Journal of Environmental Psychology 41 (2015) 112–124

Contents lists available at ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep

The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model

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ARTICLE INFO

Article history:
Available online 4 December 2014

Keywords:
Risk perception
Climate change
Global warming
Risk communication

ABSTRACT

This study advances a detailed social-psychological model of climate change risk perceptions by combining and integrating cognitive, experiential, and socio-cultural factors. The conceptual model is tested empirically on a national sample ($N = 808$) of the UK population. Results indicate that the full climate change risk perception model (CCRPM) is able to explain nearly 70% of the variance in risk perception. Gender, political party, knowledge of the causes, impacts and responses to climate change, social norms, value orientations, affect and personal experience with extreme weather were all identified as significant predictors. Experiential and socio-cultural factors explained significantly more variance in risk perception than either cognitive or socio-demographic characteristics. Results also confirm that the factor analytic structure of climate change risk perceptions can be conceptualized along two key dimensions, namely: personal and societal risk judgments and that both dimensions have different psychological antecedents. Implications for theory and public risk communication are discussed.

1. Introduction

While climate change is a complex global hazard that poses significant challenges to societies worldwide (Swim et al., 2011), the extent to which it is publicly viewed as a risk that requires urgent attention varies substantially (Kim & Wolinsky-Nahmias, 2014). This is a peculiar but inevitable result of the fact that the nature of human perception allows for a differentiation between real-world threats and the subjective perceptual experience of those threats (Pidgeon, Kasperson, & Slovic, 2003). Indeed, the perception of risk is a mental construct (Sjöberg, 2000a). As Slovic (1992) points out, the notion of "risk" is a human invention and as such, "it does not exist independent of our minds and culture" (p. 690).

To illustrate, climate change has consistently been perceived as a "very serious" problem by publics in the UK, Australia and most of continental Europe (Eurobarometer, 2014; Pidgeon, 2012; Reser, Bradley, Glendon, Ellul, & Callaghan, 2012) while concern has traditionally been much lower and less stable in the United States and China (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Rosenthal, 2014; Pew, 2010). More broadly, climate change is generally perceived as a higher risk in developing countries than in most of the Western World (Kim & Wolinsky-Nahmias, 2014). Moreover, risk judgments of climate change do not only vary between different countries: they also vary strongly between individuals in the same country (e.g., Smith & Leiserowitz, 2012; Whitmarsh, 2011).

As an object of risk representation, climate change is relatively unique (Breakwell, 2010). It is unique in the sense that both the magnitude and complexity of the climate change problem are unprecedented in terms of the scale (i.e., global) as well as the timeline involved (i.e., stretching over centuries). Furthermore, because climate change is a slow, cumulative and largely invisible process, it cannot be experienced directly (Weber, 2010) and as such, it is markedly different from the way that our ancestors have traditionally perceived threats in their local environment (Gifford, 2011; Helgeson, van der Linden, & Chabay, 2012). Thus, human-caused climate change is an evolutionarily "novel" risk (Griskevicius, Cantu, & Van Vugt, 2012).

Advancing a more detailed understanding of the psychological factors that drive and shape public risk perceptions of climate change is therefore a pivotal task, especially since an increasing

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http://dx.doi.org/10.1016/j.jenvp.2014.11.012
0272-4944/

Table 1
Overview of selected risk perception studies (ordered by explanatory power).

Authors	Key explanatory variables	Dependent variable	Sample	Explained variance
Akerlof, Maibach, Fitzgerald, Cedeno, and Neuman (2013)	(a) Personal experience, (b) cultural worldviews (proxy), (c) political ideology, (d) place attachment and (e) socio-demographics.	Local climate change risk (8 items, $\alpha = 0.96$)	Alger County, Michigan, USA (local) ($N = 765$)	55%
Spence et al. (2012)	Psychological distance variables, (a)temporal, (b) spatial and (c) uncertainty.	Risk Perception Index (3 items, $\alpha = 0.83$)	Great Britain (national) ($N = 1822$)	54%
Leiserowitz (2006) and Smith and Leiserowitz (2012)	(a) Holistic negative affect, (b) image affect, (c) naysayers, (d) alarmists, (e) political ideology, (f) cultural worldviews (egalitarian/individualist), (g) member of environmental group, (h) newspaper reader and (i) socio-demographics.	Risk Perception Index (9 items, $\alpha = 0.94/0.96$)	USA (national) ($N = 673$ and $N = 1001$)	47%–52%
Kellstedt, Zahran, and Vedlitz (2008)	(a) Ecological values (NEP), (b) personal efficacy, (c) self-reported knowledge about climate change, (d) trust in media, (e) trust in experts, (f) confidence in science, (g) political ideology and (h) socio-demographics.	Risk Perception Index (6 items, $\alpha = 0.87$)	USA (national) ($N = 1093$)	43%
Brody, Zahran, Vedlitz, and Grover (2008)	(a) Physical vulnerability variables, (b) ecological values (NEP), (c) self-efficacy, (d) knowledge, (e) network interest and (f) socio-demographics.	Risk Perception Index (3 items, $\alpha = 0.84$)	USA (national) ($N = 1093$)	42%
Milfont (2012)	(a) Ecological values (NEP), (b) political ideology, (c) self-reported knowledge about climate change, (d) perceived efficacy, (e) trust in media, (f) trust in experts, (g) confidence in science and (h) socio-demographics.	Risk Perception Index (6 items, $\alpha = 0.86$)	New Zealand (national - 1yr panel) ($N = 269$)	38%–48%
Menny, Osberghaus, Pohl, and Werner (2011)	(a) Beliefs about climate change, (b) interest in climate change, (c) knowledge about climate change, (d) mass media influence, (e) personal experience with extreme weather and (f) socio-demographics.	Personal Risk Index (17 items, $\alpha =$ not reported)	Mannheim, Germany (local) ($N = 157$)	31%
Sundblad, Biel, and Gärling (2007)	(a) Knowledge about climate change, (b) worry/affect and (c) socio-demographics.	Risk Perception Index (9 items, $\alpha = 0.91$)	Sweden (national) ($N = 621$)	24–26%
Malka, Krosnick, and Langer (2009)	(a) Self-reported knowledge, (b) trust in scientists and (c) socio-demographics.	Single-Items(Perceived general and national seriousness)	USA (national) ($N = 1002$)	22–25%

amount of studies are indicating that risk perception is an important predictor of public willingness to help reduce climate change (e.g., Leiserowitz, 2006; O'Connor, Bord, & Fisher, 1999; Semenza et al., 2008; Spence, Poortinga, Butler, & Pidgeon, 2011; Spence, Poortinga, & Pidgeon, 2012; Tobler, Visschers, & Siegrist, 2012a). In order to get a better overview of the current state of research, a survey of the peer-reviewed literature was conducted using the search terms "risk perception", "climate change" and "global warming".[1] Studies were ordered and selected based on the relative explanatory power (R^2) of the reported models and a brief overview of ten "major" studies is provided in Table 1.

A number of conclusions can be drawn from the table. To start with, (a) while a variety of different models and approaches have contributed to explaining risk perceptions of climate change, a more systematic and detailed organization of key social-psychological determinants is currently lacking, making it difficult for both researchers and practitioners to see the forest for the trees, (b) a majority of the studies have been conducted in the Unites States and (c) the amount of variance explained ranges between 22% and 55% (with an average of about 40%), leaving substantial room to further develop both the theoretical as well as the empirical explanatory power of current risk perception models.

All of the included studies (Table 1) offer correlational evidence of what predictors are potentially associated with climate change risk perceptions. However, it is worth mentioning that several factors warrant caution and make any direct comparisons between psychological determinants difficult. For example, the sizable differences in explained variance between the various models can be attributed (at least, to some extent) to the fact that many of the included studies either use a limited or substantially different set of predictors. Moreover, similar constructs are also likely to differ in terms of how they were measured and operationalized.

Perhaps most notably, different studies used different measures of risk perception. For example, whereas some studies used the

[1] The following databases were used: PsychInfo, Scopus, Google Scholar and Web of Science. Note that the search does not claim comprehensive coverage; its purpose is simply to give the reader an idea of the diversity of existing models and predictor variables (and the large variation in their explanatory power).

term "global warming" others used "climate change" or "global climate change" – which could explain some variation in itself (cf. Leiserowitz, Feinberg, et al., 2014; Villar & Krosnick, 2011; Whitmarsh, 2009). Moreover, while terms such as perceived "seriousness", "concern" and "worry" are often used synonymously in the literature, they actually mean different things (van der Linden, 2014a). Indeed, it is possible to be broadly and generally concerned about an issue without actively worrying about it (Leiserowitz, 2007).

In fact, climate change is often characterized as a distant psychological risk, both spatially as well as temporally – happening in the "future" to "other" people and places (Spence et al., 2012). To some extent, this characterization may be a natural consequence of what Weinstein (1989) referred to as; "optimism bias" (i.e., the erroneous belief that others are more likely to be affected by the same risk).

In fact, the difference between self vs. other-regarding risk judgments suggests a conceptual distinction between societal and personal level risks (Tyler & Cook, 1984). This differentiation is important to consider, as several studies have shown that when asked to assess the threat of climate change for society as a whole, people consistently report higher ratings than when asked to evaluate climate change as a personal risk (Bord, O'Connor, & Fisher, 2000; Leiserowitz, 2005).

Surprisingly, risk research has often failed to make this differentiation in the context of climate change. In fact, while occasionally noted (Bord et al., 2000; Roser-Renouf & Nisbet, 2008), no research has examined to what extent risk perceptions of climate change can be viewed empirically as a two-dimensional construct, and more importantly, whether societal and personal risk perceptions have different psychological antecedents - which could have important implications for risk communication (Bord et al., 2000; Leiserowitz, 2005; Sjöberg, 2012). The purpose of the current study is therefore twofold.

First, in order to provide a more systematic and theoretically integrated overview of the main social-psychological determinants of climate change risk perceptions, a new, more comprehensive climate change risk perception model is advanced. The explanatory power of the model is subsequently tested empirically on a national sample of the British population using a set of highly reliable measurement constructs. Second, this study examines whether climate change risk perceptions can be further divided into societal and personal level risk judgments and to what extent these dimensions have different psychological antecedents.

The rest of this paper is divided as follows; first, a detailed theoretical discussion of past research is provided, followed by the development of a new conceptual model, an overview of the methodology and a presentation and discussion of the results. Last but certainly not least, limitations are discussed and some suggestions are offered for future research in this area.

2. The present research

New risk perception models are generally welcomed (Sjöberg, 2002) - especially since "the aim of the work is to find a model which is as fully explanatory as possible" (Sjöberg, 2012, p. 665). Moreover, while existing models often slice risk perception into different dimensions, little explanation is provided as to why people experience risk in these dimensions or while explanations may exist, no coherent effort has been made to piece them together (Wåhlberg, 2001). The purpose of the current research is exactly this: to provide a new conceptual framework that helps organize and integrate different theoretical perspectives into a comprehensive overview of key psychological determinants, which jointly explain a substantial amount of the variance in climate change risk perceptions.

While public risk perceptions are clearly complex and multidimensional (Slovic, Fischhoff, & Lichtenstein, 1982), past research has suggested that risk perceptions of climate change are primarily influenced by four key dimensions, namely; *socio-demographic*, *cognitive*, *experiential* and *socio-cultural* factors (Helgeson et al., 2012). The current section expands on this broad conceptual structure by outlining and delineating each of these dimensions in further detail.

2.1. Cognitive dimensions of risk

2.1.1. Knowledge about climate change

In order to estimate both, the probability with which global warming is likely to occur and the severity of associated consequences, some "knowledge" of these factors must be acquired first. To this extent, knowledge about climate change is generally regarded as a cognitive aspect of risk judgments (Sundblad et al., 2007). However, it remains relatively unclear to what extent a cognitive understanding of climate change can explain and predict public risk perceptions. Particularly, because there is an important difference between an individual's "subjective" knowledge (i.e., what people *think* is true) and the actual "evidence" (insofar a clear scientific consensus exists, e.g., that burning fossil fuels contributes to climate change). This distinction has received little attention, but is causing much confusion. In fact, studies that use single-item measures to assess subjective, self-reported knowledge (e.g., "I know a lot about climate change") typically report inconsistent results.

For example, while Brody et al. (2008) find no significant relationship between knowledge and risk perception, Kellstedt et al. (2008) actually found that knowledge is *negatively* associated with risk perceptions of climate change. Both Malka et al. (2009) and Menny et al. (2011) provide mixed evidence, suggesting that increased knowledge about climate change only leads to higher concern for some groups (e.g., liberals) but not for others (e.g., conservatives). Yet, it is important to note that self-reported measures tend to be (a) less reliable and (b) confound different types of knowledge. Thus, ideally, their use should be avoided (Reser et al., 2012; Roser-Renouf & Nisbet, 2008).

In fact, a growing number of studies have tried to objectively assess how much "accurate" knowledge people hold about climate change. These studies report a very different story, namely; that knowledge is in fact a significant and positive predictor of climate change risk perceptions (e.g., Hidalgo & Pisano, 2010; Milfont, 2012; O'Connor et al., 1999; Reser et al., 2012; Sundblad et al., 2007; Tobler et al., 2012a). Moreover, Kaiser and Fuhrer (2003) argue that the role of knowledge often goes undetected because researchers fail to make a conceptual distinction between different forms of knowledge. Accordingly, consistent with recent research, this study aims to provide a more reliable assessment of knowledge by measuring three interrelated and converging subject areas, namely; public knowledge about the *causes*, *impacts* and *responses* to climate change.

2.2. Experiential processes

2.2.1. Affect

It is now widely recognized that human information processing is guided by emotion and affect (Damasio, 1994; Marx et al., 2007; Zajonc, 1980) and accordingly, both the "*risk-as-feelings*" hypothesis (Loewenstein, Weber, Hsee, & Welch, 2001) and the "*affect-heuristic*" have become influential in describing and understanding public risk perceptions (Finucane, Alhakami, Slovic, & Johnson,

2000; Slovic, Finucane, Peters, & MacGregor, 2004). When a risk judgment is complex and mental resources are limited, relying on a so-called "holistic affective impression" can serve as an efficient heuristic (Slovic, Finucane, Peters, & MacGregor, 2007). The term "affect" here is meant to indicate a more subtle form of emotion, defined as a positive (like) or negative (dislike) evaluative feeling towards an external stimuli (Slovic et al., 2007). An "affective response" can then be described as a first, associative and automatic reaction that guides information processing and judgment (Zajonc, 1980).

While a number of studies have shown that both *affective imagery* and *holistic affect* are strong and important predictors of climate change risk perceptions (e.g., Leiserowitz, 2006; Smith & Leiserowitz, 2012; Sundblad et al., 2007), others have argued that emotion and affect explain very little variance in risk perception (Sjöberg, 1998a, 2006). In fact, Kobbeltved, Brun, Johnsen, and Eid (2005) report in their panel study that they find little support for the "risk as feelings" hypothesis. In addition, Sjöberg (2006) argues that if affect is operationalized as an evaluative measure (like/dislike) - this tends to be closer conceptually to a measure of attitude. Thus, if affect is really operationalized as an attitudinal measure and because the term "emotion" is often mistakenly equated with affect, it is easy to falsely conclude that emotions are an important determinant of risk perception.

Although a fair criticism, Slovic et al. (2007) are careful not to confuse the term emotion with affect and duly acknowledge the similarities between evaluative attitudes and the affect heuristic. In fact, an "attitude" has traditionally been defined as: "the *affect* for or against a psychological object" (Thurstone, 1931, p. 261). Accordingly, no issue is taken here with the conceptual overlap between affect and attitudes more generally, given that it is widely agreed upon that attitudes have a strong "affective" component (Eagly & Chaiken, 1993), especially in the context of climate change (Poortinga, Spence, Whitmarsh, Capstick, & Pidgeon, 2011). While Wardman (2006) also expresses some sentiment for Sjöberg's argument, he concludes that these definitional issues do not weigh up against converging evidence from across the behavioral sciences in favor of the role of affect in risk perception.

Yet, although Peters and Slovic (2007) conclude that affect is generally best conceptualized as a global evaluative measure (i.e., valence), the present study does note that previous studies have predominantly used single-item measures to assess holistic affect (e.g., Leiserowitz, 2006; Poortinga et al., 2011; Smith & Leiserowitz, 2012) and thus the reliability of such measures cannot be sufficiently assessed. In addition, the present study also argues that when *"holistic affect"* is meant to reflect a global evaluation of the quality of an object, good/bad dimensions are best avoided since these items are likely to tap into a moral dimension[2] (Manstead, 2000). The current research constructively builds on these issues by using multiple indicators that draw on a range of affective-laden adjectives to establish a clearly formulated and reliable measure of "holistic" affect.

2.2.2. Personal experience

A more direct path to establishing visceral concern relies on personal experience with a threat or hazard (Weber, 2006), as direct experiences can elicit strong emotions, making them more memorable and dominant in processing (Loewenstein et al., 2001). Indeed, people's emotional reactions to risks often depend on the vividness with which negative consequences can be imagined or experienced (Loewenstein et al., 2001; Weber, 2006). However, since climate change (as a risk object) cannot be experienced directly (Whitmarsh, 2008), affective evaluations of global warming are often influenced by the popular media (Swim et al., 2011).

Yet, other recent research has shown that most people are able to detect broad changes in local weather patterns (Howe, Markowitz, Ming- Lee, & Leiserowitz, 2013). Moreover, several studies have indicated that heat primes and warmer days influence public perceptions of global warming (e.g., Joireman, Truelove, & Duell, 2010; Zaval, Keenan, Johnson, & Weber, 2014). In addition, people can also experience climate change indirectly through its impacts (e.g., extreme weather events) – although the nature of this relationship hinges on the assumption that people actually causally attribute their experience with extreme weather events to climate change (Helgeson et al., 2012; Weber, 2010). Yet, an increasing amount of evidence now suggests that personal experience with extreme weather events does in fact influence risk perceptions of climate change (e.g., Akerlof et al., 2013; Brody et al., 2008; Krosnick, Holbrook, Lowe, & Visser, 2006; Reser et al., 2012; Spence et al., 2011) - although some exceptions exist (e.g., Whitmarsh, 2008). In addition, the argument could be made that repeated experiences with certain types of extreme weather (e.g., heavy rain or snowfall) might in fact decrease risk perceptions of global warming. While this is a possibility, recent evidence from the United Kingdom suggests that this is rather unlikely (Capstick & Pidgeon, 2014).

It is worth noting, however, that past studies have primarily focused on experience with flooding events (given its saliency as a likely consequence of climate change). Yet, this might not accurately capture an individual's full range of experience with extreme (hot and cold) weather. Accordingly, to further build on this research, this study adopts a wider approach to personal experience, measuring a respondent's experience with both flooding as well as other types of extreme weather events (e.g., heat waves, freak/snow storms, droughts etc.).

2.3. Socio-cultural influences

2.3.1. Culture, values and worldviews

Existing theories of risk perception (including cognitive and affective explanations) have been criticized for "depoliticizing risk" and for neglecting the important role of competing social and cultural structures in shaping individual risk perceptions (Jackson, Allum, & Gaskell, 2006). To this extent, "the cultural theory of risk" (Douglas, 1970; Douglas & Wildavsky, 1982) has become a popular approach to account for cultural differences in risk perception. Cultural theory is based on anthropological research and proposes a conceptual typology of risk culture (i.e., the "grid-group" system), where four broad competing cultural types or "worldviews" are delineated. In short, these include "*egalitarianism*", "*individualism*", "*hierarchism*" and "*fatalism*". The relative position of the cultural types on the group-grid scale is determined by the extent to which individuals feel bounded by feelings of belonging and solidarity *(group)* and the amount of control and structure that people maintain in their social roles *(grid)*.

First operationalized empirically by Wildavsky and Dake (1990), recent studies have found a significant relationship between "cultural worldviews" and risk perceptions of climate change (e.g., Akerlof et al., 2013; Kahan et al., 2012; Leiserowitz, 2006; Smith & Leiserowitz, 2012). Yet, others have fiercely criticized its use. For example, Sjöberg (1997, 1998b) and others (e.g., Boholm, 1996; Oltedal, Moen, Klempe, & Rundmo, 2004) have repeatedly argued that cultural worldviews have low explanatory

[2] Moral emotions such as guilt and regret are conceptually closer aligned with a post-behavioral concept known as *anticipated affect* (van der Pligt, Zeelenberg, Van Dijk, De Vries, & Richard, 1998).

power - even positing that "cultural theory is simply wrong" (Sjöberg, 1998b, p. 150). Others have similarly argued that cultural theory explains little variance, but take a less extreme position and don't dismiss the theory in its entirety (e.g., Marris, Langford, & O'Riordan, 1998) while some continue to support its use (e.g., Slovic & Peters, 1998).

Overall, two main criticisms can be delineated. The first deals with the question of how to operationalize cultural theory empirically while the second relates to whether or not it is appropriate (or even possible) to infer cultural biases from individual-level data. With regard to the latter, existing measures have repeatedly been criticized for lacking construct validity both in terms of scale-reliability as well in terms of discriminant validity between the proposed cultural types (Boholm, 1996; Rippl, 2002; Sjöberg, 1998b). In fact, it's not uncommon for subjects to have high scores on competing scales, which is problematic, since in theory, individuals cannot be characterized by mutually inconsistent worldviews (Kahan, 2012). Yet, even when construct validity is improved, this does not appear to increase the explanatory power of the theory (Rippl, 2002). The second major criticism revolves around the idea that a cultural worldview is simply not an innate psychological tendency that can be inferred from individual-level data (Rippl, 2002). While this paper expresses some support for the idea of a latent "cultural type", this does not discount the argument that systematic cultural differences are best measured between countries and not between individuals[3] (Oreg & Katz-Gerro, 2006).

Given the many complications (both theoretical as well as empirical) associated with the cultural theory of risk (Price, Walker, & Boschetti, 2014), the current paper argues that broad value orientations are a more reliable proxy for modeling cultural influences. In order to understand why, some conceptual distinctions need to be made between the terms "values" "culture" and "worldviews". Values differ from worldviews in two important ways; first, (a) values precede worldviews (Stern, Dietz, Abel, Guagnano, & Kalof, 1999; Stern, Dietz, & Guagnano, 1995) and (b) values can be seen as fundamental guiding principles that are more specific and more stable than worldviews (Schwartz & Wolfgang, 1987; Stern, 2000). Yet, cultural worldviews and values tend to overlap conceptually[4] (Corner, Markowitz, & Pidgeon, 2014), given that cultures are essentially comprised of and characterized by their underlying value structures (Hofstede, 2001; Schwartz, 1992).

While sceptical, Sjöberg (2012) argues that the role of values in risk perception has not been explored sufficiently and that more relevant value structures need to be identified. Accordingly, instead of using Schwartz's (1992) value inventory in its entirety, in the environmental domain, three broad value orientations are considered to be relevant (Stern, Dietz, & Kalof, 1993). These include: (1) *egoistic* values (i.e., maximizing individual outcomes), (2) *socio-altruistic* values (i.e., caring about others) and (3) *biospheric* values (i.e., caring for non-human nature and the biosphere itself). While these value structures tend to be the same in different cultures (Schwartz & Sagiv, 1995), individuals are likely to prioritize them differently (Steg & De Groot, 2012).

In contrast to the cultural typology of risk, the construct validity of these broad value orientations has been reliably established in a series of extensive studies across various contexts and cultures (De Groot & Steg, 2007, 2008, 2010; Schultz, 2001; Steg, De Groot, Dreijerink, Abrahamse, & Siero, 2011; Steg & De Groot, 2012; Stern & Dietz, 1994). In fact, De Groot, Steg, and Poortinga (2013) have recently echoed similar concerns about cultural theory and provide support for the use of broad value orientations in understanding risk perception. A similar view and approach is adopted in the current paper.

2.3.2. The social construction of risk

Inevitably, the way in which people approach and evaluate risks is influenced by other people (Joffe, 2003). In fact, both "social representations theory" (SRT) developed by Moscovici (1984) and the "social amplification of risk framework" (SARF) developed by Kasperson et al. (1988) highlight that interpersonal interactions and the mass media play a crucial role in further circulating existing social representations of risk in a given culture. While the SARF highlights that public risk perceptions are often amplified or attenuated depending on how a risk is communicated, SRT focuses on how the "we'" becomes contained in the response of the "I" (Joffe, 2003, p. 60). While certainly useful in their own right (e.g., Smith & Joffe, 2013), both SRT and the SARF framework have been criticized for being rather vague meta-theories (e.g., see Wåhlberg, 2001; Voelklein & Howarth, 2005). Because both frameworks are more sociological in nature (at least in their level of analysis), it is somewhat unclear how relevant concepts can be readily applied to individual-level data. For example, Renn (2010) acknowledges; "SARF is not a causal theory and does not lead us to identify or quantify the factors that shape and influence the amplification and attenuation processes" (p. 158).

It is surprising that with few exceptions (e.g., Brody et al., 2008), relatively little (quantitative) studies have looked at the role of social factors in driving (individual) risk perceptions of climate change. Given that normative factors are likely to influence risk perceptions (Renn, 2010; Swim et al., 2011), the current study adds to this literature by measuring the normative influence of important social referents directly using a *social norms* approach (Cialdini, Kallgren, & Reno, 1991). Social norms are broadly defined as "expectations of how people are supposed to act, think or feel in specific situations" (Popenoe, 1983, p. 598).

In accordance with the "focus theory of normative conduct" (Cialdini et al., 1991), the current study measures both "*descriptive social norms*" (i.e., the extent to which referent others are taking action to help reduce the risk of climate change) as well as "*prescriptive social norms*" (i.e., the extent to which an individual feels socially pressured to view climate change as a risk that requires action). It is hypothesized that normative influences bear significantly on an individual's risk perception. In other words, the greater the extent to which climate change is viewed as a risk by important social referents (e.g., friends, family etc.), the more it amplifies and intensifies an individual's own risk perception.

2.4. Socio-demographic characteristics

It has been consistently documented that females tend to have higher risk perceptions than males for a wide range of hazards (Slovic, 1999), including climate change (e.g., Brody et al., 2008; O'Connor et al., 1999; Sundblad et al., 2007) – this has also been referred to as the "white-male" effect (Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000). One possible explanation for this is that women are more aware of environmental risks (Dietz, Stern, & Guagnano, 1998) and experience and create more vivid and intense affective imageries (Loewenstein et al., 2001). In addition to gender, political ideology is also often identified as a stable predictor of risk

[3] It should be noted however that cultural theory is sometimes (successfully) used to represent preferences for the role of government (e.g., see Akerlof et al., 2013; Price et al., 2014).

[4] To illustrate the conceptual overlap: egalitarian societies tend to be characterized by strong socio-altruistic values whereas egoistic values tend to be more pronounced in individualistic cultures.

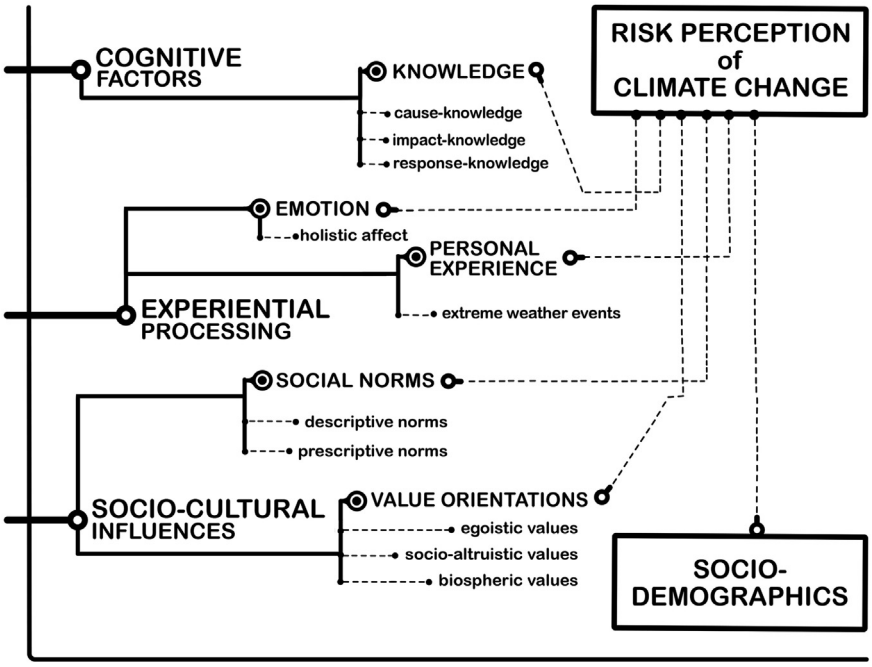

Fig. 1. The climate change risk perception model (CCRPM).

perception (e.g., Leiserowitz, 2006; Malka et al., 2009; Smith & Leiserowitz, 2012), where liberals express more concern about climate change than conservatives. Lastly, it is sometimes assumed that a higher education and socio-economic status provides people with an increased sense of control (and thus lower risk perceptions). While there is some marginal support for this hypothesis (e.g., Akerlof et al., 2013; O'Connor et al., 1999), most studies find little to no correlation between income, age, education and risk perceptions of climate change (e.g., Brody et al., 2008; Milfont, 2012; Sjöberg, 2000b; Sundblad et al., 2007). Given the often inconsistent effect of socio-demographics, they mainly serve as control variables here to assess the net influence of *cognitive*, *experiential* and *socio-cultural* factors on risk perception.

3. The climate change risk perception model (CCRPM)

Based on the preceding discussion, a conceptual overview of the overarching psychological dimensions and included predictor variables is delineated in Fig. 1. Risk perceptions of climate change can be described as a function of *cognitive factors* (i.e., knowledge about climate change), *experiential processing* (i.e., affective evaluations and personal experience) and *socio-cultural influences* (including social norms and broad value orientations) – controlling for key socio-demographic characteristics. While these dimensions are deemed to be particularly critical in explaining public risk perceptions of climate change, the framework (Fig. 1) is not meant to provide an ultimate explanation nor is the list of included predictors meant to be exhaustive. It should also be mentioned that, on a neurological level, affective and cognitive processing mechanisms typically operate in parallel and continuously interact with each other (Chaiken & Trope, 1999; van der Linden, 2014b; Marx et al., 2007; Weber, 2006). In turn, both cognitive and affective processing mechanisms might be conditioned on a third factor such as cultural differences (Kahan, 2012). The aim of this paper is however not to explore the complex interrelationship between these dimensions. Instead, the current study seeks to provide a useful framework to (a) help structurally organize key psychological predictors, (b) validate the importance of *cognitive, experiential* and *socio-cultural* factors in their own right and (c) illustrate that jointly they are able to account for most of the variance in risk perceptions of climate change.

4. Method

4.1. Participants

The data set is based on a nationwide sample ($N = 808$) of the population of the United Kingdom (i.e., England, Scotland, Wales and Northern Ireland). The high degree of internet penetration in this country (about 77% of the population) allowed for an online survey via a survey sampling company (SSI). A national quota sample[5] (based on gender, age and region) was drawn from a large mixed panel of people who were willing to participate in web-based research for a small (non-monetary) reward. The final sample obtained was composed of 50% male and 50% female respondents. The age of participants ranged between 18 and 65, with a modal age bracket of 35–44.

4.2. Materials and procedure

During the design stage of the survey instrument, input was obtained from a panel of three academic and professional experts. In addition, to ensure that the survey questions and response categories were clear and unambiguous, a pilot study was conducted at the behavioral research lab of the London School of Economics using a focus group of ($N = 15$) members of the general public. Results of the pilot study were used to refine the questionnaire. The survey was administered online in October 2012, took about 15–20 min to complete and respondents were assured that their responses remain anonymous.

[5] Although multi-stage randomization was employed to select panellists, given the use of a nonprobability (i.e., quota) sample no data was provided (or collected) on response rates.

Because the survey was part of larger study designed to explore and investigate a wide range of perceptions, attitudes and behaviors related to climate change, only relevant constructs are reported here.

4.3. Measures

4.3.1. Risk perception

Drawing on items developed by Bord et al. (2000) and Leiserowitz (2006), a total of 8 measures were used to create a holistic assessment of risk perception, covering both spatial and temporal dimensions. The first two questions asked respondents to judge how likely they think it is that they will personally experience threats to their overall well-being as a result of climate change. The same was asked for society as a whole. Three questions asked respondents to evaluate how serious of a threat they think climate change is to the natural environment, the UK and to them personally. Respondents were also asked how serious they would rate current impacts around the world, how concerned they are and how often they worry about climate change. For analysis, three indices were created, a *global/societal* risk perception index ($\alpha = 0.95$), a *personal risk* index ($\alpha = 0.87$) and a *holistic* risk perception index ($\alpha = 0.96$).

4.3.2. Knowledge about climate change

Each knowledge scale was assessed with 13 items presented in random order (7 of which were correct statements and 6 were incorrect). "Correctness" here refers to statements for which a strong "scientific consensus" exists in the literature. Thus, the correctness of all statements was based on a collection of independent scientific assessments and expert reports (e.g., IPCC) and checked by two academic climate scientists for accuracy. Responses were dichotomized as either right (1) or wrong (0) and scored and indexed based on the number of *correct* answers (0–13) – where more correct answers indicate a higher knowledge score (references and method adopted from Leiserowitz, Smith, & Marlon, 2010). For the *cause*-knowledge scale respondents were asked to what extent each item (e.g., burning fossil fuels) contributes to climate change (i.e., major, minor or no contribution). A reliable scale was obtained for cause-knowledge ($\alpha = 0.90$). The climate change *consequences/impacts* knowledge scale asked respondents to estimate whether each item (e.g., global sea level) is likely to increase, decrease or not change at all as a result of climate change. Similarly, a reliable scale was created for impact-knowledge ($\alpha = 0.88$). Finally, the *response-behaviors* scale asked respondents to rate how much each item (e.g., conserving energy) is likely to reduce climate change if done worldwide (a lot, a little, not at all). A reliable scale was obtained here as well ($\alpha = 0.94$).

4.3.3. Holistic affect

Following the recommendations of Peters and Slovic (2007), holistic affect was measured using three 7-point bi-polar adjective scales, e.g., "I feel that climate change is" (very unpleasant-pleasant, unfavorable-favorable, negative-positive). A reliable scale was obtained ($\alpha = 0.85$).

4.3.4. Personal experience with extreme weather events

Two questions were used to assess prior experience with extreme weather events. Respondents were asked to recall how often in the last five years they had experienced (a) flooding and (b) other extreme weather events (e.g., severe heat waves, droughts, freak storms etc.) while residing in the United Kingdom. Responses were combined and dichotomized to form an index describing personal experience (0 = no experience, 1 = experience).

4.3.5. Broad value orientations

Drawing on previous work by Schwartz (1992) and Stern et al. (1999), De Groot and Steg (2007) developed a standardized value scale comprised of four *egoistic*, *socio-altruistic* and *biospheric* items. The same measures were used here. Respondents were asked to rate the importance of 12 values "as guiding principles in their lives" on a 9 point scale, ranging from −1 *opposed to my values*, 0 *not important* to 7 *extremely important*. Items were randomly ordered. Reliable scales were obtained for egoistic ($\alpha = 0.79$), altruistic ($\alpha = 0.87$) and biospheric ($\alpha = 0.93$) values.

4.3.6. Social norms

Descriptive norm: On a 7-point Likert-scale, respondents answered three questions about how *likely* they think it is that important referent others are taking personal action to help tackle climate change. A reliable index was obtained ($\alpha = 0.97$).

Prescriptive norm: similarly, on a 7-point Likert-scale, respondents answered four questions about the extent to which they feel socially pressured to personally help reduce the risk of climate change. A reliable index was obtained as well ($\alpha = 0.81$).

4.3.7. Socio-demographic characteristics

Lastly, a range of socio-demographic information was collected, including a respondent's age, gender (1 = female), education, income, religiosity and political party affiliation. For ease of interpretation, political party and level of education were recoded into binary responses (1 = liberal, 0 = conservative) and (1 = higher and 0 = lower education). Please see appendix A for a full description of all measures.

5. Results

5.1. Descriptive statistics

An overview of the intercorrelations, means and standard deviations of the variables used in this study is provided in Table 2. All of the predictor variables are positively and significantly correlated with risk perception, ranging from ($r = 0.10$ to $r = 0.62$). While biospheric values, social norms and affect are most strongly correlated with risk perception, egoistic values and cause-knowledge are least correlated.

5.2. The climate change risk perception model (CCRPM)

Using a theory-based approach, hierarchical multiple regression analysis was used to evaluate to what extent cognitive, experiential and socio-cultural dimensions can explain and predict risk perceptions of climate change (Table 3). Starting with a baseline model,[6] the influence of relevant socio-demographic characteristics is presented in model 1. Results show that gender, education and political party identification are all significant predictors,[7] explaining a total of 6% of the variance in risk perception ($F(3, 643) = 15.30$, $p < 0.001$, Adj. $R^2 = 0.06$). In other words, being female, higher educated and holding liberal political views is associated with increased risk perceptions of climate change.

Model 2 tested whether cognitive factors explain any additional variance in risk perception while controlling for socio-demographic characteristics. Inspection of the beta weights revealed significant effects for knowledge of the (a) causes, (b) impacts and (c)

[6] About 80% of respondents answered all relevant socio-demographic questions ($n = 647$).

[7] Income, age and religiosity were non-significant predictors and therefore not further reported here.

Table 2
Descriptive statistics and intercorrelations.

$N = 808$	1	2	3	4	5	6	7	8	9	10	11	Mean	SD
1. Biospheric Values	(0.93)											6.22	1.79
2. Egoistic Values	0.23***	(0.79)										4.55	1.45
3. Altruistic Values	0.68***	0.27***	(0.87)									6.76	1.56
4. Cause-Knowledge	0.11**	−0.02	0.04	(0.90)								6.24	1.92
5. Impact-Knowledge	0.27***	−0.01	0.20***	0.51***	(0.88)							7.19	2.52
6. Response-Knowledge	0.22***	0.02	0.17***	0.55***	0.61***	(0.94)						8.03	2.69
7. Descriptive Social Norm	0.35***	0.09**	0.23***	−0.01	0.16***	0.18***	(0.97)					4.21	1.46
8. Prescriptive Social Norm	0.43***	0.14***	0.33***	0.07*	0.27***	0.31***	0.62***	(0.81)				4.52	1.11
9. Affect	0.31***	−0.09**	0.26***	0.22***	0.40***	0.35***	0.20***	0.33***	(0.85)			5.33	1.20
10. Personal Experience	0.13***	0.16***	0.11**	−0.02	0.09*	0.15***	0.17***	0.18***	0.08*	(1.0)		NA	NA
11. Risk Perception	0.54***	0.10**	0.38***	0.09*	0.38***	0.36***	0.51***	0.62***	0.54***	0.22***	(0.96)	4.83	1.36

Note: Mean scale reliabilities are provided along the diagonal. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. All variables are coded so that higher values reflect more of the construct.

responses to climate change, explaining an additional 21% of the variance in risk perception ($F(3, 640) = 58.72$, $p < 0.001$, Adj. $R^2_{\text{change}} = 0.21$). Thus, increased knowledge of the causes, impact and solutions to climate change is also associated with higher risk perceptions.

Model 3 explored the influence of experiential processes on risk perception above and beyond the effect of cognitive and socio-demographic factors. Both affect and personal experience with extreme weather events were significant predictors, explaining an additional 25% of the variance in risk perception ($F(2, 571) = 136.07$, $p < 0.001$, Adj. $R^2_{\text{change}} = 0.25$). Thus, personal experience and negative affective evaluations of climate change were both associated with increased risk perceptions.

Model 4 investigated the explanatory power of socio-cultural influences on risk perception in addition to experiential, cognitive and socio-demographic characteristics. Descriptive social norms, prescriptive social norms and biospheric values were all found to be significant predictors, explaining an additional 16% of the variance risk perception ($F(5, 566) = 58.35$, $p < 0.001$, Adj. $R^2_{\text{change}} = 0.16$). The more individuals perceive that others are taking action to help combat the risk of climate change and the more people perceive it is also expected of them, the higher their risk perceptions of climate change. In addition, individuals with stronger biospheric value orientations also tend to view climate change as a greater risk. In contrast, altruistic and egoistic value orientations were non-significant predictors.

In the final (full) model, gender, political party identification, cause-knowledge, impact-knowledge, response-knowledge, holistic affect, personal experience with extreme weather events, descriptive social norms, prescriptive social norms and biospheric value orientations were all identified as significant predictors, accounting for 68% of the total variance in climate change risk perceptions ($F(13, 566) = 93.53$, $p < 0.001$, Adj. $R^2 = 0.68$).[8]

Table 3
Climate change risk perception model results.

Independent variables	Socio-demographics	Cognitive factors	Experiential processes	Socio-cultural influences
	Model 1 (β)	Model 2 (β)	Model 3 (β)	Model 4 (β)
Gender	0.14***	0.13***	0.08**	0.05*
Education	0.10***	n.s.	n.s.	n.s.
Political Party	0.20***	0.13***	0.09**	0.06*
Cause Knowledge	–	0.20***	0.19***	0.11***
Impact Knowledge	–	0.31***	0.13***	0.09**
Response Knowledge	–	0.29***	0.17***	0.10**
Affect	–	–	0.54***	0.37***
Personal Experience	–	–	0.11***	0.05*
Descriptive Norm	–	–	–	0.14***
Prescriptive Norm	–	–	–	0.25***
Biospheric Values	–	–	–	0.20***
Altruistic Values	–	–	–	n.s.
Egoistic Values	–	–	–	n.s.
N	647	647	580	580
adj. R^2	0.06	0.27	0.52	0.68
Δ adj.		0.21	0.25	0.16
F_{change}	15.30	58.72	136.07	58.35

Note: Dependent variable is holistic risk perception (index). Entries are standardized beta coefficients; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ (n.s. = not significant).

Table 4
Relative importance of socio-demographic, cognitive, experiential and socio-cultural influences.

Independent Variables	Partitioning of explained variance
Socio-Demographics	
Gender	0.83%
Political Party	1.34%
Total Variance Explained	2.17%
Cognitive Factors	
Cause-Knowledge	1.02%
Impact-Knowledge	4.34%
Response-Knowledge	3.94%
Total Variance Explained	9.30%
Experiential Processes	
Affect	20.83%
Personal Experience	1.25%
Total Variance Explained	22.08%
Socio-Cultural Influences	
Descriptive Norm	7.10%
Prescriptive Norm	15.10%
Biospheric Values	12.20%
Total Variance Explained	34.40%
Overall Variance Explained	68%

Note: Judgments of relative importance of a dimension should not (only) be made in absolute terms but rather in reference to other constructs in the model. *Note:* Simple correlations can be obtained by rewriting $\sum_j(\beta_j * r_j) = R^2$ so that $r_j = \left(\frac{R^2 j}{\beta_j}\right)$

5.3. The relative importance of cognitive, experiential and socio-cultural factors in explaining climate change risk perceptions

Zero-order correlations and standardized beta weights are commonly used to judge the relative importance of predictor variables in psychological research (Darlington, 1990). Yet, examining

[8] Examination of the collinearity statistics revealed that each predictor fell within acceptable boundaries of tolerance (>0.20) and the VIF coefficient (<5.0), ruling out potential multicollinearity problems (O'Brien, 2007).

Table 5
Factor loadings for societal and personal risk perception measures.

Risk perception measures	Factor loadings (Two-factor solution)
Societal Risk Perception Measure 1	0.88
Societal Risk Perception Measure 2	0.92
Societal Risk Perception Measure 3	0.93
Societal Risk Perception Measure 4	0.92
Personal Risk Perception Measure 1	0.77
Personal Risk Perception Measure 2	0.91
Personal Risk Perception Measure 3	0.79
Personal Risk Perception Measure 4	0.93

them in isolation can be misleading. Therefore, this paper follows a method developed by Pratt (1987) who advanced a theoretically justified and intuitive way of partitioning explained variance among predictor variables. Pratt defined the relative importance of the *j*-th independent variable as the product of two terms: its bivariate correlation with the dependent variable (r_j) and its standardized coefficient in the multiple regression (β_j), where $\sum(\beta_j{*}r_j) = R^2$. Using Pratt's (1987) measure, Table 4 shows how the adjusted R^2 of the full model is partitioned among all predictor variables as well as for each conceptual dimension as a whole.

A few clear observations are made. First, it becomes evident that overall, *experiential* processes (22.08%) and *socio-cultural* influences (34.40%) contribute the majority (56.48%) of explained variance in climate change risk perceptions, whereas *cognitive* (9.30%) and *socio-demographic* (2.17%) factors (while significant) jointly contribute substantially less (11.47%). Overall, *holistic affect* (20.83%) is the single strongest relative predictor of climate change risk perceptions. It is somewhat surprising that most of the variance contribution in experiential processing can be attributed to affect while direct experience with extreme weather events only contributes marginally (1.30%). Finally, it is interesting to note that *cause*-knowledge (1.02%) contributes somewhat less to the explained variance in risk perception when compared to *impact* (4.39%) and *response*-knowledge (3.94%).

5.4. Climate change risk perception: A two dimensional construct?

Judged on a scale of 1–7, overall risk perceptions of climate change were reasonably high ($\bar{x} = 4.83$, SD = 1.36). In order to examine differences in risk judgments in more detail, the eight risk perception items were split into four "*global/societal*" and four perceived "*personal risk*" measures. The difference in mean scores between the two dimensions is highly significant ($\bar{x} = 6.45 > \bar{x} = 4.44$, $SE_{diff} = 0.03$), $t(807) = 67.88$, ($p < 0.001$). A confirmatory factor analysis (CFA) was conducted to test the hypothesis that a two-factor (societal and personal) risk perception solution fits the observed (sample) data better than a unidimensional (one-factor) solution. The factor loadings of the societal and personal risk measures are presented in Table 5 and are all sufficiently high (ranging from 0.77 to 0.92).

Model fit[9] indices are presented in Table 6. It is generally recommended to provide a range of goodness of fit statistics that cover different aspects of model fit. The first statistic in Table 6 is the Chi^2 test - where lower values indicate better fit. The CFI and TLI are comparative (relative) fit indices, where a cut off value of 0.95 indicates good fit and >0.95 excellent fit. The RMSEA and SRMR are absolute fit indices where cut off values between 0.05 and 0.10 indicate a reasonable fit and values <0.05 excellent fit. AIC and BIC are parsimony fit indices and especially useful for model comparison – lower values indicate better fit. A review of the fit statistics suggests that while a unidimensional structure is acceptable, a two-factor solution provides a significantly better fit to the data (Table 6).

5.5. Psychological antecedents of societal and personal risk perceptions

Since risk perceptions of climate change can be conceptualized as having a two-dimensional structure, in addition to analyzing holistic risk perception, a logical next step is to examine to what extent cognitive, experiential and socio-cultural factors can explain both societal and personal risk perceptions and whether these two dimensions have different psychological antecedents. In order to systematically analyze differences in determinants of societal (model 1) and personal (model 2) risk perceptions, two separate regressions were run (Table 7) using the same variables that were included in the final regression model in Table 3. Results point to three important differences. First, when controlling for all other variables in the regression, knowledge of the causes, impacts and responses to climate change are significant predictors of *societal* risk perception but *not* personal risk perception.

Second, while personal experience is a significant predictor of *personal* risk perception, it does *not* predict *societal* risk perception. Third, while egoistic value orientations are a significant predictor of *personal* risk, they do *not* predict societal risk perception. Gender, political party identification, social norms, biospheric value orientations and affect predicted both personal as well as societal risk perceptions. Comparatively, while socio-demographic, cognitive, experiential and socio-cultural factors jointly explain 56% of the overall variance in personal risk perceptions ($F(12, 572) = 61.88$, $p < 0.001$, Adj. $R^2 = 0.56$), they explain 69% of the variance in societal risk perceptions ($F(12, 585) = 106.48$, $p < 0.001$, Adj. $R^2 = 0.69$).

6. Discussion

Public risk perceptions of climate change are clearly complex and multidimensional. The purpose of this paper has been to provide a more systematic and detailed understanding of the social-psychological determinants that underlie risk perceptions of climate change. To this extent, a climate change risk perception model was advanced, combining cognitive, experiential and socio-cultural factors to explain and predict risk perceptions of climate change (while controlling for key socio-demographic factors). Using a national sample, the current study validates the predictive and explanatory power of the model.

6.1. Evidence for a climate change risk perception model (CCRPM)

It was stated earlier that "*the aim of the work is to find a model which is as fully explanatory as possible*" (Sjöberg, 2012, p. 665). The current research has shown that four conceptual dimensions can be validated empirically: cognitive, experiential, socio-cultural and socio-demographic factors all play a significant role in explaining and predicting holistic risk perceptions of climate change, accounting for more than two-thirds (68%) of the variance - which is substantially more than any published study to date (to the best of my knowledge). In fact, in terms of explaining "true variance", it may very well approximate the ceiling (Sjöberg, 2002). Overall, experiential and socio-cultural processes were most influential, weighing in substantially more than either cognitive or socio-demographic factors in explaining public risk perceptions of climate change. This study also provides empirical evidence for a two-dimensional structure (personal vs. societal risk perceptions)

[9] CFI and SRMR are generally preferred (Iacobucci, 2010). For a detailed discussion of goodness of fit statistics and appropriate cut-off values see Hu and Bentler (1999) and McDonald and Ho (2002).

Table 6
Goodness of fit statistics for a two vs. one factor solution (CFA).

Risk perception ($N = 808$)	χ^2 (d.f.)	$\Delta\chi^2$	CFI	TLI	RMSEA	SRMR	AIC	BIC
One-Factor Solution (Unidimensional)	345.11 (14)*		0.94	0.91	0.16	0.04	15700	15798
Two-Factor Solution	**181.35 (13)***	164.76(1)*	**0.97**	**0.95**	**0.11**	**0.03**	**15537**	**15641**

Note: *$p < 0.001$. The following measures of fit are reported: Comparative Fit Index (CFI); Tucker Lewis Index (TLI): Root Mean Square Error of Approximation (RMSEA); Standardized Root Mean Square Residual (SRMSR); Akaike Information Criterion (AIC); Bayesian Information Criterion (BIC). Bold is used to highlight differences between models.

and highlights important differences in their psychological antecedents.

6.1.1. Socio-demographic characteristics

In terms of the model's components, socio-demographic factors such as gender and political orientation were found to be significant and consistent predictors of both personal as well as societal risk perceptions of climate change. In particular, females and liberals tend to view climate change as a greater risk, which is consistent with previous research (e.g., Brody et al., 2008; Leiserowitz, 2006; Malka et al., 2009; O'Connor et al., 1999; Sundblad et al., 2007).

While some research has suggested that higher income and higher education should provide people with an increased sense of control and thus lower risk perceptions (e.g., Akerlof et al., 2013; O'Connor et al., 1999), the current research finds little support for this hypothesis, as level of education quickly lost its significance after controlling for knowledge-factors. Moreover, income and age had no significant effect on risk perception - which is also consistent with other recent research (e.g., Kellstedt et al., 2008; Milfont, 2012; Sundblad et al., 2007). Overall, socio-demographics only accounted for a relatively small amount of variance in climate change risk perceptions.

6.1.2. Cognitive factors

While a substantial amount of confusion has surrounded the role of knowledge in risk perception (cf. Kellstedt et al., 2008; Malka et al., 2009; Reser et al., 2012; Tobler et al., 2012a, 2012b), this study distinguishes between three types of knowledge and confirms that knowledge about the (a) *causes,* (b) *impacts* and (c) *responses* to climate change are all *positively* and *significantly* related to holistic risk perceptions of climate change. Thus, people tend to view climate change as a higher risk when they have knowledge about the causes of climate change, knowledge of what the likely impacts are as well as information about appropriate response behaviors.

Yet, overall, cause-knowledge contributed less to the explained variance than either impact or response knowledge. One possible explanation is that (as opposed to abstract knowledge about cause mechanisms) knowledge about the negative consequences of climate change is likely to elicit more vivid risk perceptions (Weber, 2006). Moreover, upon closer examination it becomes clear that the contribution of knowledge largely stems from its effect on societal risk perception, given that the knowledge items did not explain any variance in *personal* risk perceptions (when controlling for all other variables). It may very well be that since most of the knowledge items were measured on a general level they are likely to correspond more strongly with societal rather than personal risk measures. Yet, this seems to suggest that general knowledge about climate change may not readily map onto a personalized sense of risk.

Table 7
Antecedents of societal and personal risk perceptions.

Independent Variables	Societal risk	Personal risk
Gender	0.05*	0.07**
Political Party	0.06**	0.08**
Cause Knowledge	0.10***	n.s.
Impact Knowledge	0.12***	n.s.
Response Knowledge	0.09***	n.s.
Affect	0.39***	0.29***
Personal Experience	n.s.	0.06*
Descriptive Norm	0.14***	0.16***
Prescriptive Norm	0.23***	0.26***
Biospheric Values	0.22***	0.23***
Egoistic Values	n.s.	0.07*
Altruistic Values	n.s.	n.s.
N	585	585
adj. R^2	**0.69**	**0.56**
F	106.43	61.88

Note: entries are standardized beta coefficients, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ (n.s. = not significant). Bold is used to highlight differences between models.

6.1.3. Experiential processes

While some research has been dismissive of the role of emotion and affect in risk perception (e.g., Sjöberg, 2006), the current research finds that holistic *affect* is the single most important predictor of both personal as well as societal risk perceptions of climate change. These results are entirely consistent with research conducted in the United States (e.g., Leiserowitz, 2006; Smith & Leiserowitz, 2012) and provide robust evidence for the role of affect in risk perception. In addition, the current study also provides further support for the growing link between personal experience with extreme weather events and risk perceptions of climate change (e.g., Akerlof et al., 2013; Krosnick et al., 2006; Spence et al., 2011).

While, on average, people who have experienced extreme weather events tend to have significantly higher risk perceptions of climate change, the relative explanatory power of personal experience proved not particularly strong. This finding may be explained by the fact that an explicit (perceptual) link needs to be made salient in order for people to actually causally attribute their experience to climate change (Helgeson et al., 2012; Weber, 2010; Whitmarsh, 2008). For example, other recent research has highlighted a relationship between personal experience with extreme weather and belief in the reality of climate change (Myers, Maibach, Roser-Renouf, Akerlof, & Leiserowitz, 2012), possibly by helping to reduce its abstract nature, as every day weather is something people are familiar with and can easily relate to (Smith & Joffe, 2013).

Yet, although personal experience correlated significantly with both personal and societal risk perceptions, it remains questionable whether personal experience with extreme weather also breeds concern for society as a whole, given that it was not a significant predictor of societal risk perceptions (after controlling for all other factors). Thus, the role of personal experience with extreme weather (and how it influences risk perceptions) clearly deserves more attention in future research.

6.1.4. Socio-cultural influences

Surprisingly, relatively little quantitative research has investigated the role of social factors in shaping individual risk perceptions of climate change. The current study focused on assessing normative influence from a social norms perspective. Results indicate that both descriptive and prescriptive social norms influence risk perceptions of climate change. In other words, the more social referents recognize and act upon the risk of climate change,

the more it amplifies and intensifies an individual's risk perception - confirming that social norms significantly influence perceptions of climate change (Renn, 2010; Swim et al., 2011).

Furthermore, in line with other recent research (e.g., De Groot et al., 2013) the present study also supports the inclusion of broad value orientations as important predictors of climate change risk perceptions. In particular, while biospheric values (i.e., caring about nature and the biosphere) were identified as a strong predictor of both personal as well as societal climate change risk perceptions, social-altruistic values did not predict either. A likely explanation for the non-significant role of altruistic values is that biospheric and altruistic values tend to be strongly and positively correlated. Therefore, in the context of environmental problems, the activation of biospheric values is more salient and altruistic values are unlikely to add any additional variance, unless both value orientations are in conflict (De Groot & Steg, 2007). The finding that egoistic value orientations predicted *personal* but not societal risk perceptions is non-controversial: self-centred concerns about climate change impacts are unlikely to predict concern for society as a whole. Overall, socio-cultural influences explained most of the variance in risk perception.

6.2. Implications for public risk communication and future research

The present study has important implications for public risk communication. First and foremost, because risk perceptions of climate change are influenced by cognitive, experiential as well as socio-cultural factors, risk messages are likely to be more effective when they not only provide people with increased knowledge of the causes, consequences and solutions to climate change, but also appeal to affective and experiential processing mechanisms whilst being sensitive to different socio-cultural value orientations. Indeed, public interventions that appeal to multiple aspects of human behavior simultaneously are more likely to be successful (van der Linden, 2014a). For example, a recent promising strategy has been to advance public knowledge (i.e., cognitions) of the scientific consensus on climate change (van der Linden, Leiserowitz, Feinberg, & Maibach, 2014). Yet, such messages are likely to be even more effective when at the same time, a social norm is harnessed to view climate change as a hazard that needs to be addressed (i.e., social amplification).

It is important to note however, that the variables reported in this study do not necessarily have direct causal efficacy in and of themselves. For example, one-way “downstream” public risk communication messages often interact, in a complex way, with “upstream” communications part of a growing political and ideological divide on the issue of climate change (McCright, Xiao, & Dunlap, 2014). Thus, risk messages also need to be sensitive to and considerate of different socio-political audiences, especially in countries where political polarization is high, such as the United States (Hart & Nisbet, 2012; McCright & Dunlap, 2011).

Yet, when dealing with conflicting informational cues, people tend to rely more heavily on affective and experiential processing (Marx et al., 2007), potentially through personal or vicarious experience with extreme weather events (Myers et al., 2012). For example, practitioners and policy-makers could consider designing climate communications that highlight and aid the recall of such relevant personal experiences. While it has been argued that this approach could prove problematic in the face of heavy rainfall or cold weather, recent research by Capstick and Pidgeon (2014) suggests that because the term”climate change” (rather than global warming) has been used as the predominant frame in the UK, “extremely cold winters” are not necessarily interpreted by the public as evidence against a rise in average global temperatures. Nonetheless, a sensible risk communication strategy would highlight that cold weather extremes are not inconsistent with global warming. Risk messages should also take into account important differences in determinants between personal and societal risk perceptions. For example, while increased knowledge of climate change may lead to more concern for society as a whole, it does not readily translate into a personalized sense of risk. In line with recent research that has assessed the effects of global vs. local framing (Scannell & Gifford, 2013), future research could consider making information about the causes, impacts and responses to climate change more personally and locally relevant.

Lastly, the current study is of course not without limitations. First, it should be noted that results of the current study are correlational and based on a national quota sample of British respondents. Thus, it remains unclear to what extent results are generalizable to other contexts and cultures. Although, as mentioned, findings of the current study do appear to be strongly aligned with the US context, particularly regarding the importance of experiential and socio-cultural variables in explaining risk perceptions of climate change.

Second, while the aim of the current study was to examine key social-psychological determinants, the list is certainly not exhaustive, as other important factors have also been noted to influence risk perception, including trust in scientists/experts and exposure to popular media (e.g., Kellstedt et al., 2008; Malka et al., 2009; Slovic, 2006). Future research could also constructively build on the current study by further exploring the interrelated nature of cognitive, experiential and socio-cultural factors in shaping risk perceptions of climate change. Lastly, while designed for the context of climate change, future research may find the psychological framework outlined in this paper equally useful for predicting risk perceptions of other types of (environmental) risks.

7. Conclusion

This paper advanced a social-psychological model of climate change risk perceptions. Using a large set of reliable measures, the model was tested on a national sample. Results provide robust evidence for the influence of cognitive, experiential and socio-cultural factors, jointly explaining nearly 70% of the variance in climate change risk perceptions (after controlling for key socio-demographic characteristics). Findings also confirm an empirical distinction between societal and personal risk perceptions and highlight important differences in their psychological antecedents. Taken together, these results suggest that risk perceptions of climate change are complex and multidimensional and that risk communicators should take an integrative approach by appealing to multiple aspects of human judgment and behavior.

Acknowledgments

I would like to thank Anthony Leiserowitz, Richard Perkins, Breanne Chryst, Lisa Wright and two anonymous reviewers for their helpful ideas, advice and comments on earlier drafts of this manuscript. This research has been supported by the Grantham Foundation for the Protection of the Environment, as well as the Centre for Climate Change Economics and Policy, which is funded by the UK's Economic and Social Research Council (ESRC) and by Munich Re.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jenvp.2014.11.012.

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