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Determinants and Measurement of Climate Change Risk Perception, Worry, and Concern

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Summary and Keywords

Individuals, both within and between different countries, vary substantially in the extent to which they view climate change as a risk. What could explain such variation in climate change risk perception around the world? Climate change is relatively unique as a risk in the sense that it is difficult for people to experience directly or even detect on a purely perceptual or sensory level. In fact, research across the social and behavioral sciences has shown that although people might correctly perceive some changes in long-term climate conditions, psychological factors are often much more influential in determining how the public perceives the risk of climate change. Indeed, decades of research has shown that cognitive, affective, social, and cultural factors all greatly influence the public's perception of risk, and that these factors, in turn, often interact with each other in complex ways. Yet, although a wide variety of cognitive, experiential, socio-cultural and demographic characteristics have all proven to be relevant, are there certain factors that systematically stand out in explaining and predicting climate change risk perception around the world? And even if so, what do we mean, exactly, by the term "risk perception" and to what extent does the way in which risk perception is measured influence the outcome? Last but certainly not least, how important is public concern about climate change in determining people's level of behavioral engagement and policy-support for the issue?

Keywords: risk perception, climate change, global warming, worry, concern, public opinion

The Nature of Human Risk Perception

> *Risk does not exist independent of our minds and culture*.
>
> — Paul Slovic (1992, p. 690)

The perception of risk is a mental construct (Sjöberg, 2000a) and human perception is rather unique in the sense that it allows for a differentiation between the existence of objective real-world threats, such as climate change, and the subjective perceptual evaluation of those threats (Rosa, 2003). For example, although climate change is one of the greatest existential threats to life on earth, risk judgments of global warming vary greatly from one individual to another (e.g., Hine et al., 2013; Maibach et al., 2011; Metag, Füchslin, & Schäfer, 2015; Whitmarsh, 2011).

Furthermore, there is considerable cross-cultural variation in both the intensity of collective public concern as well as general willingness to address the issue (Bord, Fisher, & Robert, 1998; Brechin & Bhandari, 2011; Capstick et al., 2015 Howe et al., 2015; Kim & Wolinsky-Nahmias, 2014; Leiserowitz, 2007; Lee et al., 2015). For example, many large-scale reviews and analyses of public opinion polls have shown that climate change has consistently been perceived as a "very serious" problem in the United Kingdom, Australia, and most of continental Europe (e.g., Bord et al., 1998; Lorenzoni & Pidgeon, 2006; Pidgeon, 2012; Reser et al., 2012) whereas concern, while waxing and waning, has traditionally been lower in countries such as the United States, China, and Russia (e.g., Brechin & Bhandari, 2011; Lee et al., 2015; Leiserowitz, 2007).

Another relatively stable trend is that compared to many developed countries, climate change is generally perceived as a much greater risk in most of the developing world (Kim & Wolinsky-Nahmias, 2014; Lee et al., 2015; Leiserowitz, 2007). Last but not least, although overall "awareness" and "concern" about climate change has generally increased around the globe over the last quarter century (Capstick et al., 2015; Moser, 2010), the public still ranks climate change as a low priority compared to many other societal issues, such as terrorism, health care, and the economy (Lorenzoni & Pidgeon, 2006; Nisbet & Myers, 2007; Motel, 2014). This low sense of urgency is partly due to the fact that climate change is an abstract statistical concept that refers to long-term changes in the variability of the earth's climate (Weber, 2010). Unlike most ecological risks humans have been exposed to for millions of years, human-caused climate change is unique: it is global in nature and stretches over centuries (Breakwell, 2010). Moreover, the slow-moving, cumulative, and unsituated nature of climate change makes it not only evolutionarily novel (van Vugt, Griskevicius, & Schultz, 2014) but also difficult to directly perceive and experience for people (Weber, 2010; Whitmarsh, 2008a). These characteristics are important to understand because the subjective psychological nature of risk perception is exactly what allows for substantial heterogeneity to exist across individuals and nations.

Accordingly, the quantity of social and behavioral science research exploring what factors shape public perceptions of climate change has increased exponentially over the last

decade (Moser, 2010; Weber, 2016). The goal of this chapter is to put the field's intellectual history in perspective as well as structure, organize, and synthesize the weight of evidence on three important questions: (a) what social, psychological, cultural, political, and physical factors have shown to consistently explain and predict public risk perceptions of climate change around the world? (b) to what extent do these results hinge upon how "risk perception" is measured and operationalized in the first place? and (c) what is the evidence for a relationship between risk perception and concern about climate change on one hand, and individual behavior change on the other, including public support for climate change adaptation and mitigation policies?

The Factors That Shape Climate Change Risk Perception Around the World

The study of risk perception grew out of the observation that when it comes to assessing many technological and natural hazards, the views of the lay public often seem to diverge (quite sharply) from expert assessments (Slovic, Fischhoff, & Lichtenstein, 1982; Starr, 1969). For many researchers, this divergence was both interesting and puzzling and inspired the study of how people construe their mental representations of risks. Climate change is a perfect case in point. For example, although many independent studies have shown that over 97% of climate scientists agree that human-caused climate change is happening (e.g., Anderegg et al., 2010; Cook et al., 2016; Powell, 2016), only about half of Americans share this belief (Leiserowitz et al., 2016).

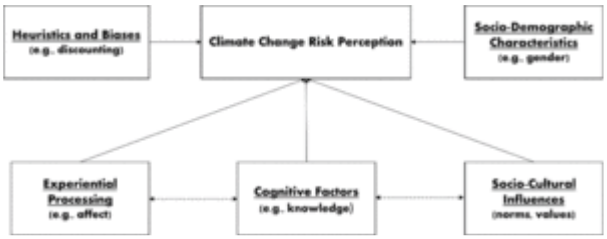
Fueled by the discovery of a number of cognitive heuristics people seem to use to navigate an uncertain world, much early risk perception research was rooted in an area of cognitive psychology known as "judgment and decision-making" (Kahneman, Slovic, & Tversky, 1982). Specifically, the so-called "psychometric paradigm" pioneered the process of identifying explanatory factors in risk perception (Slovic, 1987). Yet, following the cognitive revolution, scholars increasingly began to criticize the overly "cognitive" approach to the study of risk by highlighting the neglected yet important role of emotions in shaping risk judgments. This development led to the conclusion that how people *feel* about a particular risk often has a (more) powerful influence on their thinking (Loewenstein et al., 2001; Slovic et al., 2004). Since then, so-called "dual-process" theories have postulated that people comprehend risks in two fundamentally different ways; analytically and experientially, and although these are often referred to as "two separate modes of thinking," they often operate in parallel (Chaiken & Trope, 1999; Epstein, 1994; Kahneman, 2011; Marx et al., 2007; Sloman, 1996; van der Linden, 2014A).

The still predominantly “psychological” approach to studying risk was later criticized, most notably by cultural anthropologist Mary Douglas and political scientist Aaron Wildavsky, for neglecting the larger social, cultural, and political context in which risks are framed and debated, and for depoliticizing the nature of risk. In other words, the perception of risk was not solely to be seen as a matter of individual cognition and emotion but also a function of deeply held worldviews and values about society and its structural organization and functioning (Dake, 1992; Douglas & Wildavsky, 1982). This development led to a third revolution in the study of risk perception, which is currently still enjoying support through frameworks such as the Social Amplification of Risk (Kasperson et al., 1988) and the Cultural Cognition Thesis—which aims to combine aspects of the psychometric paradigm with the cultural theory of risk (Kahan, 2012).

All of these approaches have left a deep mark on the climate change risk perception literature and although some attempts have been made to combine various schools of thought (e.g., see Leiserowitz, 2006), when assessing the risk perception literature as a whole, a severe lack of theoretical integration has been noted, with many of the aforementioned dimensions often being assessed independently of each other (Wählberg, 2001; van der Linden, 2015a). In some sense, the field has become more theoretically contested (Moser, 2016) with scholars disagreeing on the various approaches to the study of risk perception (van der Linden, 2016a).

This complicates the process of “surveying the field.” To help advance and promote further theoretical development in the literature, van der Linden (2015a) proposed an integrated theory of risk perception that combines four key theoretical dimensions to maximize explanatory power; “cognitive,” “experiential,” “socio-cultural” and “socio-demographic” factors, also known as the “Climate Change Risk Perception Model” (CCRPM). Empirically, these factors explained about 70% of the variation in risk perception, which may well approximate the ceiling of the explanatory power of risk perception models (Sjöberg, 2002). Accordingly, the framework is adopted here to help organize, structure, and assess the empirical evidence for each of the major dimensions that have shown to influence risk perceptions of climate change. The original formulation of the Climate Change Risk Perception Model (CCRPM) included a fifth dimension, entitled; “heuristics and biases” (Helgeson, van der Linden, & Chabay, 2012). This dimension was later dropped from the model mainly for parsimony, as many heuristics could reasonably be subsumed under one of the existing categories, but given the large amount of heuristics and biases that have shown to influence global warming risk perception in recent years, it warrants a separate discussion and I therefore reintroduce the fifth dimension here for completeness.

A conceptual representation of the model is provided in Figure 1. Note that these five dimensions are not necessarily assumed to be independent, as will become clear from the review, they can often be expected to interact in complex ways. For example, cognitive and affective factors have shown to dynamically interact in shaping climate change risk perception (Marx et al., 2007; van der Linden, 2014A). Additionally, the influence of socio-demographic characteristics on risk perception and the use of heuristics and biases may be conditional on cultural, affective, and cognitive factors. Thus, although Figure 1 is a simplified representation of reality, it will be useful in organizing and synthesizing the risk perception literature.



Click to view larger

Figure 1. Climate Change Risk Perception Model adopted from van der Linden (2015A).

Cognitive Factors

The assumption that the public simply does not have enough information to accurately evaluate societal risks has dominated the risk communication field for many years. According to this view, if scientists would do a better job at explaining and communicating climate science, then perhaps the public would be more concerned about the issue. In the last two decades, the so-called “knowledge deficit” model of public attitudes towards science has received fierce criticism (Sturgis & Allum, 2004), so much so that polarization between “proponents” and “opponents” of education-based approaches has increased substantially (Ranney & Clark, 2016). Yet, this dichotomy is somewhat misleading. For example, what is meant by “knowledge” is often left undefined and the wholesale dismissal of “knowledge” as a driver of risk perception begs the age-old question of whether or not “cognition” is a necessary prerequisite for judgment formation (Lai, Hagoort, & Casasanto, 2012). In other words, if one has no basic awareness of the climate change problem, then how can a judgment about the issue be formed? Formally, risk assessment is usually thought of as the product of two properties, namely; (a) the probability with which an adverse event (e.g., climate change) is likely to occur and (b) the severity of the negative consequences associated with that event (e.g., death, damages). Thus, if the public understands that climate change is occurring, caused by

humans, and has negative consequences, they should (in theory) be concerned about the issue. Yet, while varying substantially, deeper public understanding of climate change around the world remains limited and is often rooted in influential misperceptions (Bord et al., 1998; Brechin, 2003; Leiserowitz, 2007; Weber & Stern, 2011). Climate literacy is especially low in the United States (e.g., Leiserowitz, Smith, & Marlon, 2010) while substantially less is presently known about public understanding of climate change in the non-Western world (Capstick et al., 2015).

Much early work on climate cognition was trying to understand the way in which individuals process, classify, and organize new information, the study of so-called "mental models," that is, people's intuitive and contextual understanding of how something works (Kearney & Kaplan, 1997; Morgan et al., 2002). This line of research revealed that people often have difficulty understanding the physical mechanisms underlying global climate change, are unaware of the prevailing scientific consensus, and confuse climate change with other environmental issues or hold misperceptions about the type of actions that are effective in helping to reduce climate change (e.g., Bord et al., 1998; Bostrom et al., 1994; Kempton, 1991; Nisbet & Myers, 2007; Read et al., 1994; Sterman & Booth Sweeney, 2007; Sterman, 2008; Whitmarsh, 2009).

Although public awareness has generally increased since then (Capstick et al., 2015), many of these deeper misperceptions continue to persist (e.g., see Brechin, 2003; Ranney & Clark, 2016; Reynolds et al., 2010). When it comes to investing scarce resources in public education about climate change, perhaps the more prudent and difficult question to answer is how *important* cognitive knowledge about climate change is in shaping public risk perception?

The answer, in part, depends on the method that is used to gauge the public's "knowledge" and understanding of climate change (Roser-Renouf & Nisbet, 2008; van der Linden, 2015a). For example, there is a notable and important difference between an individual's subjective self-assessment of how much they *believe* they know about climate change, and the actual level of correct knowledge people hold about the issue. Studies using single-item measures, such as, "How much do you feel you know about global warming?" have reported mixed results. For instance, Kellstedt et al. (2008) found that knowledge is largely unrelated to concern. In contrast, Heath and Gifford (2006) report a positive link whereas Malka, Krosnick, and Langer (2009) conclude that the knowledge-concern relationship may be moderated by political ideology.

Although global self-assessments may sometimes provide a crude estimate of a latent psychological disposition (van der Linden & Rosenthal, 2016), subjective, self-reported climate knowledge measures are generally deemed unreliable (Roser-Renouf & Nisbet,

2008) and often prove inconsistent with more objective assessments (Hornsey et al., 2016; Shi et al., 2016).

For example, Guy et al. (2014) found—using objective measures—that greater knowledge actually attenuates the (negative) effect of ideological worldviews, resulting in a positive relationship between more knowledge about climate change and public concern.

More generally, research that has attempted to objectively score and assess how much people know about climate change typically finds a significant positive relationship between more accurate knowledge about climate change and public risk perception (Hidalgo & Pisano, 2010; Milfont, 2012; O'Connor, Bord, & Fisher, 1999; Sundblad et al., 2007; Shi et al., 2016; van der Linden, 2015A).[1] To further deconstruct the role of knowledge in risk perception, scholars have proposed a conceptual distinction between three different types of knowledge, including (declarative) knowledge about the *causes* and physical mechanisms underlying climate change, knowledge about the *impacts* and consequences of climate change, and (procedural) knowledge about how to respond and implement potential *solutions* (Tobler et al., 2012; van der Linden, 2015A). In fact, a number of recent large-scale studies have shed new and important light on the role of knowledge as a predictor of risk perception. For example, in an unprecedented analysis of 119 countries, Lee et al. (2015) find that both educational attainment and the understanding that climate change is *human-caused* are important predictors of public risk perception worldwide. Similarly, in another large study, Shi et al. (2016) find that across three continents, different forms of climate knowledge are significant predictors of climate change risk perception.

Although the weight of evidence is clearly in favor of a positive association between knowledge about climate change and public concern, a logical next question is whether it is possible to quantify how *much* knowledge matters? In an attempt to partition out the unique variance explained by different forms of objective climate knowledge (while controlling for other key constructs, such as norms and values), van der Linden (2015A) estimates that knowledge about climate change explains roughly 10% of the variance in public concern about climate change. In a cross-cultural follow-up study, Shi et al. (2016) place this estimate between 2% and 18%, thus, there may be significant cross-cultural variation in how much knowledge contributes (Lee et al., 2015; Shi et al., 2016). Overall, a recent meta-analysis synthesizing 171 studies across 56 nations revealed that objective knowledge shares a small to medium correlation with climate beliefs ($r = 0.25$), explaining about 6.5% of the variance (Hornsey et al., 2016).

In conclusion, knowledge is likely a *necessary* but clearly not sufficient condition for public concern. Having said this, it is reasonable to hypothesize that some forms of

knowledge may be more important than others (Kaiser & Fuhrer, 2003). Indeed, not all types of knowledge about climate change exert an equal amount of influence on risk perception (Shi et al., 2016; van der Linden, 2015A). To illustrate, perhaps better procedural knowledge of what actions people can take to help reduce climate change is most pressing (van der Linden, 2015A). On the other hand, understanding the human causes of climate change is often a prerequisite for accepting the need for mitigatory action in the first place (Guy et al., 2014; Lee et al., 2015). Accordingly, the potential synergy between these different forms of climate knowledge should not be neglected or underestimated (Kaiser & Fuhrer, 2003; van der Linden, 2015A). In short, researchers interested in studying the role of climate knowledge in public risk perception are advised to take note of these conceptual distinctions and implement objective assessments whenever possible.

Experiential Processing

Negative Affect

In addition to holding cognitive knowledge about a particular risk, people frequently experience risks in affective and emotional terms as well. In fact, the "*risk-as-feelings*" hypothesis suggests that when cognitive and affective risk judgments diverge, affective reactions are often more dominant in processing (Loewenstein et al., 2001). Early research in affective neuroscience postulated that over time, through learning and experience, people's mental representations of objects and events become "tagged" with affective associations that guide subsequent judgment formation. These instantaneous and evaluative judgments of things people like, dislike, find positive or negative are known as "somatic markers" (Damasio, 1994). Closely associated with a risk-factor known as "dread," this later formed the basis of what has become widely known as the "affect-heuristic" (Slovic et al., 2004, 2007). In particular, people often rely on what is called an "affective pool," which essentially includes all the positive and negative associations that people hold in memory with respect to a given risk object (Breakwell, 2010).

Yet, at the same time, some conceptual confusion over the meaning of the term "affect" has led to a notable debate in the risk perception literature (e.g., see van der Pligt et al., 1998; Wardman, 2006). For example, the concept of "affect" is theoretically distinct from other, more discrete types of emotions such as fear or worry. Instead, affect is generally described as a quick associative judgment or a "faint whisper of emotion" (Slovic & Peters, 2006). Other scholars have noted that this definition is analogous to what is

generally considered to be the evaluative component of an individual's attitude. In fact, the concept of "attitude" has traditionally been defined as "the *affect* for or against a psychological object" (Thurstone, 1931, p. 261).

Sjöberg has argued that if "affect" reflects an "attitude" and if "affect" is often falsely equated in the literature with the term "emotion," then we would mistakenly assume that "emotions" play a crucial role in risk perception (Sjöberg, 2006). In addition, the operational validity of the affect-heuristic and the explanatory power of the "dread" factor in risk perception have both been questioned (e.g., Sjöberg, 2006, 2007). For example, while negative affect is often inferred from self-reports in surveys, some implicit association tests have revealed that affective judgments correlate more strongly with explicit attitudes rather than quick associative reactions to stimuli (Townsend, Spence, & Knowles, 2014). Other research has questioned the structure of the "risk-as-feelings" model (Kobbeltved et al., 2005) and has suggested that some dimensions of the "affect-heuristic," e.g., the good-or-badness of an object (Slovic et al., 2007) likely conflates affective with moral judgments (van der Linden, 2015A), at least to the extent that one is interested in affective and not affective-based moral judgments (Roeser, 2009).

Nonetheless, it should be stressed that some of these conceptual objections, while valid, do not weigh up against the depth and breadth of empirical evidence that has documented the critical function of emotion in risk perception (Finucane, 2012; Wardman, 2006). For example, pioneering research examining global warming "affective imagery" finds that the first thing that comes to mind for most people when thinking about global warming are bleak and negative associations related to the impacts of climate change (Leiserowitz, 2006; Leviston et al., 2014; Lorenzoni et al., 2006; Smith & Leiserowitz, 2012). Accordingly, affective imagery and holistic negative affect have both shown to be important predictors of global warming risk perception (Leiserowitz, 2006; Smith & Leiserowitz, 2012; Sundblad et al., 2007; van der Linden, 2015A). In fact, explaining about 20%–30% of the variance by itself, negative affect often emerges as one of the single most important determinants of global warming risk perception (Leiserowitz, 2006; van der Linden, 2015A). Having said this, there is a much needed but notable lack of research exploring the affective basis of concern about global warming in the non-Western world.

A final issue concerns the conceptual relationship between "affect" and "cognition," which is particularly important to the context of climate change. A large body of converging research across social, cognitive, and clinical psychology has pointed towards a complex "dual" or "parallel" process relationship between cognition and affect, suggesting that the human brain processes information about risks in two fundamentally different ways, with one system being slower, conscious, analytical, and rule-based, whereas the other is faster, unconscious, associative, and automatic (Chaiken & Trope,

1999; Epstein, 1994; Kahneman, 2011; Loewenstein et al., 2001; Marx et al., 2007; Pessoa, 2008; Sloman, 1996).[2]

The primacy of "affect" as an independent force in shaping (risk) judgments has been debated at length in psychology (Clore & Ortony, 2000; Lazarus, 1984; Loewenstein et al., 2001; Zajonc, 1984), and although the human brain is fast and experienced in mapping environmental cues directly into affective responses (Weber, 2006), it is increasingly recognized that the "primacy" of affect versus cognition is context-dependent (Lai, Hagoort, & Casasanto, 2012). For example, because the risk of climate change does not automatically trigger the brain's "affective" system (Weber, 2006), some cognitive mediation is likely to occur. In other words, while the public may personally experience the *impacts* of global warming, in order for people to form negative affective judgments about climate change, such personal experiences need to be mentally associated with climate change (Weber, 2010; van der Linden, 2014A). Accordingly, research has started to reveal how the dynamic bi-directional relationship between cognitive and affective processes shape public risk perceptions of global warming (van der Linden, 2014A).

This raises some important questions about the conceptual relationship between "affect" and "risk perception." In particular, it suggests that modeling affect solely as a determinant of risk perception (and not risk perception also as a determinant of affect), may fail to specify the true nature of the relationship between affect and cognition (Jackson, Allum, & Gaskell, 2006). This issue is not particular to risk researchers, linear models and linear thinking is widespread throughout the social sciences, but as tools are being developed to allow for more complex, dynamic, and accurate representations of reality, future research would be well-advised to focus on the link between cognition and emotion in shaping global warming risk judgments. For example, it remains unclear whether exposing people to vicarious imagery about global warming activates neural substrates related to affective-based information processing, and, moreover, to what extent such activation interacts with, or is mediated by, cognitive processes. With new technological advances such as virtual reality simulations of climate change impacts (Zaalberg & Midden, 2013) and emerging fields such as "communication neuroscience" (Berkman & Falk, 2013), such integrated methodologies may become increasingly accessible to social scientists.

Personal Experience

Akerlof et al. (2013) ask a crucial question; "Do people 'personally experience' global warming, and if so, how, and does it matter?" Although experience can be a powerful teacher, this is a difficult question to answer. From an indirect point of view, the answer

would appear “yes,” as it is through personal experiences that people form affective associations, and affective judgments of future risks largely depend on the vividness with which negative impacts can be imagined (Damasio, 1994; Risen & Critcher, 2011; Weber, 2006). Whether personal experience with climate change also has a direct impact on global warming risk perception has become a source of debate and somewhat hinges upon how “personal experience” is defined and measured.

As the literature and methodologies available to researchers examining this question has grown over the years, it is useful to introduce a conceptual distinction between “detection of environmental change” and personal experiences with “extreme weather.” A common sense assumption among many climate scientists has been that as the average global temperature continues to rise, people will eventually “catch on.” Yet, perceptual detection of global warming is difficult because people only experience highly variable local weather patterns, which are not always reflective of long-terms trends in the earth’s climate (Pawlik, 1991). Nonetheless, in a large study covering 89 countries, Howe et al. (2013) find that, on average, individuals living in places with rising temperatures are indeed more likely than others to perceive local warming. Other studies also find that public perceptions do broadly track with instrumental climate data, such as seasonal weather, temperature, and precipitation change (Akerlof et al., 2013; Hamilton & Keim, 2009; Howe & Leiserowitz, 2013). In addition, a large body of work shows that the experience and detection of heat and warm daily temperatures is associated with concern about global warming (e.g., Brooks et al., 2014; Li, Johnson, & Zaval, 2011; Risen & Critcher, 2011). In contrast, Marquart-Pyatt et al. (2014) argue against the theory that changes in climatic conditions will produce noticeable shifts in public perception, as their analyses suggests that objective climatic changes only have a negligible effect on concern about climate change. McCright, Dunlap, and Xiao (2014) provide mixed evidence, supporting the finding that actual temperature anomalies influence perceived warming, but question how much this practically “matters.”

The relationship between global warming risks perception and (subjective) personal experience with visceral extreme weather events, such as hurricanes, flooding, heat waves, and droughts appears more robust, with a large body of evidence supporting a significant association (Akerlof et al., 2013; Capstick & Pidgeon, 2014; Howe et al., 2014; Krosnick et al., 2006; Myers et al., 2012; Reser et al., 2014; Spence et al., 2012; Taylor et al., 2014; van der Linden, 2015A)—with only a few exceptions (Brulle et al., 2012; Whitmarsh, 2008A). Yet, in determining the importance of accurate detection and personal experience, a major theme that has cropped up is the finding that the magnitude of the association appears rather small in comparison to the role of political ideology (Marquart-Pyatt et al., 2014; McCright et al., 2014; Shao & Goidel, 2016).

This finding particularly makes sense in countries where the issue of climate change is highly politicized, such as the United States (McCright & Dunlap, 2011a). Accordingly, studies have revealed a more complex and dynamic relationship between perceived "local" experience and worldviews, so that personal beliefs about global warming color one's perception of local change and vice versa (Myers et al., 2012; Howe & Leiserowitz, 2013; Schuldt & Roh, 2014).

Other studies have noted that the association between personal experience and risk perception is not attenuated by political ideology (Akerlof et al., 2013; Egan & Mullin, 2012), although the magnitude of the remaining effect appears low (e.g., van der Linden, 2015a). In their recent meta-analysis, Hornsey et al. (2016) classify the effect-size of local and extreme weather experience as "low to medium." Part of the issue in quantifying the importance of personal experience is a lack of operational consistency in terms of what qualifies as a significant "weather anomaly," over what time period the change is assessed, and whether people accurately recall their experiences. In addition, frequent media use of the term "global warming" rather than "climate change" may limit the range of experiences and weather phenomena that people associate with climate change and thereby dampen its impact on risk perception (e.g., see Capstick & Pidgeon, 2014; Schuldt & Roh, 2014). Other research suggests that the influence of (extreme) weather experiences on public opinion decay rather quickly (Egan & Mullin, 2012) and so more longitudinal assessments are therefore necessary (Reser et al., 2014). Lastly, it remains an open question as to whether "personal experience" is best thought of as an indirect factor, shaping people's affective responses to climate change by making future impacts more salient and easier to imagine (Risen & Critcher, 2011) or whether personal experience should also be conceptualized as a direct predictor of global warming risk perception in its own right.

Social and Cultural Influences

The Social Construction of Risk

In addition to both cognitive and affective theories, early sociological research criticized existing approaches to the study of risk for the notable lack of consideration of social influence processes (Dake, 1992; Douglas, 1978). This lack of attention for the social context in which risks are framed and debated is indeed surprising, given that the way in which people process and evaluate risks is clearly influenced by the thoughts, feelings, and

decisions of other people (Joffe, 2003). In response, two sociological approaches were developed, including Social Representations Theory (Moscovici, 1984) and the Social Amplification of Risk Framework (Kasperson et al., 1988; Pidgeon et al., 2003). Albeit different theories, what both approaches have in common is a focus on how interpersonal interactions, societal norms, and the mass media shape and circulate social representations of a given risk in society. The process of how risk signals are received, interpreted, and diffused is particularly relevant in understanding how the communication of climate risks is impacted and moderated by social processes. For example, qualitative studies have argued that although climate change risks have indeed been societally amplified (e.g., Renn, 2010; Smith & Joffe, 2013), it remains difficult to quantify what the impact of these processes are on concern about global warming. Accordingly, both approaches have been criticized for their vague "meta-theoretical" nature (Voelklein & Howarth, 2005; Wåhlberg, 2001), particularly because the "societal" level of analysis makes it difficult to identify and quantify the causal impact of various social influence processes on risk perception (Renn, 2010).

In turn, social psychologists have focused more specifically on the role of social and group norms and generally distinguish between "descriptive" and "prescriptive" norms, where the former simply describes the behavior of similar others while the latter prescribes how one *ought* to think or behave (Cialdini, Kallgren, & Reno, 1991). More generally, social norms can be thought of as "expectations of how people are supposed to act, think, or feel in specific situations" (Popenoe, 1983, p. 5). Although norms are generally studied in relation to behavior (Cialdini & Goldstein, 2004; Doherty & Webler, 2016), they influence perceptions too. In one study, van der Linden (2015A) showed that both descriptive and prescriptive social norms exert a notable influence on global warming risk perception, jointly contributing a substantial amount of the explained variance (22%). In other words, the greater the extent to which climate change is viewed as a serious risk by influential social referents, such as friends and family, the more it amplifies and intensifies an individual's own risk perception (van der Linden, 2015A). These findings extend to communicating high social consensus about climate change among influential out-groups too, such as scientists (Lewandowsky et al., 2013; van der Linden et al., 2015). Other research has started to focus on the role of "network influence" and the frequency with which people talk to or are influenced by close friends and family on the issue of climate change (e.g., see Butts, 2016). Although this body of research is still limited, studies have found that social network variables, such as homophily, network size, and centrality have a significant influence on concern about global warming (Brody et al., 2008; Leombruni, 2015). Nonetheless, unlike the rich behavioral literature, there remains a substantial lack of research on the link between social influence processes and climate change risk perception. For example, current studies infer network influence

from self-reported survey data (Brody et al., 2008; Leombruni, 2015) rather than analyzing and constructing actual social networks. Yet, with the increasing spread and transmission of risk information on social media, new theories and methods are being developed, including "social contagion theories of risk" (Scherer & Cho, 2003), social tipping points (Kinzig et al., 2013; van der Linden, 2017), "sentiment" analyses on Twitter (Cody et al., 2015), and the role of network opinion leaders (Nisbet & Kotcher, 2009). In short, much exciting research remains to be done on the topic of normative influence and its impact on concern about global warming.

Culture, Values, and Worldviews

The notion that culture gives rise to socially constructed systems of beliefs, or so-called, "worldviews" has gained increased attention over the last decades (Dake, 1992). Perhaps the most well-known response to the criticism that cognitive and affective psychological theories "depoliticize" the nature of risk by failing to take account of the competing socio-cultural structures of societies was rooted in the development of the "Cultural Theory of Risk" (Douglas, 1970; Douglas & Wildavsky, 1982). Originally based on anthropological research, cultural theory proposes a conceptual typology of risk-culture, also known as the "grid-group" system, where four overarching worldviews are delineated. These include: egalitarianism, individualism, hierarchism, and fatalism. The relative position of these cultural types is determined by the degree to which individuals feel bounded by a sense of belonging and solidarity (*group*) and the amount of control and structure that people maintain in their social lives (*grid*). Wildavsky and Dake (1990) later operationalized these cultural types so that they could be measured and tested empirically. Since then, the Cultural Theory of Risk has generated a fierce and long-standing debate in the risk perception literature, polarizing "proponents" and "opponents."

On one hand, cultural worldviews, particularly the individualism and egalitarianism dimensions, have shown to differentially influence global warming risk perception (Akerlof et al., 2013; Kahan et al., 2012; Leiserowitz, 2006; Smith & Leiserowitz, 2012; Xue et al., 2014). On the other hand, scholars have argued that the actual explanatory power of the cultural worldview scales are very low (Boholm, 1996; Marris, Langford, & O'Riordan, 1998; Oltedal et al., 2004; Sjöberg, 1997, 1998, 2012; van der Linden, 2015A, 2016A), which has led some scholars to conclude that "cultural theory is simply wrong" (e.g., Sjöberg, 1998, p. 150). Yet, leaving the explanatory power of the theory aside for a moment, the other point of contention revolves around two major issues in the literature, namely: (a) the conceptual and empirical validity of the cultural worldview scales themselves and (b)

whether it is appropriate or even informative, for that matter, to try to infer latent cultural dispositions from individual-level data.

Starting with the more practical concern, the initial worldview scales were criticized for having rather low scale reliability scores and for lacking basic construct and discriminant validity (e.g., Boholm, 1996; Price, Walker, & Boschetti, 2014; Rippl, 2002; Sjöberg, 1998). This issue is of particular relevance given that in practice, individuals often score high on competing dimensions, which is problematic, because according to cultural theory, individuals cannot be characterized by mutually incompatible worldviews (Kahan, 2012). Moreover, even when scale reliabilities are improved, their explanatory power often remains low (Rippl, 2002).[3] In an attempt to combine research from the psychometric paradigm with cultural theory, Kahan and colleagues advanced an alternative conception of the cultural theory of risk known as the "cultural cognition thesis" (Kahan, 2012). The basic premise of the cultural cognition thesis is that people are expected to credit or dismiss empirical evidence about societal risks based on whether it coheres or conflicts with their cultural values, a process described as "identity-protective cognition" (Kahan, 2012). The more recently developed cultural cognition scales have also shown to influence climate change risk perception (e.g., Kahan et al., 2012).

In turn, the cultural cognition thesis has been heavily criticized, particularly for its questionably low explanatory power (e.g., Boholm, 2015; Fremling & Lott, 2003; Sunstein, 2007; Swanson, 2010; van der Linden, 2016A). Although it may be argued that small effects can still have important and practical consequences (Prentice & Miller, 1992), especially when aggregating small changes across individual opinions, when the purpose is to develop a theory of risk perception, the quality of the theory should be judged by its overall explanatory power (Boholm, 2015; Sjöberg, 2012; van der Linden, 2015A). To this end, recent meta-analyses do find some support for the cultural theory scales, but note that consistent with prior research, the effect-sizes are often modest (Xue et al., 2014; Hornsey et al., 2016).

One of the primary issues with both the original conception of cultural theory and its successor, cultural cognition, is that the theory is tautological in its reasoning. In other words, it is circular to suggest that "people of culture A habitually do X because they share this particular culture A that prescribes that they do X" (Boholm, 1996, 2015). Indeed, "by definition, the idea of cultural cognition is to illuminate risk perceptions only for those risks that are culturally contested" (Sunstein, 2007, p. 17). In other words, to explain public risk polarization on an issue such as climate change by (artificially) categorizing the public into essentially two polarizing groups (individualists vs. egalitarians) is a so-called "*strange loop*" (van der Linden, 2016A). Although such theoretical inconsistencies are often overlooked, the consequences of pseudoscientific theorizing are serious

(Gigerenzer, 2000). For example, they may render the empirical predictions resulting from cultural cognition theory suspect (van der Linden, 2016A).

Another major issue in the literature is rooted in the systematic conflation of concepts such as culture, values, worldviews, and ideology. For example, cultural cognition explores how different political groups in the United States perceive a select number of contemporary societal issues. In fact, the cultural cognition scales feature the word "government" over 10 times (van der Linden, 2016A) and so it is unclear to what extent cultural cognition is conceptually distinct from partisan motivated reasoning (e.g., see Bolsen, Druckman, & Cook, 2014; Hart & Nisbet, 2012).

Furthermore, research has shown that the cultural scales proposed by both Dake (1991) and Kahan and colleagues do not translate well to other cultures, such as China (Xue et al., 2015).

Part of the issue is rooted in a problematic conception of the term "culture," what it refers to, and how different levels of culture interact with each other (e.g., political vs. national culture). Moreover, values are not the same as worldviews (Koltko-Rivera, 2004; van der Linden, 2016A). Whereas worldviews are very broad, situation-invariant orienting dispositions, values are usually defined as fundamental guiding principles that not only precede but are also more stable and specific than worldviews (Rokeach, 1973; Schwartz & Wolfgang, 1987; Stern et al., 1999). It has been noted that cultural worldviews and values overlap conceptually (Corner, Markowitz, & Pidgeon, 2014; Koltko-Rivera, 2004), because cultures are essentially comprised of and characterized by their underlying values structures (Hofstede, 2001; Schwartz, 1992).

The difficulty lies in the argument that latent cultural worldviews may not be an innate psychological tendency that can reliably be inferred from individual-level data (DeGroot, Steg, & Poortinga, 2013; Rippl, 2002). This is mainly so because cultural differences are best observed between different countries and not between individuals within the same country, given that cultural variation decreases when people with different backgrounds assimilate into the same culture (Oreg & Katz-Gerro, 2006). Mary Douglas herself noted that the motivation behind the concept of "cultural bias" was to explain cross-cultural differences in risk construal (Douglas, 1978), not conflicts between political groups within the same country (with the same culture). Although it can therefore be argued that the concept of "culture" cannot be reduced to a single variable, the large-scale aggregation of value preferences within and between societies may offer a conceptually more stable and direct way to "proxy" shared enculturation in models of risk perception (DeGroot et al., 2013; Slimak & Dietz, 2006; van der Linden, 2015A, 2016A).

A prominent example is the conceptual distinction between so-called “egoistic,” “socio-altruistic,” and “biospheric” value orientations (Stern, Dietz, & Kalof, 1993; Stern, 2000).[4] Some attractive properties of the values-approach are: (a) these value structures tend to be the same in different countries (Schwartz & Sagiv, 1995), which makes standardization and comparison easier and more meaningful; (b) values are not mutually exclusive, i.e., individuals can simultaneously express egoistic, socio-altruistic, and biospheric value preferences but people (and therefore cultures) may prioritize these values differently (Steg & De Groot, 2012); and lastly, (c) these value scales have been reliably validated in a series of cross-cultural studies (De Groot & Steg, 2007, 2008, 2010; Schultz, 2001; Steg et al., 2011; Stern & Dietz, 1994). Having said this, some scholars have noted that altruistic and biospheric values tend to be strongly correlated (e.g., van der Linden, 2015A). Nonetheless, it is possible that people’s concern for others and the environment could diverge, at which point, the theoretical distinction may become more meaningful (DeGroot et al., 2013). Although the application of values to the study of risk perception is relatively new in comparison to cultural theory, biospheric or “environmental” values have shown to reliably predict global warming risk perception (e.g., Brody et al., 2008; Milfont, 2012; Hornsey et al., 2016; Slimak & Dietz, 2006; van der Linden, 2015A).

In conclusion, it should be acknowledged that any attempt to model individual risk perception inevitably decontextualizes risk from the situation in which it arises. Accordingly, there is some inherent difficulty in acknowledging the dynamic and emergent nature of social practice on one hand, and the pursuit to try to represent the “socio-cultural” as part of the individual, on the other. Nonetheless, over the last decades, these questions have forced risk scholars to think harder and more carefully about how culture shapes risk perception and the field would be well-served by further attempts to bridge the “levels of analysis” divide (Jackson, Allum, & Gaskell, 2006). In part, by clearly distinguishing and defining conceptual predictors (e.g., ideology, values, culture, worldviews) so that better standardized comparisons can be conducted of the various “cultural constructs” used to predict risk perceptions of climate change.

Socio-Demographic Characteristics

With a few exceptions, the weight of evidence on the influence of various socio-demographic and social-structural factors on climate change risk perception is rather mixed, as the results tend to vary from sample to sample and from study to study. For example, while some studies find that higher education predicts stronger risk perceptions of climate change (Hornsey et al., 2016; Lee et al., 2015; van der Linden, 2015A), other studies find no education-effect (Akerlof et al., 2013; Brody et al., 2008; Kellstedt et al., 2008; Milfont, 2012; O’Connor et al., 1999 Sundblad et al., 2007) or even an inverse relationship between

higher education and concern about climate change (e.g., Malka et al., 2009; Slimak & Dietz, 2006). Results are equally inconsistent for age, with some studies revealing a small negative correlation between (older) age and global warming risk perception (Heath & Gifford, 2006; Hornsey et al., 2016; Kellstedt et al., 2008; Malka et al., 2009; Milfont, 2012), whereas others find no significant (Akerlof et al., 2013; O'Connor et al., 1999; Sundblad et al., 2007) or a positive correlation (e.g., Slimak & Dietz, 2006).

It has been hypothesized that individuals with higher income and resources might have an increased sense of perceived control and thus view themselves as less vulnerable to the impacts of climate change. Yet, evidence for this hypothesis is also quite mixed, as the impact of income on risk perception appears marginal (cf. Akerlof et al., 2013; Hornsey et al., 2016; Kellstedt et al., 2008; Malka et al., 2009; Milfont, 2012; Smith & Leiserowitz, 2012). The influence of religion also appears limited (Kellstedt et al., 2008; Milfont, 2012; Smith & Leiserowitz, 2012) with some U.S. studies finding a small negative effect (Clements, Xiao, & McCright, 2014; Hamilton & Keim, 2009; Smith & Leiserowitz, 2013) while little is currently known about non-Christian denominations. One reason for these inconsistencies is that cognitive, affective, social, and cultural influences generally trump or mediate much of the initial effect of socio-demographic characteristics on risk perception (e.g., see Akerlof et al., 2013; Dietz et al., 1998; Leiserowitz, 2006; van der Linden, 2015A). Accordingly, most studies generally reveal weak direct effects, with socio-demographics typically explaining only a small amount of the (unique) variance in global warming risk perception (Hornsey et al., 2016; Slimak & Dietz, 2006; van der Linden, 2015A).

Nonetheless, some stable patterns have emerged for at least three factors in particular, namely gender, race, and political ideology. To start with the latter, one robust finding is that both political ideology (Liberal vs. Conservative) and political identity (Republican vs. Democrat) consistently predict global warming risk perception, with Conservatives and Republicans expressing systematically less concern about climate change than Liberals and Democrats (Dunlap & McCright, 2008; Hamilton, 2011; Hornsey et al., 2016; Leiserowitz, 2006; McCright & Dunlap, 2011B).

In the United States, this trend is part of a larger growing political divide on environmental issues (McCright, Xiao, & Dunlap, 2014), which is often thought to be driven by "party sorting," a theory which suggests that political party activists fuel a process of conflict between political elites, which then leads to party sorting within the general public (McCright & Dunlap, 2011A). Political ideology has also shown to interact with other factors in shaping risk perceptions of climate change, including knowledge, media attention, and (lower) trust in climate science (Malka et al., 2009; McCright & Dunlap, 2011B; Leiserowitz et al., 2013). Yet, how important are political views outside of the U.S. context? Although political ideology has also shown to play some role in driving concern

in many European countries (e.g., McCright, Dunlap, & Marquart-Pyatt, 2016; van der Linden, 2015A), much less is known about the importance of political beliefs in shaping risk perception in the rest of the world (Lee et al., 2015).[5]

Another relatively stable finding in the risk perception literature is known as the "white-male" effect (Finucane et al., 2000), which refers to the finding that compared to white females and ethnic minorities of both genders, white (conservative) males are generally less concerned about a wide range of risks, including climate change (McCright & Dunlap, 2011B). Indeed, studies show that females and nonwhites are generally more worried about climate change than white males (Bord & O'Connor, 1997; Brody et al., 2008; Hornsey et al., 2016; Leiserowitz, 2006; Malka et al., 2009; McCright, 2010; O'Connor et al., 1999; van der Linden, 2015A). In fact, political polarization is also less pronounced among nonwhites (Schuldt & Pearson, 2016). Aside from any cultural differences, racial minorities are often thought to have higher risk perceptions because of their increased vulnerability to negative environmental impacts, stress, and hardship (Mohai & Bryant, 1998; Vaughan & Nordenstam, 1991). Yet, at the same time, the interaction between race and gender is complicated, as some studies show that levels of concern between nonwhite males and females are generally similar, which renders any biological explanations for the "white male" effect rather unlikely (Flynn, Slovic, & Mertz, 1994).

Yet, strong evidence for gender socialization theories has also proven elusive. Competing theories include the "Institutional Trust Hypothesis," the "Social Roles" and the "Safety Concern Hypothesis" (Davidson & Freudenburg, 1996). Whereas the first theory posits that females are generally less trusting and place less confidence in technology and institutions, the latter two suggest that social roles, such as nurturing and caregiving, might lead to higher health and safety concerns among females. Although studies have found some evidence for the Safety Concern Hypothesis (Davidson & Freudenburg, 1996; Xiao & McCright, 2012), less evidence is found for the theory that females are less trustful of institutions or that the performance of different societal roles account for gender differences (Cutter et al., 1992; Xiao & McCright, 2012, 2013).

In short, although results vary, there is some evidence for a socio-demographic "risk profile" where typically younger, female, higher educated, politically liberal, and racial minorities express more concern about climate change. Yet, socio-demographics are often included in models of risk perception without much theorizing as to what their conceptual relevance is (Dietz et al., 1998). Much like the growing literature examining the interaction between gender, race, and ideology, climate risk scholars are advised to constructively add to the literature by more clearly explicating theoretical motivations to include socio-demographic factors, as opposed to merely reporting on their "statistical significance" (or lack thereof).

Heuristics and Biases

In addition to cognitive, experiential, socio-cultural, and demographic factors, a number of key heuristics and biases have also shown to influence climate change risk judgments in predictable ways. Although the phrase “heuristics and biases” has come to have a rather negative connotation, I should stress here that reliance on evolved cognitive shortcuts (“heuristics”) can often be adaptive and lead to more accurate judgments than more “rational” or deliberative processes (Gigerenzer & Brighton, 2009).[6] However, when there is a clear mismatch between the environment in which such heuristics evolved and their application in modern (“global”) contexts, this can cause people to misperceive or underestimate the risk of climate change in a number of important ways (Gifford, 2011; van Vugt et al., 2014). I will review five heuristics and biases here that have arguably proven most relevant to understanding how people form risks judgments about global warming (van der Linden, Maibach, & Leiserowitz, 2015).

Optimism Bias, Judgmental Discounting, and Psychological Distance

Humans are optimistic about the future, which is generally a healthy state of mind. It is often hypothesized that because humans evolved with a unique awareness of their own mortality, it is adaptive to be unrealistically optimistic about the future (Varki, 2009). At the same time, however, optimism bias often leads people to systematically overestimate the likelihood of positive events while underestimating the probability of experiencing negative life events (Sharot, 2011; Weinstein, 1989). For example, research across nearly 20 nations has revealed that people generally judge environmental risks and the impacts of climate change to be much more likely and more serious for other people and places than for themselves (Gifford et al., 2009; Leiserowitz, 2005; van der Linden, 2015a). Part of this optimism stems from the fact that people tend to heavily discount uncertain future risks (e.g., climate change impacts) a process known as “intertemporal discounting” (Berns, Laibson, & Loewenstein, 2007). To some extent, temporal discounting is a natural by-product of the way in which human psychology evolved; day to day concerns often take precedent over planning for the future (van Vugt et al., 2014). Accordingly, people mentally construe future risks differently from those in the present (Trope & Liberman, 2010), particularly as temporal distance increases, mental representations of risks tend to become less concrete and increasingly abstract. This process is generally referred to as the “psychological distance” of climate change (Spence, Poortinga, & Pidgeon, 2012). In other words, people often underestimate the extent to which climate change is a serious

personal risk, believing it is more likely to happen in the distant future to other people in other places.

The Local Warming Effect

It is difficult for people to detect global environmental change on a purely perceptual or sensory level (Pawlik, 1991). Accordingly, for everyday survival, it made good sense for humans to rely on daily and local weather patterns. Yet, the use of variation in local weather as a heuristic for climate change is a form of "attribution-substitution," that is, individuals rely on simple available information, such as daily temperature, to make judgments about a more complex and less accessible phenomenon, such as global warming (Zaval et al., 2014). Accordingly, much research has shown that people are more concerned about global warming on hot days than on cold days and when exposed to so-called "heat primes" (Joireman et al., 2010; Lewandowski, Ciarocco, & Gately, 2012; Li, Johnson, & Zaval, 2011; Risen & Critcher, 2011; Zaval et al., 2014; Schuldt & Roh, 2014). The problem is that due to the high variation in short-term weather, the local warming heuristic is an unstable inference tool for forming risk judgments about global warming, with less concern on cold days and more concern on warmer days. Importantly, recent research has indicated that the local warming effect may be eliminated by prompting people to think about trends rather than current or ambient temperature (Druckman, 2015).

The Consensus-Heuristic: Perceived Scientific Agreement

Consensus describes the collective judgment of a group of individuals, such as experts. People tend to rely on consensus cues when making judgments about social and political issues (Mutz, 1998; Panagopoulos & Harrison, 2016; van der Linden, Clarke, & Maibach, 2015; van der Linden et al., 2017). In fact, in a complex and uncertain world, relying on consensus cues is often adaptive because it reduces the cost of individual learning by harnessing the "wisdom of the crowd" (Surowiecki, 2004), which is most pronounced among experts, such as climate scientists (Maibach & van der Linden, 2016). Indeed, in contrast to relying on the opinion of a single expert, people generally prefer to take cues from the combined judgment of multiple experts (Mannes, Soll, & Larrick, 2014).

Accordingly, in light of the strong scientific consensus on human-caused climate change (Cook et al., 2016), a growing body of research has found that the public's perception of the degree of scientific consensus acts as a so-called "gateway cognition": influencing "key" beliefs about climate change, including concern about global warming (Ding et al.,

2011; Hornsey et al., 2016; Malka, Krosnick, & Langer, 2009; McCright et al., 2013; van der Linden et al., 2015). Moreover, while widespread public misperceptions of the degree of scientific consensus dampen concern about global warming, recent research has found that conveying the scientific consensus on human-caused climate change can increase acceptance of and concern about climate change across the ideological spectrum (e.g., Lewandowsky et al., 2013; van der Linden et al., 2015, 2017).

System Justification and Motivated Science Denial

Although people are often biased in favor of the status quo, system justification theory suggests that some people will not only defend and justify the status quo but also adopt motivated perceptions to view the current system as stable, fair, just, and legitimate even when the system may be disadvantageous to others (Jost & Hunyady, 2005). Systematic justification is distinct from, but related to, free-market ideologies and political conservatism (Jost et al., 2003). Because global warming and associated mitigation policies strongly threaten the status quo, much research, particularly in the United States, has shown that system justification, strong endorsement of free-market capitalism, and conservatism predict motivated cognitions that result in reduced concern and widespread climate change denial (Dunlap, 2013; Feinberg & Willer, 2010; Feygina, Jost, & Goldsmith, 2010; Heath & Gifford, 2006; Lewandowsky et al., 2013; van der Linden, 2015B).

Finite Pool of Worry

At the end of the day, people can only worry about so many things at the same time. In an experimental study with Argentine farmers, Hansen et al. (2004) show that increasing concern for one political risk (e.g., terrorism), typically reduces concern about another societal risk (e.g., global warming) even although objectively, the nature of the risk has not changed. Moreover, worry is often a draining emotional process. The cost of worry is therefore likely cumulative so that the more people worry about an issue, the longer it takes to regenerate (Marx et al., 2007). Unfortunately, many studies show that in light of issues such as national security, the economy, health care, and other ecological issues such as water scarcity, global warming generally remains a low priority for most people, consistently occupying the lower ranks of the finite “pool of worry” (Leiserowitz, 2007; Lorenzoni & Pidgeon, 2006; Nisbet & Myers, 2007; Motel, 2014).

Measuring Public Risk Perception of Climate Change

Risk perception is a multidimensional construct (Slovic, Fischhoff, & Lichtenstein, 1982) and accordingly, a wide range of different items have been used to tap into and measure how the general public perceives the risk of global warming. For example, some studies have used “perceived seriousness” as an indicator of risk perception, whereas others have asked how “concerned” the public is in general about the issue, how likely various climate change impacts are to occur on varying timescales, how much people personally “worry” about climate change while still others use a combination of all or some of these measures (c.f., Akerlof et al., 2013; Brody et al., 2008; Ding et al., 2011; Hidalgo & Pisano, 2010; Malka et al., 2009; McCright, 2010; Milfont, 2012; Kellstedt et al., 2008; Leiserowitz, 2006; Li et al., 2011; O’Connor et al., 1999; Spence et al., 2012; Sundblad et al., 2007; van der Linden, 2015A).

This notable lack of consensus on how to measure and operationalize a complex and multidimensional construct such as global warming risk perception creates two main challenges for scholars and practitioners. First, it is difficult to systematically quantify how differences in risk perception measurement influence the observed relationship between the various cognitive, experiential, socio-cultural, and demographic factors that predict concern about climate change. For example, if it were the case that most risk perception measures are highly correlated with each other (and thus “tap” into the same latent “risk perception” factor), we would expect that differences in measurement would not bear much on the relationship between the dependent and independent variables. However, empirically, this is often not the case, as correlated measures can still differentially relate to their predictors (Van Liere & Dunlap, 1981). Second, it is unclear how different conceptualizations of concern subsequently relate to behavioral responses, such as support for climate change adaptation and mitigation policies. What is known, however, is that not all risk perception measures are created equal[7] (van der Linden, 2014B) and indices that combine and tap into the various temporal, spatial, cognitive, and affective bases of climate change concern are generally more reliable than single-items. Particularly, because on average, multi-item measures cancel out item-specific variance and measurement error (Epstein, 1983).

The Hierarchy of Concern (HoC) Model

To further elaborate on the observation that not all measures of risk perception are created equal, I have developed a "hierarchy of concern" model that should help inform future risk perception research (Figure 2). For example, there is a particularly notable difference between generalized concern for an issue and personal worry. Worry is an active emotional state that is often closely linked to adaptive behavioral responses aimed at reducing a particular threat, whereas broad concern is not and can be expressed without any particular motivational or emotional content (Leiserowitz, 2007; Smith & Leiserowitz, 2014; van der Linden, 2014b).[8] In fact, a logical "hierarchy of concern" can be construed using similar reasoning. In short, an individual may think that climate change (and associated impacts) are likely to occur, but that doesn't mean that someone also perceives climate change to be a *serious* issue. In turn, an individual can perceive climate change to be a serious issue, but that doesn't necessarily imply that they are *concerned* about it. Finally, although the public may express generalized concern about climate change, this often does not mean that people also personally worry about the issue or think it is a high priority (Leiserowitz, 2007; Lorenzoni & Pidgeon, 2006; Nisbet & Myers, 2007; Motel, 2014).

In other words, concern may be a necessary but not sufficient condition for worry and perceived seriousness and likelihood ratings are in turn components of generalized concern (Levy & Guttman, 1976).[9] Although public perception may of course not perfectly abide by such a transitive axiom (likelihood < perceived seriousness < concern < personal worry), it is a useful heuristic that can help guide researchers conceptualize measures of risk perception.

Click to view larger

Figure 2. "Hierarchy of Concern" (HoC).

Another key finding that has been neglected in the literature concerns the distinction between "societal" (i.e., other-regarding) and "personal"-level risk judgments (Tyler & Cook, 1984). People are generally optimistically biased in the sense that they believe that global warming is a serious concern for others, society at-large, and non-human nature, whereas personal concern and worry is typically much lower (e.g., Leiserowitz, 2005; van der

Linden, 2015A). A direct consequence of this conceptual distinction is that risk perception measures which solely rely on people's "global" or "societal" level risk judgments are likely to seriously overestimate public concern. Although this distinction has been implicitly acknowledged (Bord et al., 2000; Leiserowitz, 2005; Sjöberg, 2012), it has received scant attention in the literature. In one study, van der Linden (2015A) provides empirical support for the two-dimensional factor structure of risk perception and further shows that each dimension may have different antecedents. For example, generalized knowledge influenced societal but not personal-level risk judgments.

Accordingly, to help guide future research, I have delineated a three-step process of risk perception measurement (Figure 3). Essentially, any multidimensional risk perception scale should include both "global" societal-level as well as "personal"-level risk judgments of global warming in order for researchers to be able to meaningfully compare and differentiate the two. These two broad dimensions can in turn be broken out by the different ways in which risk perception can be conceptualized, including likelihood estimates, measures of perceived seriousness, generalized concern, and personal worry.[10]

Of course, it may not always be feasible for risk scholars to construct multidimensional risk scales that include a wide range of risk perception measures. For example, opinion polls typically include single-items asking whether people broadly think that climate change is a serious issue. Yet, Figure 3 would suggest that the next question to ask is: a serious issue to whom? Sometimes the purpose of the research might come with practical restrictions on how many questions or items can be included in a given survey. If the goal of the research is to describe public opinion, then perceived seriousness or generalized concern may both be appropriate measures. However, if the goal of the research is to understand how concern about climate change relates to behavior or policy-support, then personal worry might be a better indicator to use (e.g., Smith & Leiserowitz, 2014). Similarly, if researchers only wish to tap into cognitive dimensions of risk, then perceived "likelihood" is probably a better measure to use than personal "worry." Nonetheless, single-item measures are now generally discouraged (Epstein, 1983; Roser-Renouf & Nisbet, 2008) and more careful consideration of personal vs. other-regarding risk judgments, the inclusion of multiple items, and how they map onto specific research questions will likely help improve and standardize future risk perception research.

Click to view larger

Figure 3. Three-step process of measuring and operationalizing risk perception.

Risk Perception, Behavior Change, and Support for Adaptation and Mitigation Policies

Although people are generally aware of and broadly concerned about the issue of climate change, scholars have repeatedly noted that deeper behavioral engagement is often still lacking (e.g., Whitmarsh, Lorenzoni, & O'Neill, 2012; van der Linden, 2014B). Yet, in contrast to the rich literature on pro-environmental attitudes and behavior, much less is known about the relationship between public concern about climate change and people's intentions and behaviors to address the issue. Having said this, evidence has increased over the last decade, revealing a clear but inconsistent link between different measures of climate change concern on one hand, and individual behaviors and support for adaptation and mitigation policies, on the other. This discrepancy can be explained by what I will refer to as the "measurement paradox" (Figure 4).

On one hand, studies find that public concern about climate change is broadly related to adaptation and mitigation measures in consistent and important ways. For example, Smith and Leiserowitz (2014) find that worry about climate change is one of the strongest predictors of global warming policy support, such as regulating CO_2 emissions, signing international treaties, and increasing taxes on gasoline. Similarly, Brody, Grover, and Vedlitz (2012), O'Connor et al. (1999), and Krosnick et al. (2006) all find that climate change risk perceptions are predictive of general intentions to implement individual behavior changes and/or broad policy-support to address the issue. Spence, Poortinga, Butler, and Pidgeon (2011) also find that concern about climate change influences broad preparedness to reduce energy use. More generally, there are numerous studies that find robust

evidence for an association between risk perception, broad intentions to address climate change, and self-reported policy support (e.g., see also Dietz, Dan, & Shwom, 2007; Ding et al., 2011; Heath & Gifford, 2006; Hidalgo & Pisano, 2010; McCright et al., 2013; Semenza et al., 2008; van der Linden et al., 2015; Zahran et al., 2006).

Yet, on the other hand, robust evidence for a significant link between risk perceptions of climate change and specific behavioral actions is much less consistent. For example, although it is often hypothesized that people might be more willing to implement adaptation measures due to their greater personal relevance (e.g., Helgeson et al., 2012), reviews of the role of climate change risk perception in decisions to purchase flooding insurance (or other protective behaviors) suggest that the relationship is extremely weak with most studies finding no effect (Bubeck, Botzen, & Aerts, 2012; Kreibich, 2011). Similarly, in their meta-analysis, Hornsey et al. (2016) find that although climate beliefs share moderate effect-sizes with broad support for climate policies and behavioral intentions, the association between climate perceptions and more specific pro-environmental behaviors is much weaker (about half the magnitude).[11]

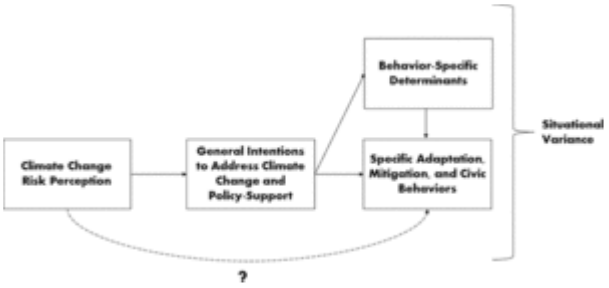
Part of the explanation for this discrepancy is rooted in the well-known "gap" between stated intentions/concern and actual behavior (Sheeran, 2002) but also in an inherent "measurement paradox." In particular, there is a notable lack of studies specifically exploring the role of risk perception in actual adaptation, mitigation, and voting decisions and behaviors, either self-reported or observed.[12] This is important because of the conceptual relationship (or lack thereof) that researchers hypothesize between risk perception and behavior. For example, how are risk perceptions of global warming conceptually related to climate-friendly behaviors? Whitmarsh (2009) notes that many specific energy conservation behaviors are generally not performed "out of concern" for climate change. This makes sense; many personal behaviors, such as running the dishwasher, changing light bulbs, or even decisions to purchase a fuel-efficient car are probably driven by considerations specific to those behaviors and contextual circumstances. For example, in a national study investigating over 20 (low- and high-cost) climate-friendly behaviors, van der Linden (2016B) developed a causal model of climate change mitigation behavior known as the Domain-Context-Behavior (DCB) model. The DCB model reveals that specific actions that help reduce climate change are best predicted by the specific attitudes, perceptions, beliefs, and barriers that are associated with performing those behaviors.

The logic of the model is based on the notion of "measurement correspondence" (Ajzen & Fishbein, 1977)—a principle which suggests that predictors of behavior (e.g., risk perception) should be operationalized at the same level of specificity as the behavior being predicted (e.g., purchasing green energy). For example, whether an individual

purchases green energy is probably best predicted by behavior-specific determinants, such as that individual's particular attitude toward or available resources to purchase green energy.[13] Nonetheless, van der Linden (2016B) shows that more distal predictors such as people's concern about climate change still play an important role by shaping a general orienting intention to help curb climate change, which, when activated by a specific decision-context, can in turn influence behavior-specific determinants to act environmentally-friendly (van der Linden, 2016B).[14]

The paradox arises from the fact that because many individual actions are often predicted by the "power of the situation" (Nisbett & Ross, 1991), one way to try to relate a broad construct such as risk perception to a specific behavioral measure, is by creating an *aggregate* index of behavior and policy-support to help equalize the level of specificity between the predictor and criterion. Aggregation has the desirable property of canceling out situation-specific variance between different behaviors (Epstein, 1983; Weigel & Newman, 1976). This allows researchers to examine common variation between public concern about climate change and a broad range of behaviors. A drawback of this approach is that it confounds the differential relationship that each individual behavior or policy-item in the scale bears in relation to the model's predictors (Van Liere & Dunlap, 1981; Roser-Renouf & Nisbet, 2008). Although this paradox is unlikely to be resolved, risk researchers would benefit from being (more) mindful of this trade-off.

Nonetheless, a large body of research has established that public risk perception and concern do consistently co-vary with "good intentions" and broad-stroke policy support. Yet, at the same time, much less is known about how and in what ways people's concern about climate change drives them to adopt specific behaviors or vote for specific policies in specific situations. In order to learn more about the complex relationship that public risk perception plays in driving public engagement with climate change, future research would benefit from more specific investigations, including examining the role of risk perception in driving real-world adaptation and mitigation behaviors and decisions. In addition, in order to not overestimate the relationship between concern about climate change and behavior, researchers should explore the magnitude of the associations when controlling for other key motivational factors that can be expected to influence specific low-carbon behaviors and support for climate policy. As illustrated in Figure 4, this will also further help evaluate whether risk perception primarily acts as a direct or indirect driver of climate change response behaviors. Although the study of risk perception is important in its own right, the field would benefit from becoming more decision-focused (Arvai, 2014) and to this end, there is much work left to be done in terms of exploring risk-behavior relations.



Click to view larger

Figure 4. The conceptual relationship between risk perception and behavior prediction.

Conclusion

Public risk perceptions of climate change are complex and influenced by a multitude of cognitive, affective, social, cultural, and socio-demographic factors. Overall, experiential and socio-cultural factors are most influential in driving public risk perceptions of climate change with negative affect being one of the strongest determinants. Much of the evidence comes from Western countries, however, and more research is needed from other parts of the world. There is a notable inconsistency in the measures used to assess public risk perception, which makes standardized comparisons difficult. Although public concern is widespread and most people around the world view climate change as a serious issue, personal worry is typically much lower. Research also shows that the way in which people judge the risk of climate change for themselves and others frequently diverge. Overall, while measures of risk perception have shown to influence self-reported policy-support and general intentions to change behavior, the link between concern about climate change and real-world adaptation and mitigation decisions remains less clear.

Suggested Readings

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Notes:

(1.) A notable exception is Kahan et al. (2012). Although it should be mentioned that this study assessed public science literacy in *general* rather than domain-specific knowledge about climate change.

(2.) I should note that the “two systems of reasoning” model is mostly used as a metaphor (Kahneman, 2011), given that the human brain does not literally have two distinct “systems”—but since some scholars have proposed an alternative, unified model (Kruglanski & Gigerenzer, 2011), I feel compelled to highlight this here.

(3.) A notable exception is Smith and Leiserowitz (2012).

(4.) These were derived from Schwartz’s (1992) *self-enhancing vs. self-transcending* value clusters.

(5.) A related measure that is somewhat less U.S.-specific but produces similar results is known as “free-market ideology” (e.g., see Heath & Gifford, 2006).

(6.) This is so because prediction error is a function of both bias and variance. Although heuristics are necessarily “biased” by ignoring information, they typically capitalize on having low variance (Gigerenzer & Brighton, 2009).

(7.) An additional debate revolves around the terms “climate change” vs. “global warming” where use of the latter may elicit more public concern than the former (c.f., Schuldt, Konrath, & Schwarz, 2011; Whitmarsh, 2008b).

(8.) A “healthy” amount of worry is different from the experience of fear. Fear can often result in so-called “amygdala hijack” (Goleman, 2006), which can interfere with risk processing and produce maladaptive behavioral responses.

(9.) Of course, similar to criticisms of Maslow’s (1943) “hierarchy of needs,” it is possible that knowing what the likely impacts of climate change are (bottom) can directly lead to worry (top) about the issue as well.

(10.) The model is actually drawn in reverse order for conceptual clarity, in a modeling sense, the societal and personal level variables would be latent factors with the four risk perception items each being indicators. The two broad risk perception dimensions would in turn be components of the latent multidimensional risk perception scale.

(11.) To the extent that this is due to differences in measurement, there is some evidence to suggest that when risk perception is operationalized as personal worry, it bears a stronger relationship to behavioral measures (Bubeck et al., 2012; Smith & Leiserowitz, 2014).

(12.) Notable exceptions include Semenza et al. (2008) and van der Linden (2016b).

(13.) In the health domain, the link between threat perception and behavior tends to be more direct, because people are often motivated to “protect” themselves from visceral health risks (e.g., see Floyd, Prentice-Dunn, & Rogers, 2000).

(14.) Climate beliefs and risk perception also tend to correlate less strongly with more high-cost behaviors, as these are typically more difficult to implement for people due to economic and structural barriers (van der Linden, 2016b).

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