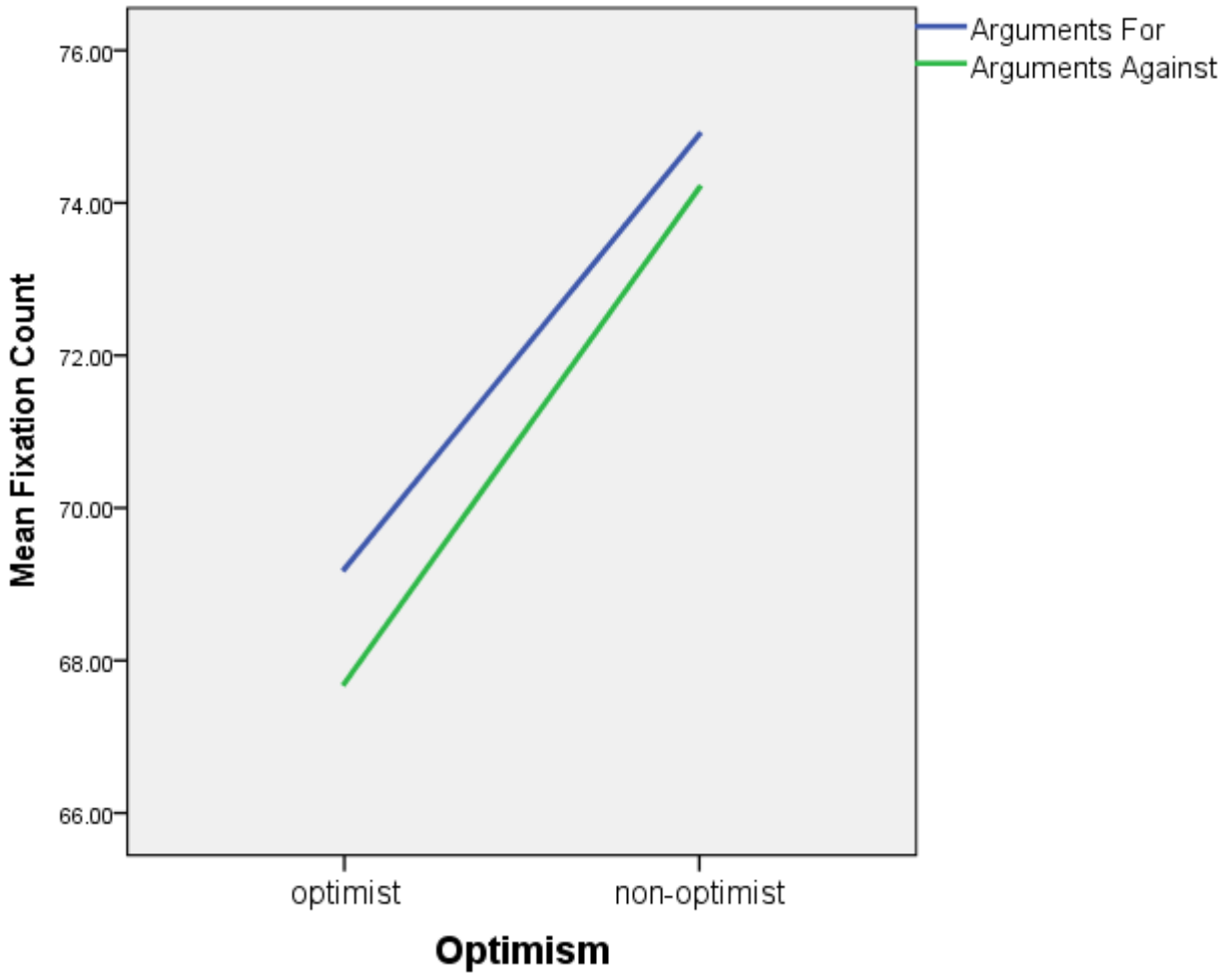
An 2*2 ANOVA revealed no significant relationship between optimism level and fixation count. The interaction between argument and optimism was also not

significant (see Figure 3), indicating that the fixation counts to ‘for’ and ‘against’ arguments were similar for optimists and non-optimists.

An 2*2 ANOVA also revealed that there was no significant relationship between optimism level and fixation duration, but there was a significant interaction effect between optimism (optimist/non-optimist) and fixation duration $F(1,40) = 5.804$, $p < 0.05$ (see Figure 4). The two groups significantly differed on fixation durations to ‘for’ arguments ($t(40) = 2.188$, $p < 0.05$), but did not differ in fixation durations to ‘against’ arguments ($t(40) = 1.506$, $p = .140$). Furthermore, for optimists, fixation durations were significantly shorter to ‘for’ arguments ($M = 194.22$, $SD = 33.73$), than to ‘against’ arguments ($M = 198.24$, $SD = 35.69$), $t(21) = -2.516$, $p < 0.05$. Non-optimists, on the other hand, had very similar fixation durations to both types of climate change argument.

There was also a significant main effect of optimism on dwell time, $F(1,40) = 6.013$, $p < 0.05$ (see Figure 5). Analysis of mean scores revealed that non-optimists had significantly greater dwell times to both types of arguments than optimists. However, the interaction between argument and optimism was not significant, indicating that the dwell times to 'for' and 'against' arguments were similar for both optimists and non-optimists.

Figure 3: Mean number of fixations for optimists and non-optimists reading



arguments 'for' or 'against' climate change

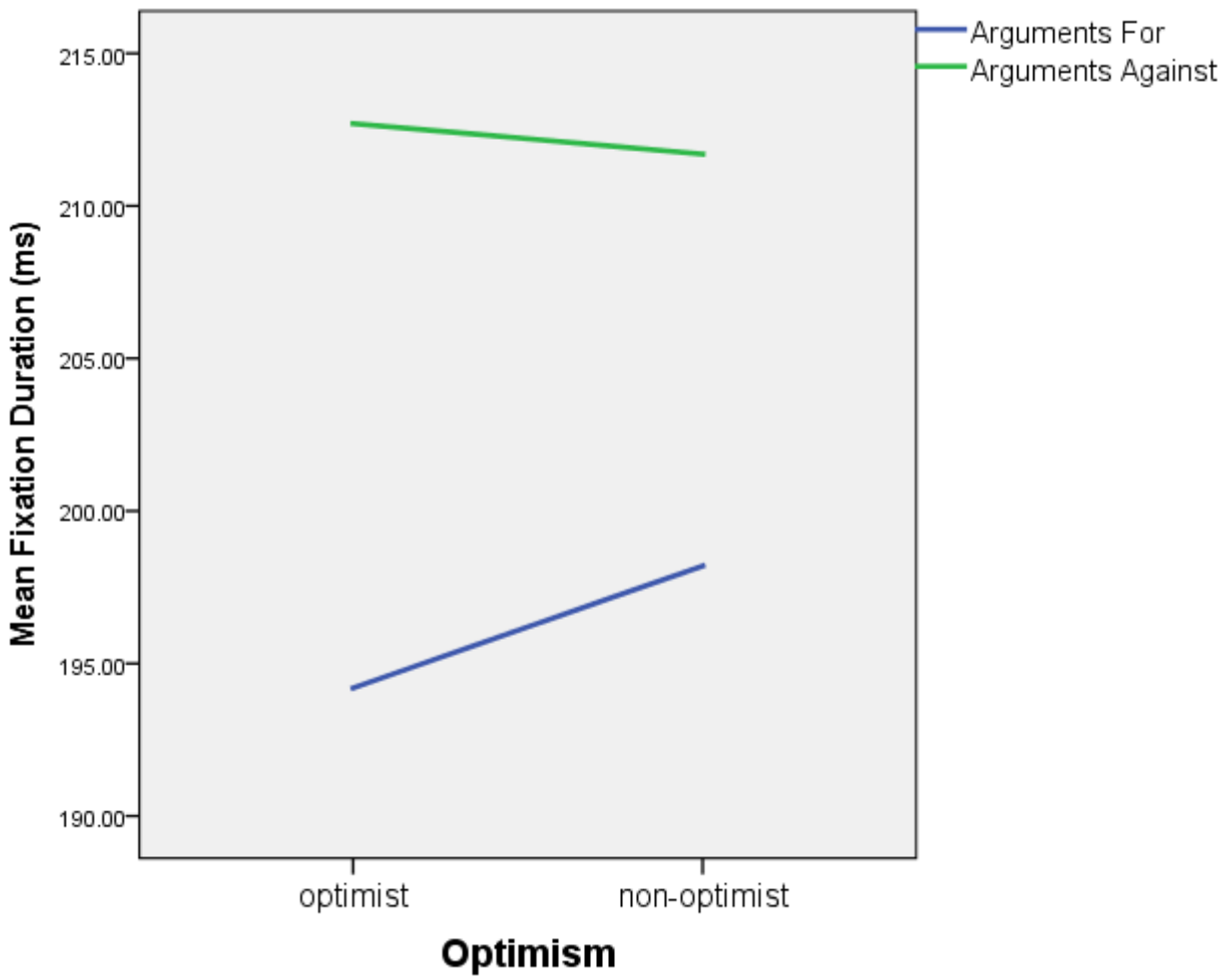


Figure 4: Mean fixation duration for optimists and non-optimists reading arguments 'for' or 'against' climate change

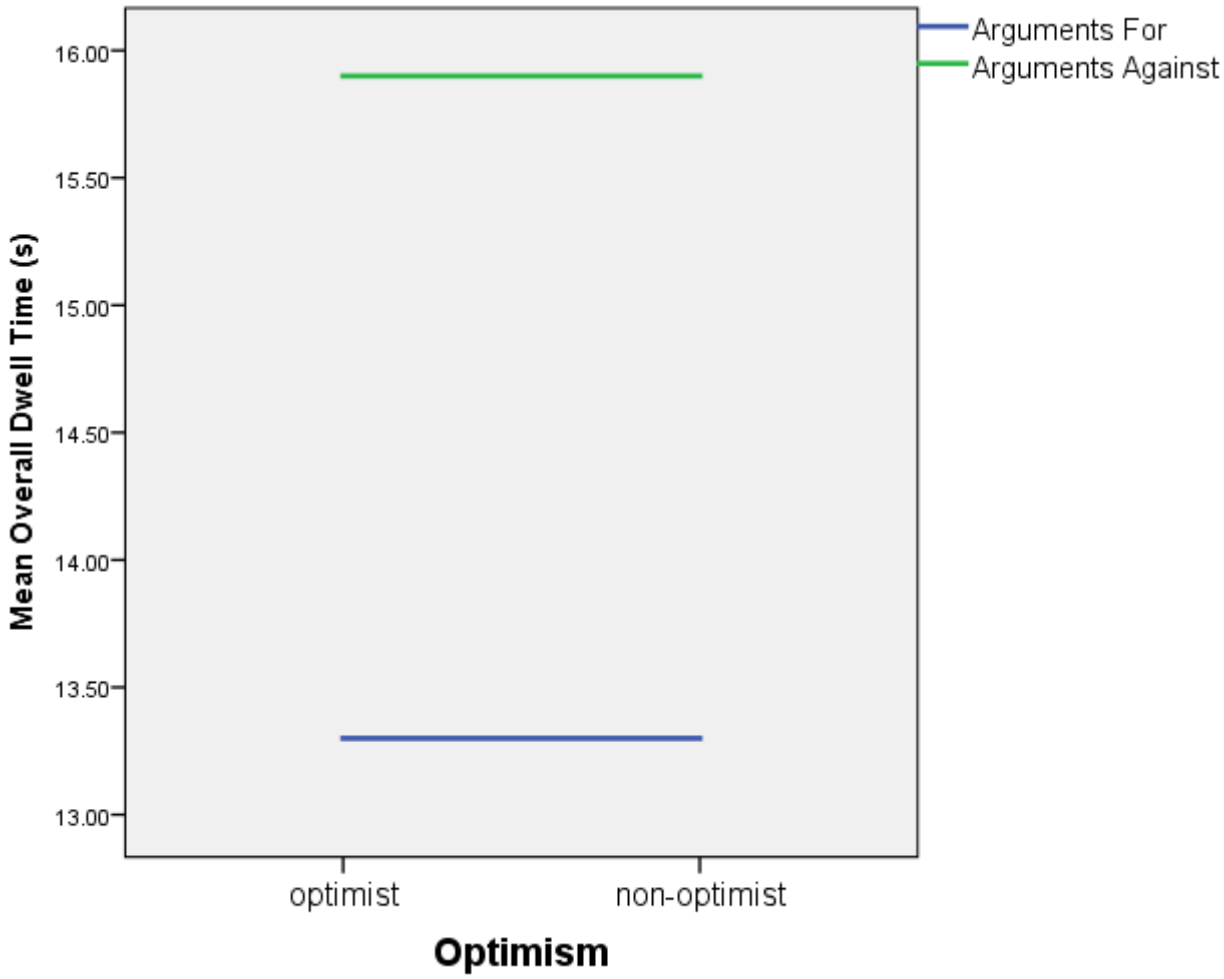


Figure 5: Mean dwell time for optimists and non-optimists reading arguments 'for' or 'against' climate change

Recall

When participants were asked to summarise the articles, non-optimists recalled more propositional units 'for' climate change (mean=5.80; S.D.=2.66) than optimists (mean=5.30; S.D.=2.00). However, using a t test, we found that this difference was not significant t(18)=.475, p=.640. Similarly, non-optimists recalled more propositional units 'against' climate change (median=7.00) than optimists

(median=6.50). But again, this difference was not significant (U=37.50, z=-.960, p=.356). Non-optimists seemed to recall more propositional units than optimists, but not significantly so. The high standard deviations here were undoubtedly a factor However, propositional recall is only one aspect of memory performance. Another critical aspect of memory is what has been termed 'effort after meaning' (Bartlett 1932). When people recall accounts from memory they make sense of what they have heard, and frame the discourse in particular ways in the light of their own cognitions, emotions and cultural views (Bower 1978; Storbeck and Clore 2005). Hence, a good deal can be learnt from an analysis of how accounts from memory are constructed and how these constructions function (Beattie and Doherty 1995; Edwards 1997: Edwards, Potter and Middleton 1992). No significant differences in level of 'propositional' recall might disguise very important differences in how the recall is constructed and framed. When one is asked to summarise articles about climate change in which both the arguments for and against climate change are included, there is considerable scope for differing constructions of gist (Bransford and Franks 1972). We decided to consider this issue in detail, and employed three broad categories for coding how these recalled accounts were framed:

(1) 'For': the account was framed as being *primarily* about the evidence for climate change (and its general or specific effects on flooding, food scarcity and conflict etc.) and the role of human activity in this.

(2) 'Against': the account was framed *primarily* in terms of there not really being a strong link between human activity and climate change (or its specific effects), or doubts about the very existence of climate change.

(3) Debate: the account was framed as primarily being a debate between two opposing positions.

For example -

'For':

'This article is about global warming and how 95% of it is due to human activity.'

'It was about an IPCC report about climate change saying that Britain is going to be subjected to a lot more flooding in the future…'

'Against':

'So again the IPCC have been kind of criticized for some errors in their reports.'

'Climate change could result in extreme weather, such as flooding, and how there is not really a strong link to this.'

Debate:

'This one's looking at….whether climate change can be explained by human behaviour – so there are arguments going backwards and forwards.'

'It's about climate change, about trying to understand what's happening with the weather and there are different points of view.'

The frames are summarised in Tables 3 to 8 below. We exclude any interpersonal comments at the start of the account or meta-comments about the task itself e.g. 'sorry um um um sorry….I had it a second ago and now it's gone', 'no problem' in response to being asked to summarise the article, or 'I struggle to think of this one now'. Two coders independently coded the gist of the recall, blind to whether they had been generated by an optimist or non-optimist. This was done for

all three articles. Cohen's kappa in the coding was 0.88, which is regarded as highly satisfactory (anything above 0.70 is regarded as satisfactory).

Table 3: The framing of the recall narratives of optimists for the general article about climate change.

OPTIMISTS (General)		
Optimism score	**Frame**	**Coding: for/against/debate**
15	This article is concerned with the debate…	Debate
16	This article is about global warming and how 95% of it is due to human activity	For
16	It was showing both sides of the debate about whether humans are affecting global warming…	Debate
17	This was about climate change and looking at whether it was humans that were responsible…discounted through possibly inaccurate data…	Against
18	They were saying that climate change is primarily due to human living....but there could be an error in these studies.	Debate
19	This one's looking at….whether climate change can be explained by human behaviour – so there are arguments going backwards and forwards.	Debate
19	The IPCC keep putting forward warnings ...but they are countered by sceptics'…	Debate
19	That article was about climate change and was debating the controversy…	Debate
21	It is a discussion about how true all the reports are about the humans impact on the climate change…	Debate
22	It was talking more about greenhouse gases, climate change and about how humans are to blame based on their lifestyles…	For

Table 4: The framing of the recall narratives of non-optimists for the general article about climate change.

NON-OPTIMISTS (General)		
Optimism score	**Frame**	**Coding: for/against/debate**
7	It was about an IPCC report about climate change saying that Britain is going to be subjected to a lot more flooding in the future…	For
8	It is about whether or not human beings are actually the cause behind climate change...	Debate
10	It is a report from the IPCC again saying about human contribution to climate change and how they think it is 95% certain that it is humans that are causing climate change	For
11	It was climate change, but more from the scientists' perspective and how there is a difference between the sceptics and pro-greenhouse believers.	Debate
11	So what they're saying is that the global greenhouse emissions and people's behaviour has a high effect on the atmosphere.	For
12	It's about climate change, about trying to understand what's happening with the weather and there are different points of view.	Debate
12	So this one's looking at the claim the IPCC make about human behaviour is the key culprit of climate change.	For
13	It was talking about the fact that global warming is basically by humans.	For
13	It was about climate change, it talked about how-more to do with natural aspects…global warming is due to political and economical…	For
14	...discussed the effects of humans on global warming; it was 95% certain that they did have an effect.	For

Table 5: The framing of the recall narratives of optimists for the article about flooding caused by climate change.

OPTIMISTS (Flooding)		
Optimism score	**Frame**	**Coding: for/against/debate**
15	…there were different arguments given, suggesting that changes in global warming …global warming contributes to changes in the weather	Debate
16	…global warming is having an effect on the floods and the extreme weather.	For
16	That one was about the weather affecting Britain and how we should start preparing for more extreme storms because of climate change.	For
17	It was looking at the effect of climate change on the weather that we have experienced in this country for the last few years.	For
18	Climate change could result in extreme weather, such as flooding, and how there is not really a strong link to this.	Against
19	The U.K. has been warned to accept greater flooding and storms as a direct effect of climate change caused by the burning of fossil fuels – however, the computer models they use for rainfall are not as accurate as computer models for temperature change so not absolutely sure they can trust it.	Debate
19	It is a debate about the causes of climate change and it has come to light because of the recent storms over the last winter period…	Debate
19	Again, that was about the debate over climate change climate.	Debate
21	…it seems to be some confusion as to whether it is caused by human intervention, the burning of fossil fuels or whether that is having an effect on the heavy rainfall we have been experiencing.	Debate
22	So it was talking about any evidence about global warming….there was also some debate about whether it is actually climate change	Debate

Table 6: The framing of the recall narratives of non-optimists for the article about flooding caused by climate change.

NON-OPTIMISTS (Flooding)		
Optimism score	**Frame**	**Coding: for/against/debate**
7	It was about an IPCC report about climate change saying that Britain is going to be subjected to a lot more flooding in the future.	For
8	It was about climate change, which they said that it was quite a new area of science so there is not an exact correlation between the rise in greenhouse gasses and the things like the floods	Debate
10	It was about a report on climate change and the recent flooding this winter in the U.K. and the fact that the scientists couldn't actually say whether it was due to global climate change.	Debate
11	Climate change again but more specific to the UK and the flooding and the weather conditions that happen here, I remember it saying that you cannot completely attribute it to human causality.	Debate
11	Very conflicting – scientists either some knowing or some believe in that it is due to fossils, climate change and some think it is the jet stream.	Debate
12	So it's looking at climate change and global warming and it's coming from the IPPC report which the U.N. did. It says that small countries, and I think it said Asia as well, are more likely to be affected by extreme weather conditions.	For
12	So again the IPCC have been kind of criticized for some errors in their reports	Against
13	It was talking about climate change and how they're blaming the recent storms that we had on climate change.	For
13	It was on climate change – it discussed climate change in relation to the weather talking about flooding and heat waves – there was a lot of argument whether the floods in Britain were associated with global warming and climate change.	Debate
14	It was talking about another IPCC report and the effects of global warming on severe weather fronts, in particular the effects on smaller islands like the UK discussing whether the increased rainfall over, especially the last winter was a result of global warming.	For

Table 7: The framing of recall narratives of optimists for the article about food scarcity and conflict resulting from climate change.

OPTIMISTS (Food Scarcity and Conflict)		
Optimism score	**Frame**	**Coding: for/against/debate**
15	The article is concerned with climate change and its effects on conflict and global politics, and gave various different arguments as to what the relationship actually entails, if at all.	Debate
16	Wasn't it looking at climate change effects in different areas and they had noticed that people, like gang leaders sort of using it to control food.	For
16	This article says that the IPCC says that due to the case of global warming there is going to be an increase of violent attacks because different countries don't often have the resources available to feed their country.	For
17	This is a debate about whether climate change could cause conflicts because there could be a shortage of food and water, so it could cause a conflict.	Debate
18	Some people are saying that climate change could lead to conflict.	For
19	It's another United Nations IPCC report and it is looking at and trying to link climate change to conflict.	Debate
19	There is an argument in the United States that climate change affecting food sources will result in greater conflict because people will be fighting over food and water…the counterargument would be…	Debate
19	The IPCC report was explaining that there might be a correlation between climate change and conflict and poverty, possibly, in the next 10 years due to climate change - however, other people and scholars were arguing there is no direct, causal influence between those two factors.	Debate
21	It is a report from the IPCC discussing how climate change might well be responsible for acts of violence and general unrest in countries. – there's some discussion about whether that in itself…	Debate
22	This one was talking about the effects of climate change on conflict and also on food production and things like that – so saying about how potentially changing conflict might be a result of climate change…but it good be a good thing.	Debate

Table 8: The framing of recall narratives of non-optimists for the article about food scarcity and conflict resulting from climate change.

NON-OPTIMISTS (Food scarcity and Conflict)		
Optimism score	**Frame**	**Coding: for/against/debate**
7	This was another report about global climate change saying that the food will be more scarce, saying basically food and water will be more scarce and maybe even people like warlords will come into play here.	For
8	This one was about how climate change could affect the amount of food and water we've got – some people were arguing that it would actually do well for countries like Asia and things like wheat production will go up, but for the rest of the country it could mean a decrease in food and water supplies.	For
10	The IPCC to say that climate change will decrease food supply.	For
11	A general report on the effects of climate change and what will happen in politics, agriculture, and the possibility of war breaking out – not war – but conflict.	For
11	Basically, what they are saying is that climate change can either make people react positively or negatively and create conflict throughout the world.	For
12	The global climate may be impacting on the scarcity of foods and affecting the growth…	For
12	So this one was looking at conflict as an outcome of climate change with the IPCC report claiming that an increase in climate change will lead to an increase in conflict as people will fight over resources and water.	For
13	It was talking about global warming could affect people in other ways other than, like, death and destruction – it could affect them in the food sector.	For
13	It said that global warming is often more to do with political and economical issues – it can have a negative effect.	For
14	Another IPCC report on climate change and food scarcity and whether this could lead to war and conflict in areas where there was this food scarcity - the converse argument was that most conflict was due to power, terror, money.	Debate

Tables 3 to 8 are summarised in the contingency table below, which collapses the three types of article. It is immediately apparent that the *non-optimists* were most likely to frame their recall in terms of the arguments *for* climate change ('this article is about global warming and how 95% of it is due to human activity). 66.7% of their recalls were framed in this way. The *optimists*, on the other hand, were most likely to frame it in terms of a debate between two opposing positions ('it's about climate change, about trying to understand what's happening with the weather and there are different points of view'). 66.7% of their recalls were framed as a debate. There were few summaries of the content framed in terms of the arguments 'against' climate change for either groups (only 5% of the total). A X^2 test revealed that optimists and non-optimists differed significantly in the framing of their recalls ('for' versus 'against'/debate) – X^2 (1) =13.42, p=0.001 (2-tailed).

Table 9: A summary of the framing of recall narratives about climate change ('for', 'against' or 'debate') for optimists and non-optimists.

	For	**Against**	**Debate**
Optimists	8	2	20
Non-optimists	20	1	9
Totals	28	3	29

In summary, it would appear that those higher in dispositional optimism (with scores ranging from 17-22) spend less time fixating on arguments 'for' climate change than on arguments 'against' climate change. Non-optimists (with scores ranging from 3-14), on the other hand, had very similar fixation durations to both types of climate change arguments. Non-optimists also had significantly greater dwell times to both types of arguments than optimists. Optimists are also more likely to frame their recall of articles about climate change (in which arguments 'for' and

'against' climate change are included) as a 'debate', whilst non-optimists are more likely to frame their recalls as being about the arguments *for* climate change.

The next important question is whether dispositional optimism could be linked to level of optimism bias? Our prediction, following Sharot et al. (2011), is that it would.

Study 2:

Method

Participants were a sample of university staff (administrative and support staff) from the North West of England taking part in a staff development course. They were asked to take part in a survey to measure dispositional optimism and possible optimism bias. The 10-item Life Orientation Test - Revised (LOT-R) was again used to measure dispositional optimism. A questionnaire was devised to measure optimism bias. It consisted of three broad questions:

1. What is the probability of you personally being affected by climate change?
2. What proportion of people (living today) will be affected by climate change?
3. What proportion of future generations will be affected by climate change?

Participants had to write a number between 0 and 100% in response to each of the questions. Each question had seven additional questions asking participants to rate (in the case of question 1) the probability of them being personally affected by severe drought, severe flooding, major threats to

infrastructure, food shortages, major conflict, heat-related increased mortality and major disruption to your life. In the case of the other questions, they had to rate the proportion of people living today (question 2) being affected by each of these, and then the proportion of future generations (question 3) being affected by them. There were thus 24 questions in all to assess possible optimism bias. There was no financial incentive for taking part, and it was stressed that participation was entirely voluntary and anonymous. The sample of 50 participants was 84.0% female, the ages ranged between 22-64. The research had been passed by the Departmental Research Ethics Committee (DREC).

Results:

We split our participants into 3 groups – 'high' (optimism score 18-23), 'medium' (optimism score 15-17) and low (optimism score 8-14). In Study 1, the median split distinguished optimists (scores 17-22) and non-optimists (scores 3-14). A score of 14 and below identified an N of 17 in the lowest category in Study 2, so we decided to divide the remaining 33 participants into 2 categories (high and medium optimists).

Tables 10-12 show the estimates for all 3 groups on the various questions. It seems that those participants *lowest* in dispositional optimism (i.e. the most pessimistic) are more likely to judge that they will be personally affected by climate change than those *highest* in dispositional optimism. In addition, they judge that more people living today will be affected by climate change, and that future generations will be more likely to be affected by climate change, compared to those highest in optimism. Indeed, those lowest in dispositional optimism were approximately twice

as likely than the optimists to think that they would be personally be affected by climate change across all eight responses averaged.

Table 10: Mean estimates for participants varying in level of dispositional optimism for question 1.

Question 1	**High Optimists (optimism score: 18-23) n=17**	**Medium Optimists (optimism score: 15-17) n=16**	**Low Optimists (optimism score: 8-14) n=17**
Q1.1: What is the probability of you personally being affected by climate change?	36.5	51.3	56.8
Q1.2: What is the probability of you personally being affected by severe drought because of climate change?	10.3	18.1	29.4
Q1.3: What is the probability of you personally being affected by severe flooding because of climate change?	18.2	22.6	38.8
Q1.4: What is the probability of you personally being affected by food shortages because of climate change?	18.6	24.3	29.1
Q1.5: What is the probability of you personally being affected by food shortages because of climate change?	19.9	25.4	27.9
Q1.6: What is the probability of you personally being affected by major conflict over natural resources because of climate change?	19.8	31.8	35.4
Q1.7: What is the probability of you personally being affected by heat-related increased mortality because of climate change?	13.9	19.0	38.4
Q1.8: What is the probability of you personally suffering major disruption to your life because of climate change?	12.8	20.3	39.8
Overall mean	18.8	26.6	37.0

Table 11: Mean estimates for participants varying in level of dispositional optimism for question 2.

Question 2	High optimists	Medium optimists	Low optimists
Q 2.1: What proportion of people living today will be affected by climate change?	52.8	75.3	68.5
Q 2.2: What proportion of people living today will be affected by severe drought because of climate change?	38.5	49.7	52.1
Q 2.3: What proportion of people living today will be affected by severe flooding because of climate change?	38.4	47.8	51.2
Q 2.4: What proportion of people living today will be affected by major threats to infrastructure because of climate change?	39.0	46.3	47.9
Q 2.5: What proportion of people living today will be affected by food shortages because of climate change?	44.9	46.6	51.8
Q 2.6: What proportion of people living today will be affected by major conflict over natural resources because of climate change?	35.1	46.3	50.9
Q 2.7: What proportion of people living today will be affected by heat-related increased mortality because of climate change?	32.0	40.0	48.2
Q 2.8: What proportion of people living today will suffer major disruption to their life because of climate change?	32.8	45.9	58.2
Overall means	39.2	49.7	47.6

Table 12: Mean estimates for participants varying in level of dispositional optimism for question 3.

Question 3	High optimists	Medium optimists	Low optimists
Q 3.1: What proportion of future generations will be affected by climate change?	76.4	88.1	84.1
Q 3.2: What proportion of future generations will be affected by severe drought because of climate change?	56.8	54.1	69.4
Q 3.3: What proportion of future generations will be affected by severe flooding because of climate change?	54.4	53.8	69.4
Q 3.4: What proportion of future generations will be affected by major threats to infrastructure because of climate change?	56.2	53.1	67.9
Q 3.5: What proportion of future generations will be affected by food shortages because of climate change?	59.4	52.8	68.2
Q 3.6: What proportion of future generations will be affected by major conflict over natural resources because of climate change?	61.2	56.3	65.9
Q 3.7: What proportion of future generations will be affected by heat-related increased mortality because of climate change?	55.2	53.6	59.4
Q 3.8: What proportion of future generations will suffer major disruption to their life because of climate change?	57.9	55.4	74.1
Overall means	59.7	58.4	69.8

Non-parametric Mann-Whitney U tests were used to compare the estimates of the participants highest and lowest in dispositional optimism. The Mann-Whitney U values and the significance levels are detailed in tables 13-15. One-tailed tests were used throughout because the direction of difference was predicted – those highest in dispositional optimism were predicted to show the highest level of optimism bias (following Sharot et al. 2011). In the case of whether our participants thought that they personally would be affected by aspects of climate change, 6 out of 8 questions

yielded a significant effect (at the 0.05 level of significance) for level of dispositional optimism (highest versus lowest tertile), including the most general question ('What is the probability of you personally being affected by climate change'). In the case of their estimates of people living today, again 6 out of 8 questions yielded a significant effect for optimism level, again including the general question ('What proportion of people living today will be affected by climate change?'). In the case of their estimates of future generations, only 1 of the 8 questions revealed a significant effect for optimism level. It would seem that all of our participants, regardless of optimism level, were fairly pessimistic about the future. Our dispositional optimists were, however, much more optimistic about the present, as revealed by their answers throughout questions 1 and 2.

It has been argued that when multiple comparisons are carried out we increase the likelihood of incorrectly rejecting a null hypothesis (a Type 1 error) and consequently need to apply the Bonferroni correction. A ! next to the outcome of the test indicates whether the results are still significant when this correction is made. This procedure is considered very conservative. It yields a much smaller set of statistically significant results, which interestingly only now occur in response to Question 1. In other words, dispositional optimists differ from non-optimists only in terms of whether they think that they *personally* will be affected by climate change.

Table 13: Mann-Whitney U test comparing high optimists and low optimists (Question 1).

High Optimists v Low Optimists		
	Question	**Mann-Whitney U test**
Q1.1	What is the probability of you personally being affected by climate change?	U=90.5, p=0.031 (1-tailed)*
Q1.2	What is the probability of you personally being affected by severe drought because of climate change?	U=88.5, p=0.026 (1-tailed)*
Q1.3	What is the probability of you personally being affected by severe flooding because of climate change?	U=92.0, p=0.034 (1-tailed)*
Q1.4	What is the probability of you personally being affected by food shortages because of climate change?	U=110.5, p=0.123 (1-tailed)
Q1.5	What is the probability of you personally being affected by food shortages because of climate change?	U=111.5, p=0.130 (1-tailed)
Q1.6	What is the probability of you personally being affected by major conflict over natural resources because of climate change?	U=89.5, p=0.029 (1-tailed)*
Q1.7	What is the probability of you personally being affected by heat-related increased mortality because of climate change?	U=68.5, p=0.004 (1-tailed)*!
Q1.8	What is the probability of you personally suffering major disruption to your life because of climate change?	U=68.0, p=0.004 (1-tailed)*!

* represents a statistically significant result.

Table 14: Mann-Whitney U test statistical analyses comparing high optimists and low optimists (Question 2).

High Optimists v Low Optimists		
	Question	**Mann-Whitney U test**
Q 2.1	What proportion of people living today will be affected by climate change?	U=94.0, p=0.041 (1-tailed)*
Q 2.2	What proportion of people living today will be affected by severe drought because of climate change?	U=90.0, p=0.029 (1-tailed)*
Q 2.3	What proportion of people living today will be affected by severe flooding because of climate change?	U=94.0, p=0.041 (1-tailed)*
Q 2.4	What proportion of people living today will be affected by major threats to infrastructure because of climate change?	U=113.0, p=0.140 (1-tailed)
Q 2.5	What proportion of people living today will be affected by food shortages because of climate change?	U=116.0, p=0.166 (1-tailed)
Q 2.6	What proportion of people living today will be affected by major conflict over natural resources because of climate change?	U=86.5, p=0.022 (1-tailed)*
Q 2.7	What proportion of people living today will be affected by heat-related increased mortality because of climate change?	U=74.5, p=0.007 (1-tailed)*
Q 2.8	What proportion of people living today will suffer major disruption to their life because of climate change?	U=82.5, p=0.015 (1-tailed)*

* represents a statistically significant result

Table 15: Mann-Whitney U test statistical analyses comparing high optimists and low optimists (Question 3).

High Optimists v Low Optimists		
	Question	**Mann-Whitney U test**
Q 3.1	What proportion of future generations will be affected by climate change?	U=131.5, p=0.322 (1-tailed)
Q 3.2	What proportion of future generations will be affected by severe drought because of climate change?	U=101.5, p=0.069 (1-tailed)
Q 3.3	What proportion of future generations will be affected by severe flooding because of climate change?	U=90.5, p=0.029 (1-tailed)*
Q 3.4	What proportion of future generations will be affected by major threats to infrastructure because of climate change?	U=104.5, p=0.085 (1-tailed)
Q 3.5	What proportion of future generations will be affected by food shortages because of climate change?	U=112.0, p=0.133 (1-tailed)
Q 3.6	What proportion of future generations will be affected by major conflict over natural resources because of climate change?	U=286.0, p=0.350 (1-tailed)
Q 3.7	What proportion of future generations will be affected by heat-related increased mortality because of climate change?	U=124.5, p=0.249 (1-tailed)
Q 3.8	What proportion of future generations will suffer major disruption to their life because of climate change?	U=104.0, p=0.081 (1-tailed)

* represents a statistically significant result
! represents a statistically significant result after applying the Bonferroni correction.

Discussion

There is consternation amongst politicians, the CEOs of multinationals and major NGOs (including the IPCC) that many members of the public are not getting

the message about climate change. Many government campaigns, it would seem, have been largely ignored. There have been many attempts to explain this over the past few years, including Marshall (2015) who considers a wide range of possible explanations. One explanation that he considers is the well-known cognitive bias found in many aspects of life referred to as the 'optimism bias'. Many of us (estimated at around 80%) do apparently suffer from some form of this bias (Sharot 2012). We believe that our marriages will work (Baker and Emery 1993), our businesses will succeed (Bracha and Brown 2012), and that we will have a long and fulfilling life compared to everyone else (Weinstein 1980). This sort of unrealistic optimism would seem to be pervasive, affecting not just our personal relationships but also our attitudes to finance, work and health. It has also been found across a range of environmental issues (Gifford et al. 2009), as well as in estimates of the risk of health damage from specific environmental hazards, like water pollution (Pahl at al. 2005). Gifford et al. (2009) reported that individuals believe that across a number of environmental issues they are safer than others living elsewhere ('spatial bias') and that they are safer than future generations ('temporal bias'). Marshall (2015) attempts to use the concept of 'optimism bias' as an explanatory resource. If you think that climate change will not affect you personally, and that your own neighbourhood will be relatively safe, then there is less urgency in fundamentally changing your behaviour to mitigate the effects of climate change.

However, we took a somewhat different perspective on this issue. We began by recognising that optimism bias is a form of biased cognition, essentially the *product* of various social and cognitive processes (rather than an actual process per se). We attempted to determine what processes could potentially contribute to this type of bias. One plausible hypothesis is in terms of fundamental differences in

personality linked to dispositional optimism. It seems that optimists and pessimists differ in fundamental ways, for example, in terms of attributional reasoning (Seligman 2002), where we attribute causality to events, as well as (possibly) in terms of underling patterns of perception (Isaacowitz 2006). Both perception ('what') and attributional reasoning ('why') are critical steps in making sense of the world and in building a meaningful representation of events in it to mediate future action. According to Isaacowitz (2006) and Seligman (2002) optimists have distinct cognitive 'strategies', involving both attention and attributional reasoning, for staying optimistic. At the level of the individual this might be a very good thing because there is evidence that optimists live longer and healthier lives than pessimists (Harker and Keltner 2001; Seligman 2002), and consequently using a range of techniques (including CBT) people have been trained to become more optimistic. The question we asked was - does this have a downside? Do optimists and non-optimists process climate change messages differently in terms of patterns of fixations and can this be linked in any way to level of optimism bias?

We found that level of dispositional optimism does affect visual attention to climate change messages, containing arguments both 'for' and 'against' climate change. Optimists spent less time (overall dwell time) attending to any arguments about climate changes (either 'for' or 'against') with substantially shorter individual fixations on aspects of arguments *for* climate change, i.e. those that reflect the scientific consensus but are bad news. Previous research has shown that optimism bias derives partly from a failure to learn systematically from new undesirable information and that this bias is most pronounced with those highest in dispositional optimism (Sharot et al 2011). Other research has shown that dispositional optimists have an unconscious, automatic attentional bias to positive rather than negative

stimuli (Isaacowitz 2006). Our study suggests that this attentional bias might also apply when we present individuals with substantive messages about climate change. It also seems to affect what optimists and non-optimists recall from these messages. We found that when asked to summarise what they had read, non-optimists were more likely to frame their recall in terms of the arguments *for* climate change ('this article is about global warming and how 95% of it is due to human activity') with two thirds of their recalls being framed in this way. Optimists, on the other hand, were significantly more likely to frame it in terms of a debate between two opposing positions ('it's about climate change, about trying to understand what's happening with the weather and there are different points of view') with two thirds of them framing their recall as a debate.

This study suggests that many individuals are showing an attentional bias linked to maintaining their optimistic state when presented with climate change messages. We also found that those highest in dispositional optimism had the strongest and most pronounced optimism bias when it came to estimating the probability of climate change affecting them. For example, those participants lowest in dispositional optimism (i.e. the most pessimistic tertile) were approximately twice as likely as the most optimistic group (the highest tertile) to think that they would be personally be affected by climate change across the eight questions put to them on this topic. Our results suggested that all of our participants, regardless of optimism level, were relatively pessimistic about the *future*. Our dispositional optimists were, however, much less concerned about the present, and particularly about whether climate change would ever impact on them personally.

Optimism may have positive effects on our lives because underestimating the likelihood of future negative events can reduce our levels of stress and anxiety about

the future and add to our longevity. Many people, it seems, have developed cognitive strategies rooted in basic brain functioning that allows them to remain optimistic despite evidence to the contrary. The problem, however, is that some events really do need to be considered with great urgency and optimism bias can have very significant negative consequences particularly regarding the discounting of serious risk. Climate change is one such risk.

This experimental study opens up a number of new avenues of research. As is often the case in intensive experimental research of this type, it employed a comparatively small number of participants from fairly narrow cultural and economic backgrounds, but the question of the relationship between level of dispositional optimism and optimism bias could easily be explored in very large samples. In addition, it would be interesting to determine what differences in processing related to level of dispositional optimism emerge when different media are used to present the information (text compared with televison or film, news sources versus authored pieces), as well as how processing relates to the discursive organisation of the text itself (Potter and Wetherell 1986).

Notwithstanding these critical points, this study has a number of potential general implications. We cannot assume that members of the public are attending to messages about climate change in the same way (regardless of the source). The underlying messages may not be getting through because of inherent cognitive biases designed to sustain mood state. This new research suggests that we must pay some regard to these biases in designing our communicational strategies about climate change. It may well not be enough simply to publicise the scientific evidence about climate change (and the cataclysmic predictions for the future) without framing it in a more optimistic way to highlight the positive aspects of mitigation strategies

(Bardwell 1991; Davis 1995). A more positive overall frame highlighting possible solutions, interwoven throughout the message, should increase both feelings of self-efficacy and visual attention to the underlying message. Without this, we have the grave danger that many will selectively attend to the information that we are presenting, and ultimately show little behavioural adaptation or concern about the underlying issue.

There is something else that we might need to consider. For the past few decades, we have been striving to increase optimism particularly in Western societies because of its health benefits (through both positive psychology and a cultural emphasis on 'the power of positive thinking'). Some have argued that we have now managed to produce a profound socio-psychological change in Western societies with unrealistic expectations about the future (Ehrenreich 2009). Ehrenreich has argued that this has actually 'undermined preparedness' to deal with real threats like global terrorism, financial bubbles, or climate change, with the public having 'no ability or inclination to imagine the worst' (Ehrenreich 2009: 11). Optimism can be a very positive thing, but it clearly has its limits. Over-optimism can be very damaging indeed. Perhaps, it is time to re-evaluate this over-arching cultural focus and consider new ways to train the public to imagine worst case scenarios including climate change (whilst still allowing people to feel positive about the possibility of change). We clearly do need to simultaneously spell out things that people can do to mitigate the effects of climate change. That way the message is not uniformly negative, rather within it there are the elements of hope that many people crave.

We need to remember that for many human beings the regulation and maintenance of their positive mood state is a core part of how they process *any* message. They have developed a number of cognitive strategies to allow them to do

this. These strategies will be rooted in automatic processing (Kahneman 2011; Beattie 2012) so we need to think carefully about how to construct climate change warnings that can influence these fast, automatic processes. The general conclusion of this research, however, is very simple - we need *everybody* to see the clear and present danger of climate change, even though many people, it would seem, have developed ways to prevent this very thing happening. We need to be aware of this and redesign our communications appropriately. Then, and only then, will our messages get through.

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References

Arnett, Jeffery J .2000. Optimistic bias in adolescent and adult smokers and non-smokers. *Addictive Behaviours* 25. 625-632.

Baker, Lynn & Robert Emery. 1993. When every relationship is above average: Perceptions and expectations of divorce at the time of marriage. *Law and Human Behaviour* 17. 439-450.

Bardwell, L.V. 1991. Problem-framing: a perspective on environmental problem-solving. *Environmental Management* 15. 603-612

Barthes, Roland. 1957. *Mythologies.* Trans. Annette Lavers. New York: Hill.

Bartlett, Frederic C. 1932. *Remembering: An Experimental and Social Study.* Cambridge: Cambridge University Press.

Beattie, Geoffrey. 2010. *Why Aren't We Saving the Planet? A Psychologist's Perspective.* London: Routledge.

Beattie, Geoffrey. 2011. *Get the Edge: How Simple Changes Will Transform Your Life*. London: Headline.

Beattie, Geoffrey. 2012. *Our Racist Heart? An Exploration of Unconscious Prejudice in Everyday Life.* London: Routledge.

Beattie, Geoffrey. 2016. *Rethinking Body language*: *How Hand Movements Reveal Hidden Thoughts.* London: Routledge.

Beattie, Geoffrey & Kathy Doherty. 1995. "I saw what really happened" The discursive construction of victims and perpetrators in first-hand accounts of paramilitary violence in Northern Ireland. *Journal of Language and Social Psychology* 14. 408-433.

Beattie, Geoffrey & Laura McGuire. 2011. Are we too optimistic to bother saving the planet? The relationship between optimism, eye gaze and negative images of climate change. *The International Journal of Environmental, Cultural, Economic and Social Sustainability* 7. 241-256.

Beattie, Geoffrey & Laura McGuire. 2014. The psychology of consumption: or why we don't do what we say. In Ulph, A. and Southerton, D. *Sustainable Consumption: Multidisciplinary Perspectives*. London: Oxford University Press.

Beattie, Geoffrey, Laura McGuire & Laura Sale. 2010. Do we actually look at the carbon footprint of a product in the initial few seconds? An experimental analysis of unconscious eye movements. *International Journal of Environmental Cultural Economic and Social Sustainability* 6. 47–66.

Beattie, Geoffrey & Heather Shovelton. 1999a. Mapping the range of information contained in the iconic hand gestures that accompany spontaneous speech. *Journal of Language and Social Psychology* 18. 438-462.

Beattie, Geoffrey & Heather Shovelton. 1999b. Do iconic hand gestures really contribute anything to the semantic information conveyed by speech? An experimental investigation. *Semiotica* 123. 1-30.

Beattie, Geoffrey, & Laura Sale. 2009. Explicit and implicit attitudes to low and high carbon footprint products. *International Journal of Environmental, Cultural, Economic and Social Sustainability* 5. 191-206.

Beattie, Geoffrey, & Laura Sale. 2011. Shopping to save the planet? Implicit rather than explicit attitudes predict low carbon footprint consumer choice. *International Journal of Environmental Cultural Economic and Social Sustainability* 7. 211-232.

Bower, Gordon H. 1978. Experiments on story comprehension and recall. *Discourse Processes* 1. 211-231.

Bracha, Anat & Donald J. Brown. 2012. Affective decision making: A theory of optimism bias. *Games and Economic Behavior* 75. 67-80.

Bradley, Brendan. P., Karin Moog & Stacey C. Lee. 1997. Attentional biases for negative information in induced and naturally occurring dysphoria. *Behaviour Research and Therapy* 35. 911–927.

Bransford, John. D. & Jeffery. J. Franks. 1972. The abstraction of linguistic ideas: A review. *Cognition* 1. 211-249.

Buswell, Guy T. 1922. *Fundamental Reading Habits: A Study of their Development.* Chicago: University of Chicago Press.

Costa-Font, Joan, Elias Mossialos & Caroline Rudisill. 2009. Optimism and the perceptions of new risks. *Journal of Risk Research* 12. 27-41.

Davis, Joel J. 1995. The effects of message framing on response to envoronmental communications. *Journalism and Mass Communication Quarterly* 72. 285-299.

Department of Environment and Climate Change. 2010. Act on CO2. http://webarchive.nationalarchives.gov.uk/20101007164856/http:/actonco2.direct.gov.uk/home/about-us.html. Accessed 4th March 2016

Department for Environmental Food and Rural Affairs. 2007. *Step Forward on Reducing Climate Change Impacts of Products*. http://www.defra.gov.uk/news/2007/070530a.htm. Accessed 10th February 2016.

Edwards, Derek. 1997. *Discourse and Cognition*. London: Sage.

Edwards, Derek, Jonathan Potter & David Middleton. 1992. Toward a discursive psychology of remembering. *The Psychologist* 5. 441-446.

Ehrenreich, Barbara. 2009. *Bright-Sided: How the Relentless Promotion of Positive Thinking has Undermined America*. New York: Holt.

Elgaaied, Leila. 2012. Exploring the role of anticipated guilt on pro-environmental behavior-A suggested typology of residents in France based on their recycling patterns. *Journal of Consumer Marketing* 29. 369-377.

Fredrickson, Barbara L. & Christine Branigan. 2005. Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition & Emotion* 19. 313-332.

Gifford, Robert. 2011. The dragons of inaction. Psychological barriers that limit climate change mitigation. *American Psychologist* 66. 290-302.

Gifford, Robert, Leila Scannell, Christine Kormos, Lidia Smolova, Anders Biel, Stefan Boncu, Victor Corral, Kazunori Hanyu, Donald Hine, Florian G. Kaiser, Kalevi Korpela, Angela G. Mertig, Ricardo Garcia Mira, Gabriel Moser, Paola Passafaro, Luisa Pedroso, José Q. Pinheiro, Sunil Saini, Toshihiko Sako, Elena Sautkina, Yannick Savina, Peter Schmuck, Wesley Schultz, Karin Sobeck, Eva-Lotta Sundblad & David Uzzell. 2009. Temporal pessimism and spatial optimism in environmental assessments: An 18-nation survey. *Journal of Environmental Psychology* 29. 1-12

Harker, Lee Anne & Dacher Keltner. 2001. Expressions of positive emotion in women's college yearbook pictures and their relationship to personality and life outcomes across adulthood. *Journal of Personality and Social Psychology* 80. 112 - 124.

IPCC. 2015. *Climate Change 2014: Synthesis Report*. *Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* IPCC: Geneva, Switzerland.

Isaacowitz, Derek M. 2006. Motivated gaze. The view from the gazer. *Current Directions in Psychological Science* 15. 68-72.

Just, Marcel A. & Patricia A. Carpenter. 1976. Eye fixations and cognitive processes. *Cognitive Psychology* 8. 441-480.

Just, Marcel A. & Patricia A. Carpenter. 1980. A theory of reading: from eye fixations to comprehension. *Psychological Review* 87. 329-354.

Kaakinen, Johanna K. & Jukka Hyönä. 2005. Perspective effects on expository text comprehension: Evidence from think-aloud protocols, eyetracking, and recall. *Discourse Processes* 40. 239-257.

Kahneman, Daniel. 2011. *Thinking, Fast and Slow*. London: Macmillan.

Kellstedt, Paul, Sammy M. Zahran & Arnold Vedlitz. 2008. Personal efficacy, the information environment, and attitudes toward global warming and climate change in the United States. *Risk Analysis* 28. 113-126.

Kretzschmar, Franziska, Dominique Pleimling, Jana Hosemann, Stephan Füssel, Ina Bornkessel-Schlesewsky & Matthias Schlesewsky. 2013. Subjective impressions do not mirror online reading effort: Concurrent EEG-eyetracking evidence from the reading of books and digital media. *PloS One* 8. e56178.

Leahy, Terry. 2007. *Tesco, Carbon and the Consumer*. www.tesco.com/climatechange/speech.asp. Accessed 5th March 2016.

Luo, Jiang & Derek M. Isaacowitz. 2007. How optimists face skin cancer information: Risk assessment, attention, memory, and behavior. *Psychology and Health* 22. 963-984.

Marshall, Peter. 2015. *Nature's Web: Rethinking our Place on Earth*. London: Routledge.

Mathews, Andrew & Colin MacLeod. 2002. Induced processing biases have causal effects on anxiety. Cognition and Emotion 16. 331-354.

Matin, Ethel. 1974. Saccadic suppression: a review and an analysis. *Psychological Bulletin* 81. 899-917.

McGuire, Laura & Geoffrey Beattie. In press. Consumers and climate change: Can the presence of others promote more sustainable consumer choice? *International Journal of Environmental, Cultural, Economic & Social Sustainability*.

Mosing, Miriam A., Brendan P. Zietsch, Sri N. Shekar, Margaret J. Wright & Nicolas G. Martin. 2009. Genetic and environmental influences on optimism and its relationship to mental and self-rated health: A study of aging twins. *Behavioural Genetics* 39. 597-604.

Oreskes, Naomi & Erik M. Conway. 2010. *Merchants of Doubt.* New York: Bloomsbury Press.

Pahl, Sabbine, Peter R. Harris, Helen A. Todd, H.A. & Derek R. Rutter, D.R. 2005. Comparative optimism for environmental risks. *Journal of Environmental Psychology* 25. 1-11.

Potter, Jonathan & Wetherell, Margaret. 1986. *Discourse and Social Psychology: Beyond Attitudes and Behaviour*. London: Sage.

Power, Nicola, Geoffrey Beattie & Laura McGuire. In press. Mapping our underlying cognitions and emotions about good environmental behaviour. Why we fail to act despite the best of intentions. *Semiotica*.

Rayner, Keith, Arnold D. Well, Alexander Pollatsek & James H. Bertera. 1982. The availability of useful information to the right of fixation in reading. *Perception & Psychophysics* 31. 537-550.

Rayner, Keith. 1978. Eye movements in reading and information processing. *Psychological Bulletin* 85. 618-660.

Rayner, Keith. 1998. Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin* 124. 372-422.

Rayner, Keith. 2009. Eye movements and attention in reading, scene perception, and visual search. The *Quarterly Journal of Experimental Psychology* 62. 1457-1506.

Rayner, Keith, Alexander Pollatsek, Jane Ashby & Charles Clifton. 2012. *Psychology of Reading*. London: Psychology Press.

Scheier, Michael F., Karen A. Matthews, Jane F. Owens, George J. Magovern, R. Craig Lefebvre, R. Anne Abbott & Charles S. Carver. 1989. Dispositional optimism and recovery from coronary artery bypass surgery: The beneficial effects on physical and psychological well-being. *Journal of Personality and Social Psychology* 57. 1024-1040

Schulz, Richard, Jamila Bookwala, Judith E. Knapp, Michael Scheier & Gail M. Williamson. 1996. Pessimism, age and cancer mortality. *Psychology and Aging* 11. 304-309

Segerstrom, Suzanne C. 2001. Optimism and attentional bias for negative and positive stimuli. *Personality and Social Psychology Bulletin* 27. 1334-1343.

Segerstrom, Suzanne C., Shelley E. Taylor, Margaret E. Kemeny & John L. Fahey. 1998. Optimism is associated with mood, coping and immune change in response to stress. *Journal of Personality and Social Psychology* 74. 1646-1655.

Seligman, Martin. 2002. *Authentic Happiness. Using the New Positive Psychology to Realize Your Potential for Lasting Fulfilment*. New York: Free Press.

Sharot, Tali. 2011. The optimism bias. *Current Biology* 21. 941-945.

Sharot, Tali. 2012. The Optimism Bias. *Why We're Wired to Look on the Bright Side*. London: Constable & Robinson.

Sharot, Tali, Christoph W. Kom & Raymond J. Dolan. 2011. How unrealistic optimism is maintained in the face of reality. *Nature Neuroscience* 14. 1475-1479.

Shiller, Robert. 2000. *Irrational Exuberance*. Princeton: Princeton University Press.

Stocker, Thomas. F., Dahe Qin, Gian-Kasper Plattner, Melinda Tignor, Simon K. Allen, Judith Boschung & Pauline. M. Midgley. 2014. IPCC, 2014: Climate Change 2014: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Storbeck, Justin & Gerald L. Clore. 2005. With sadness comes accuracy; with happiness, false memory mood and the false memory effect. *Psychological Science* 16. 785-791.

Taylor, Shelley. 1998. The MacArthur Research Network on Socioeconomic Status and Health http://www.macses.ucsf.edu/research/psychosocial/optimism Accessed 2nd March 2016

Ulph, Alistair & Southerton, Dale, eds. 2014. *Sustainable Consumption: Multi-disciplinary Perspectives in Honour of Professor Sir Partha Dasgupta*. London: Oxford University Press.

Unilever. 2013. Unilever Sustainability Plan. http://www.unilever.com.tw/Images/slp_Unilever-Sustainable-Living-Plan-2013_tcm13-388693_tcm206-395956.pdf accessed 26th January 2016

Wall, Rob, Patrick Devine-Wright & Greig A. Mill. 2007. Comparing and combining theories to explain pro-environmental intentions. *Environment and Behavior* 39. 731-753.

Weinstein, Neil D. 1980. Unrealistic optimism about future life events. *Journal of Personality and Social Psychology* 39. 806-820.

Wegener, Michael. 1994. Operational urban models state of the art. *Journal of the American Planning Association* 60. 17-29.

World Wildlife Fund. 2008. *Stop Climate Change Before it Changes You*. http://www.wwf.org.uk/. Accessed 7the March 2016.

Xing, Cai & Derek M. Isaacowitz. 2006. Aiming at happiness: How motivation affects attention to and memory for emotional images. *Motivation and Emotion* 30. 243-250.

Yang, Janet Z. & Lee Ann Kahlor. 2012. What, me worry? The role of affect in information seeking and avoidance. *Science Communication* 35. 189–212.

Yarbus, Alfred L. 1967. *Eye movements during perception of complex objects*. New York: Plenum Press.

Suplimentary Material

There has been a lot of heated discussion lately of the role of human beings in climate change. Climate change sceptics argue that even if the planet is warming up, it is not clear that it is because of human behaviour. They point out errors in previous United Nations IPCC reports and accuse the global warming 'industry' of ratcheting up the risks of climate change, which have subsequently led to the cripplingly expensive introduction of green energy policies.

But the arguments that climate change is caused by humans are considered by many to be convincing. The latest United Nations IPCC report, published in 2014, confirms that climate scientists appear more certain than ever before that human behaviour is the key culprit for global warming. Based on all scientific evidence, the report concluded it was 95% likely that the rise in global temperatures were due to human activity, such as greenhouse gas emissions and deforestation.

Previous IPCC reports on climate impact have been plagued by errors that have damaged the body's credibility. Most famously, in the 2007 report, it said that glaciers in the Himalayas could disappear by 2035, a claim it has since withdrawn. One reason for errors in the IPCC reports could be the over-reliance on computer models of predicted data, rather than on physical science.

The recent IPCC report raised the threat of climate change to a whole new level - based on new scientific evidence - warning of sweeping consequences to life and livelihood. The report concluded climate change is already having detrimental effects – melting sea ice in the Arctic, killing off coral reefs in the oceans, and leading to heat waves, heavy rains and mega-disasters. And the worst was yet to come.

But sceptics say almost every global environmental scare of the past half century has been exaggerated - from the population "bomb," pesticides and acid rain, to the ozone hole, genetically engineered crops and killer bees. In every case, sceptics argue, scientists gain a lot of funding from these scares and before quietly agreeing that the problem wasn't that bad; global warming is no different.

Climate scientists say this is irrelevant. The good news from the IPCC report is that many of consequences of climate change can be reduced by cutting greenhouse gas emissions. The IPCC report states with high confidence that risks associated with rising global temperatures – such as water scarcity, sea-level rise, heat waves, and floods - can be reduced by cutting human greenhouse gas emissions.

The recent United Nations IPCC report on climate change stated extreme weather patterns, including a higher risk of flooding, are a consequence of rising greenhouse gas emissions - with Europe, Asia and small island states highlighted as being particularly vulnerable. An author of the latest IPCC report warned, “Britain should brace itself for a rise in floods, heatwaves and coastal storms. The UK is likely to face a growing number of extreme weather events as a result of global warming”.

However, attributing extreme weather events to human influence is only an emerging area of research, and is acknowledged by climate scientists to be extremely challenging. Computer models used to explore the impacts of different levels of greenhouse gases are weaker on rainfall than on temperature. For example, “Climate and weather is an extraordinarily complex new form of science. I don’t blame the climate scientists for not knowing the answers”, said one senior politician.

But some do clearly believe that the flooding experienced in England this winter was a consequence of climate change. "What we've seen this winter with the floods is consistent with what we would expect to see in a changing climate," said an leading academic. “The floods in Britain, and other weather-related disasters on Earth, are clear indications of the effects of global warming caused by the uncontrolled burning of fossil fuels”.

Yet, others insist that there is no link between the storms that have battered England this winter and global warming. The UK Environment Secretary did not say whether the the winter floods were caused by climate change. This argument is supported by a UK academic who said, “Scientists just don’t know whether the persistence of the rainfall this winter was due to climate change or not”.

But, the record rainfall and storms that caused flooding this winter could be part of a trend of unprecedented extreme weather caused by global warming according to some senior scientists. Four of the five wettest years recorded in the UK occurred in the past 14 years. Over that same period, the UK also had the seven warmest years.

But a major factor of the extreme weather this winter was the position of the jet stream. A Met Office expert said, “There is no evidence that global warming can cause the jet stream to get stuck in the way it has this past winter. If this is due to climate change, it is outside scientific knowledge.” Indeed, the recent IPCC report did not mention that climate change had any effect on the jet stream getting stuck.

The recent United Nations IPCC report on climate change drew a clear line connecting climate change to food scarcity, and conflict. The report states that climate change will indirectly increase the risk of violent conflict, by increasing hunger and fight over resources. The leader of the World Bank agrees, “Fights over water and food will erupt in the next 5-10 years as a result of climate change.” But, not all agree with the IPCC’s conclusion. “There is no evidence that global warming directly increases conflict. The causes of conflict are primarily political and economic, not climatic. Warlords may exploit draught, flooding, starvation, or agricultural disasters. What drives their fight is not the rain, the temperature, or the sea level - but power, territory, and money” says one leading academic.

This recent IPCC report, however, highlights that climate change had already cut into the global food supply. Global crop yields were beginning to decline – especially for wheat – raising doubts as to whether production could keep up with population growth. Under some scenarios, the report said, climate change could lead to dramatic drops in global wheat production as well as reductions in maize.

But contradictory evidence is also available. For example, the recent United Nations IPCC report also states that northern parts of Asia will benefit from global warming, resulting in increased production of wheat and other cereals. Furthermore, satellites have recorded a 14% increase in greenery on the planet in the past 30 years, partially because of greater greenhouse gas emissions, which enable plants to grow faster and use less water.

Some governments are taking this seriously and have started to investigate the national security implications of climate change. The US Defence Department has called climate change a 'threat multiplier' that could increase the risk of military conflict. Climate-induced crises, such as drought and mass migration, could topple governments, bolster terrorist movements and destabilise regions.

However, resource scarcity might encourage cooperation. “When people face climate dangers or scarcity, they may decide to fight, but similarly they may decide to co-operate. For example, a consequence of the 2004 ‘Boxing Day’ tsunami in Southeast Asia was greater cooperation among states and peace in Aceh,” said a university researcher.