

Risk Perceptions and Terror Management Theory: Assessing Public Responses to Urban Flooding in Toronto, Canada

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Abstract Terror Management Theory (TMT) suggests that mortality salience (MS), or death reminders, should impact environmental behaviour and decision-making by increasing consumption and resource usage, shifting aesthetic preferences toward cultivated landscapes, and affecting adherence to environmental norms. We examined MS effects on residential flood risk perceptions in Toronto, Canada, following the major urban flood in July 2013. Survey responses were analyzed to assess risk perceptions across nine categories; analyses through the Wilcoxon-Mann-Whitney test show statistically insignificant differences between MS and control groups for all subcategories. Coupled with the TMT literature, the results indicate that existential anxiety is more likely to affect flood risk perceptions through worldview defense when the social dimension of flooding is made clear. Toronto residents' societal beliefs about flooding play a major role in guiding flood management strategies. Our results provide scholarly and practical direction for flood risk communication strategies to promote the adoption of private flood-prevention measures, suggesting that anthropocentric framing of flooding issues will not induce negative environmental behaviour and may increase concern for flooding issues.

Keywords Canada · Communication · Mortality salience · Risk perceptions · Social psychology · Urban flooding · Water

1 Introduction

Flooding can be a devastating event that causes significant property damage, health problems and loss of life. Flood risk is increasing because of development in low-lying flood-prone areas in riparian and coastal zones, compounded by climactic changes to weather patterns (Proença

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de Oliveira et al. 2015). Across Europe, flooding and storm-related disasters accounted for 77 % of economic damages caused by extreme weather between 1980 and 2006 (Bubeck et al. 2012); new risk management strategies are needed for urban areas (Hegger et al. 2014). In Australia climate changes are driving extreme variability in both water scarcity and flooding (Godden and Kung 2011).

In Canada, recent extreme floods have highlighted the threat of flooding to safety and livelihoods across the country. For example, in June 2013 flooding in Calgary, Alberta forced the evacuation of 100 000 people and caused municipal property damage of an estimated CND \$400 million (Schnebele et al. 2014). Only 1 month later, Toronto, Ontario experienced the most expensive natural disaster in the province's history: damages of CND \$940 million caused by severe urban flooding (Insurance Bureau of Canada 2014). As Canada's most populated city, Toronto is particularly vulnerable to flood damage because of the age of its infrastructure, population density, water demands, urban river system and its location on the shores of Lake Ontario (Nirupama et al. 2014).

In addition to the large-scale flood management infrastructure undertaken by provincial or municipal governments, small-scale private flood mitigation strategies can help to reduce flood risks and damage (Bubeck et al. 2012). For example, homeowners' precautionary measures at the lot level can effectively reduce flood damage to buildings and contents by 53 % (Kreibich et al. 2005). Given the potential of private precautionary measures to reduce overall harm, improving individuals' or households' flood preparedness can be an important strategy. Individual beliefs about flooding issues greatly influence effectiveness of strategies (Soane et al. 2010; Terpstra 2011). Effective risk communication tools are essential for improving private mitigation capacities and increasing informed decision-making (Kellens et al. 2013).

Flood risk perceptions research is an emerging multidisciplinary field that allows for diverse methods and results (Correia et al. 1998; Kellens et al. 2013). For example, 'multi layered safety' principles have emerged from the flood-prone Netherlands (Hegger et al. 2014) and integrated approaches sensitive to evolving social realities attempt to improve preparedness through more effective risk communication tools. This research emphasizes the importance of local knowledge and flooding perceptions (Kellens et al. 2013).

There has been notable success in identifying some underlying predictors of lay risk perceptions (Soane et al. 2010). However, many studies have found a large influence of non-measured confounding variables, indicating that further research is required (Kellens et al. 2013). Risk perception researchers have observed significant differences between "objective" expert risk assessment and the public's "intuitive" risk judgements (Ho et al. 2008). Understanding this disconnect and the underlying factors will enable more effective risk communication, help to design mitigation policies that better reflect social beliefs, and promote active mitigation behaviour at the residential level (Ho et al. 2008).

In this study we consider urban floods and risk assessments. We used insights from social psychology's Terror Management Theory (TMT) to examine the role of individuals' mortality fears in altering flood risk perceptions. This is the first research incorporating mortality salience and water risk perceptions or, more broadly, the values and decisions associated with water. Previous work in flood risk perceptions has focused on more traditional assessments of emotional affect, whereas TMT research on environmental issues is limited largely to material consumption, perceptions of nature and climate change response. Only two known papers have integrated TMT principles with risk perceptions research (Goodwin et al. 2011; Ng and Rayner 2010), and neither of these papers addressed flood risk or water decision-making.

Our research was designed to explore the role of mortality salience – death reminders – in moderating risk perceptions of future urban flooding. We hypothesized that mortality salience primes would affect flood risk perceptions in measurable ways, specifically by increasing perception of risk. In TMT studies, subconscious death fear has been shown to measurably alter perceptions and behaviours, most notably by increasing respect for personal worldview and increasing dislike for people or behaviours threatening to that worldview (Arndt et al. 2004; Solomon et al. 2004). Our results explain the effects of mortality salience on urban flooding risk perceptions, and suggest communication options.

2 Theoretical Foundations

Terror Management Theory is a dynamic field that codified and expanded on the work of social anthropologist Ernest Becker, who argued that fear of death haunts the human mind (Becker 1973). Our unique sense of self-awareness allows us to comprehend the inevitability of our own death. Recognition of our mortality challenges the human mind by contrasting our symbolic and creative selves against our physical needs; we are unable to fully escape from nature's constraints. This dualism creates cognitive tension and an existential dilemma that we spend our lives trying to overcome. Awareness of inevitable death drives engagement in anxiety-buffering actions to repress that knowledge and pursuit of personal value, usefulness and meaning.

2.1 Terror Management Theory and Risk Perceptions

Culture provides a framework of diverse symbolic meanings that exists above and beyond the natural world (Becker 1973). By engaging in culturally sanctioned activities, individuals can increase their feelings of self-esteem; greater self-esteem mitigates one's existential anxiety (Rosenblatt et al. 1989). For example, symbolic immortality is sought through “hero projects”, which offer both a greater sense of self-esteem and a sense of being part of something larger and more important than the self. The longevity of a “symbolic self” is exemplified by hero projects that include nations and nationalism, monumental architecture, or social movements. Because individuals use hero projects to generate self-esteem and to be “part of something” that will extend beyond their physical existence, any threat to that “something” will cause them significant distress.

A substantial body of empirical research, primarily from clinical psychology, has emerged to test TMT principles (Greenberg et al. 1994; Pyszczynski et al. 1996; Florian and Mikulincer 1997; Solomon et al. 2004). Mortality salience (MS), or the death reminder, has been shown to affect behaviour in multiple ways. Most notably, MS increases people's esteem for their own worldview and its cultural heroes, and increases their condemnation of people or behaviours that threaten it (Rosenblatt et al. 1989). Threats to one's personal worldview and culture are subconsciously or consciously viewed as a threat to one's literal or symbolic immortality (Arndt et al. 2004; Solomon et al. 2004).

While many clinical TMT studies are designed to induce MS by asking the participants direct questions about their own death, MS primes outside of the laboratory setting – e.g., the sight of a funeral home, death scenes on television or life insurance company brands – are also influential (Pyszczynski et al. 1996; Fransen et al. 2008; Dar-Nimrod 2012). Given the

frequency of exposure in everyday life, death fears may play a much more significant – if largely subconscious – role in behaviour and social perceptions than widely appreciated.

2.2 Terror Management Theory and Environmental Behaviour

The human capacity to recognize our own mortality explicitly influences our relationships with the environment in multiple ways. Three are outlined below: how mortality salience influences our material consumption patterns; perceptions of, and preferences for, different types of natural settings; and our pro-environmental behavioural choices.

2.2.1 *Material Consumption*

Many societies, particularly contemporary western culture, use wealth accumulation and luxury goods consumption as indicators for individual worth, thereby providing culturally sanctioned symbolic immortality (Arndt et al. 2004). One's status and luxury consumption are inextricably linked: in a research study, MS-primed participants indicated an increased appeal for luxury goods such as a Rolex watch, but a decreased appeal for low- or non-status goods like Pringles (Mandel and Heine 1999). Individuals who were primed with death thoughts had elevated expectations of their future financial worth and spending practices compared to participants in the control groups (Kasser and Sheldon 2000). High material consumption levels are directly connected to increased, unsustainable resource usage and the corresponding degradation of the environment. In studies concerning management of common-pool resources, MS-primed participants were greedier than control participants, taking more resources for their own gain (Kasser and Sheldon 2000).

2.2.2 *Perceptions of Nature*

Humanity has a complex relationship with nature and wilderness. While nature is known to provide an individual with restorative and health benefits (Frantz et al. 2005), humans have long sought to control and distance themselves from nature (Kinsley 1995). Environmental historians document how the social and cultural relationships with nature have resulted in the human manipulation of landscapes with significant environmental consequences (Tvedt 2010). Because wilderness is intrinsically associated with human vulnerability and potential death, mortality salience increases one's positive reactions to cultivated nature and decreases acceptance of wilderness areas (Koole and Van den Berg 2005). Preferences for highly-managed landscapes have a direct impact on flooding dynamics in the built environment, and creating a more dynamic and decentralized decision-making process that includes homeowners is critical for reducing flood vulnerability (Pearson et al. 2010; Makropoulos and Butler 2010).

2.2.3 *Pro-Environmental Behaviour*

Perhaps one of the most expansive TMT-environment research themes pertains to MS effects on environmental norms and behaviour. Recent studies have indicated that existential threat affects environmental behaviours both positively and negatively depending on multiple factors. For example, existential threat in combination with awareness of pro-environmental norms increases individuals' pro-environmental attitudes, sustainable behaviour, and frequency of positive environmental actions (Fritsche et al. 2010b). By extension, positive

environmental behaviour may increase when mortality is made salient in societies where environmental knowledge is already high (Vess and Arndt 2008; Fritsche et al. 2010b).

Mortality salience primes for individuals who derive self-worth from environmental action increase concerns for environmental degradation, while the opposite is true for those who do not derive self-esteem from environmental action (Vess and Arndt 2008). In the latter case, conventional anthropocentric framing of environmental issues may actually undermine behavioural change efforts because individuals consume ever-greater amounts of goods as a distal defense. On this basis, Dickinson (2009) argued that the climate change discussion should instead promote community-led conservation projects that focus on “charismatic” species such as birds, and build human-nature connections that highlight significance of nature, the cosmos and humanity’s place within those alongside rational analytical thinking and knowledge.

However, the motivations underlying one’s environmental concern for the environment are also influential: MS decreased motivation to protect nature for biocentric reasons, but did not affect environmental action taken for anthropocentric reasons (Fritsche and Hafner 2012). The motivation question is critical for the discussion of how to most effectively frame climate change issues – and specifically urban water issues – for the public. Particularly in water crises, where efforts at the household level can be critical, the importance of understanding individuals’ motivation and risk perceptions could prove to be essential to good management. For example, one study found that environmental action was valued higher when climate change threat was framed as relevant to the individual’s in-group or their children, rather than connecting the relevance to unidentified future generations or distant populations (Fritsche and Hafner 2012). Perceptions of climate change threat are also influenced by the individual’s place attachment and by messaging that frames the threat as a local issue (Scannell and Gifford 2013). Based on these findings, the most effective climate change framing will identify the direct threat to the local area to promote positive environmental action, particularly for individuals who are parents and who might derive their self-esteem from ecological action.

2.3 Flood Risk Perceptions

Flood management techniques are increasingly shifting from large-scale engineering projects toward integrated, small scale, and risk-based approaches (Godden and Kung 2011; Bubeck et al. 2012; Hegger et al. 2014; Ballesteros-Cánovas et al. 2013). Research focuses on the relationship between individuals’ risk perceptions and their preparedness for, or mitigation behaviour to promote, lot-level flood preparedness (Correia et al. 1998; Soane et al. 2010). The term “risk perceptions” is used in a variety of ways in the literature; throughout this paper, we define risk perceptions as incorporating two dimensions—perceived probability (likelihood) and perceived consequences (severity) of an event (Bubeck et al. 2012).

The relationship between flood risk perceptions and preparedness behaviour is tempered by multiple variables. Personal threat perceptions are strongly correlated with the adoption of positive environmental actions (Baldassare and Katz 1992). This relationship is known as threat appraisal, where perceptions of threat influence personal preparedness and mitigation behaviour. However, protection motivation theory asserts that threat responses are mediated not only by threat appraisal, but also by coping appraisal, the perception of the efficacy of various possible risk responses (Bubeck et al. 2012). It is therefore critical to address not only perceptions of risk, but also perceptions of various coping strategies and their effectiveness. Perceived efficacy of protective measures against flooding showed a stronger positive correlation with preparedness behaviour than the relationship between either risk perceptions and

preparedness behaviour, or resource-related attributes such as cost of preparing, and preparedness behaviour (Soane et al. 2010; Terpstra and Lindell 2012). There is also evidence that anxiety and insecurity about flooding are more influential on preparedness behaviour than either material or financial concerns (Harries 2012). Other factors affecting preparedness behaviour include fear or worry about flooding, knowledge of flooding hazards, age, trust in flood regulators, and socioeconomic factors such as building ownership (Bubeck et al. 2012).

These threat and coping perceptions, which influence behaviour in various ways, are themselves moderated by multiple factors. Previous flood experience is one of the primary factors that increase an individual's perceived flooding risks, even when flood risks are not actually high (Correia et al. 1998; Siegrist and Gutscher 2006; Ho et al. 2008; Kellens et al. 2011). Individuals with previous flood experience perceived a higher likelihood of future floods, saw flooding as more life threatening, and dreaded this occurrence more than others (Ho et al. 2008).

The effect of past experience on flood risk perceptions is formalized in two separate but related risk perception frameworks: the availability heuristic and the affect heuristic. According to the availability heuristic, the ease with which hazard examples can be accessed in an individual's conscious mind is directly related to their estimation of the probability of hazards occurring (Siegrist and Gutscher 2006). Applying the availability heuristic, Siegrist and Gutscher (2006) found that participants who could better remember flood experiences perceived higher flood risks than those who did not have flood experience. The affect heuristic suggests that the intuitive, almost automatic experiential system of risk response—the affect—increases the accessibility of hazard-related thoughts (Keller et al. 2006). Affect guides decision-making through emotional risk representations, which in combination with a rational analytical system, creates more advanced risk perceptions by combining emotional response with factual evidence (Slovic et al. 2004). In their application of the affect heuristic to flooding, Keller et al. (2006) showed that participants with flood experience perceived higher flood risk, and perceived statistical flooding data to be more serious than people without previous experience.

These recognized, mostly negative, emotional responses to flooding play an important role in altering individuals' flood risk perceptions. Siegrist and Gutscher (2008) argued that fear played a much more influential role in affecting perception for those affected by flooding than those unaffected. Those with previous flooding experience indicated emotions of insecurity, fear, shock and helplessness; non-affected participants rarely mentioned these negative emotions when they considered future flooding (Siegrist and Gutscher 2008).

Not all emotional responses to risk are negative, particularly when risks are undertaken voluntarily (Keller et al. 2006). Applying the affect heuristic to flooding, Terpstra (2011) explored the role of positive emotions in flood experiences. Similar to other studies, negative emotions increased risk perceptions, but positive emotions, such as feelings of solidarity, had the opposite effect. Higher personal levels of trust in public flood prevention reduced risk perceptions, reduced dread of flooding and hampered flood preparedness (Terpstra 2011). This finding is consistent with the affect heuristic, which states that while negative emotions increase risk perceptions, positive emotions should decrease risk perceptions (Slovic et al. 2004).

One of the most influential metrics within risk perceptions research is the psychometric paradigm, which also explores the factors affecting individual's risk perceptions. According to the psychometric paradigm, the two principle components correlated with risk perceptions are "dread risk" and "unknown risk" (Siegrist et al. 2005). Dread risk pertains to perceptions of lack of control, dread potential and fatality potential, while unknown risk relates to perceptions of

newness, scientific expertise and delay of effects (Siegrist et al. 2005). A third principal “exposure”—or number of people affected—is also included as a significant factor. The psychometric paradigm usually accounts for up to 70 % of variations in data sets, although it is criticized for its use of aggregate data that may conceal individual variances (Siegrist et al. 2005). Addressing this critique, Marris et al. (1997) considered the effectiveness of the psychometric paradigm at the individual level, and found that most relationships between characteristics and risk perceptions still held true except for some areas such as “lack of knowledge of those exposed”. Based on these findings, the psychometric paradigm accounts for statistical variation relatively effectively for both aggregate and individual risk perceptions data.

Several other factors also influence how closely individuals’ flood risk perceptions relate to actual flood risk levels. For example, Botzen et al. (2009) found that absence of physical flood barriers, respondents’ age and higher education levels all decreased flood risk perceptions, while awareness of the causes of flooding increases risk perceptions. In contrast, Kellens et al. (2011) found age and risk perceptions to be positively correlated, where older participants indicated higher risk perceptions. Women typically perceive higher levels of risk than men (Ho et al. 2008; Kellens et al. 2011) and a higher likelihood for negative outcomes.

The literature on flood risk perceptions provides extensive and sometimes conflicting findings on the underlying psychological and experiential factors. In a review of flood risk literature, the lack of methodological standardization in risk perceptions theories, measurement, and data analysis reduced the comparability of studies’ results (Kellens et al. 2013). Such diversity is likely caused by the field’s comparative youth, in which interdisciplinary researchers apply a variety of methods to reach the same goals. Researchers often use their own regression models to make predictions, which, although able to detect some predictors of risk perceptions, often indicate a high presence of non-measured confounding variables (Kellens et al. 2013).

2.4 Linking Risk Perceptions Research and Terror Management Theory

There are limited studies that have explored the relationship between risk perceptions and TMT. Goodwin et al. (2011) assessed risk perceptions of swine flu held by Malaysian pig farmers at the geographic centre of the swine flu pandemic. The researchers assessed differences in risk perceptions and identified mortality salient participants by their relative anxiety level toward contracting and dying from the swine flu. TMT grounded the research and the results indicated that mortality anxiety caused by swine flu increased bias against out-groups. These out-groups included homosexuals, prostitutes and the homeless, who participants considered to be at higher infection risk (Goodwin et al. 2011). Although only 4 % of participants admitted to directly discriminating against out-groups, 46 % indicated that they had known of friends avoiding contact with out-groups, a discriminatory avoidance response that was unsupported by epidemiological evidence.

Ng and Rayner (2010) found that outcomes in risk perceptions research may be confounded by MS when risk primes include death reminders. Such unintentional MS may invoke cultural bias, leading to more extreme perceptions of risk. Ng and Rayner (2010) suggest that because of the inevitable link between hazard thoughts and mortality thoughts, the two considerations cannot be studied separately without acknowledging some confounding potential. Risk researchers should modify questionnaires very carefully to minimize both implicit and explicit MS priming (Ng and Rayner 2010).

Complementary to our study, Vastfjall et al. (2008) used a similar prime with survey methodology but without the terror management theoretical foundation. Participants in a

survey who were primed with an article on the 2004 East Asia tsunami, which did not contain explicit reminders of mortality, perceived their life to be more finite and to present fewer opportunities, than those in the control group who were primed with a neutral reminder (Vastfjall et al. 2008). Thus mortality was still salient, despite the absence of explicit death primes, reconfirming Ng and Rayner's (2010) insights into confounding potential between risk primes and death primes.

While Goodwin et al.'s research (2011) provides support for a positive correlation between MS and risk perceptions, other research offers a different perspective. Risk perceptions research indicates that negative affect increases risk perceptions, however TMT research shows that induced mortality salience does not exert lasting negative affect on participants (Arndt et al. 2001). Arndt et al. (2001) found that a death prime provoked subtle negative affect only during the stimulus period - the affective state dissipated quickly - and only for death primes but not for pain primes. Because the affective state was not sustained, the researchers concluded that the effect was subtle and insignificant. Based on these conclusions, any effects of MS on flood risk perceptions would likely not be caused by negative affect but would be a result of another pathway or underlying factor.

Based on this literature we explored the effect of mortality salience priming on Torontonians' flood risk perceptions. We hypothesized that mortality salience primes would affect flood risk perceptions in measurable ways, specifically by increasing perception of risk within subcategories of risk perception. These nine subcategories included: belief in climate change; trust in flood protection; perceptions of control over flood events; perceptions of the likelihood of flooding; perceptions of the consequences of flooding; feelings of dread; perceptions of unknown; perceptions of exposure; and individual preparedness intent for future flooding. These subcategories were largely drawn from Terpstra's (2011) work on affective and cognitive routes of risk perception, with the addition of perceptions of unknown and exposure (drawn from the psychometric paradigm) and participant belief in the role of climate change in increasing flooding. The following section details our methodology for exploring perceptions within these subcategories.

3 Methods

3.1 Case Study

On July 8, 2013, the Greater Toronto Area (GTA) experienced a severe thunderstorm and subsequent flood event. Post-storm data indicated that 126 mm of rainfall were recorded at the Toronto Pearson International Airport, with most of the rainfall occurring from 4:00–6:00 p.m. (Environment Canada 2014). Approximately 300,000 people were affected by electrical power outages, with 1400 people stranded for hours on public transit because of flooded roadways, train tracks and subway lines (Canadian Broadcasting Corporation 2013). The storm was the most expensive natural disaster in Ontario's history, resulting in CND \$940 million in damages to local properties (Insurance Bureau of Canada 2014).

Our data was collected using a survey that was completed on June 12, 2014 at a community centre in downtown Toronto. On that day, the community centre was providing multiple services to a wide demographic: in addition to providing regular services including special interest workshops, child day care, and a public cafeteria, it also served as a polling station for the Ontario provincial election. The community centre therefore drew a diverse group from the downtown area, including voters, business people, seniors, young parents, and employees who

lived in the area and other parts of the city. A description of the study sample is presented in the Results section.

3.2 Procedure

Our study was reviewed by the Office of Research Ethics from the University of Waterloo and received clearance using the following procedure and methods. Participants entering the building by the main entrance were asked to participate in university research related to flooding risks in Toronto. If they agreed to participate in the study, individuals randomly received one of two survey packages from a mixed pile; each package contained two separate surveys and an MS or control prime, which was a short excerpt of a newspaper article ([Appendix A](#)). Participants were asked to read their prime first, which was framed verbally and in the research consent letter as discussing climate change effects. The MS prime described the aftermath of Typhoon Haiyan in the Philippines, including explicit discussion of bodies, graves, funerals, and so on. The control prime described the effects of climate change on wine production.

After reading the priming article, participants completed the first survey, the Positive and Negative Affect Schedule (PANAS) ([Appendix B](#)), to assess their current mood. This survey generated a baseline by asking participants to rate on a scale (1–5) their present experience of 20 emotions – ten assessing positive affect, ten assessing negative affect (Watson et al. 1988). Because a time delay of approximately two minutes is required for death thoughts to move into the subconscious and trigger distal defenses of symbolic protection (Pyszczynski et al. 1999; Greenberg et al. 2000; Greenberg et al. 1994; Arndt et al. 2002), completion of the PANAS was critical to ensure MS-primers were taking effect.

Participants then completed the second survey, consisting of both quantitative and qualitative questions based on Terpstra's (2011) survey structure. Our survey began with questions regarding past flood experience to further extend the cognitive time lag between the MS prime and subsequent MS questions later in this second survey. Participants identified past flood experience on a five-point Likert scale of agreement for seven statements, for example, "I was affected (inconvenienced, injured, damage to property) by the flooding that occurred in Toronto during July 2013." Participants then identified their own emotional response to past flood experience, selecting from a list including both positive emotions (curiosity, relief, awe, amusement, etc.) and negative emotions (fear, annoyance, dread, powerlessness, etc.). Participants also had the option to add other emotional responses to their list.

Part Two of the survey was designed to assess risk perceptions associated with future flooding. Again a five-point Likert scale of agreement was used for statements within nine subcategories. [Appendix C](#) shows the survey questions, organized by subcategory.

Cronbach's alpha assessed internal consistency of the PANAS and comparison between the MS and control groups was assessed using the Wilcoxon-Mann-Whitney test. Because we assessed MS effects on nine subcategories of risk perceptions, we used the Bonferroni correction method to control the familywise error rate and reduce the chance of making a Type I error. The results of these analyses for each sub-category are presented below.

4 Results

The study sample included 77 survey responses. Thirteen surveys were excluded from analysis: 12 were incomplete and one had the priming article removed so we could not identify

whether the survey was from the MS or control group. Data analysis was performed on the remaining 64 surveys. There were 30 female respondents, 33 male, and one unidentified. Participant age was collected in age groups, with three aged 16–24, thirteen aged 25–34, seven aged 35–49, 26 aged 50–64, four aged over 65, and one unidentified.

The data analysis had multiple elements. First, Cronbach's alpha was calculated to address the internal consistency of the PANAS survey. A high alpha value, generally taken as $\alpha > 0.70$ indicates high internal consistency (Tavakol and Dennick 2011). For the MS group in our study, Cronbach's alpha was 0.901 for positive affect and 0.879 for negative affect. For the control group, Cronbach's alpha was 0.914 for positive affect and 0.913 for negative affect. That is, there was a high level of internal consistency for all groups.

Second, the Wilcoxon-Mann-Whitney test compared the mean response between the MS and control groups for each subcategory (Appendix D). Using a Bonferroni-corrected P-value of $(0.05/9) = 0.006$, calculated P-values show no statistically significant differences between MS and control groups for all nine subcategories.

Finally, to further refine our analysis, responses were divided between participants with and without previous flood experience. Thirty-five participants had prior experience with flooding (Appendix E), of whom 16 (46 %) were in the MS group and 19 (54 %) were in the control group. Of the total participants, 12 (34 %) participants had experienced only the previous summer's flood, eight (23 %) had experienced a different flood event, and 15 (43 %) had experienced the Toronto flood as well as another flood. Twenty-nine (45 %) participants had never experienced a flooding event (Appendix F); of these, 13 (45 %) were in the MS group and 16 (55 %) in the control group. With this participant sub-division, we see a slightly larger variation in perception between MS and control groups, although still no statistically significant differences. For example, the smallest p-value was $p = 0.113$ for belief in climate change in the group without previous flood experience, which is well above our 0.006 significance level.

Of the 35 participants, the most frequently identified emotional responses to past flood experiences were: annoyance (21), worry (19), curiosity (19), anxiety (17), frustration (17), awe (16), powerlessness (15). While many studies focus on the negative emotional responses associated with flood risk (Keller et al. 2006), our participants self-identified both negative and positive emotional responses.

For those participants in the MS group, seven participants (44 %) experienced only negative emotions while nine (56 %) experienced both positive and negative emotions. Conversely, only three participants (16 %) of the control group reported solely negative emotions, while 15 (84 %) indicated experiencing both positive and negative emotions (one participant did not indicate any emotions). Given this vast difference in emotional response between MS and control participants, it is possible that mortality reminders – such as the MS prime used in our survey or, in a broader context, extensive media coverage of flooding events – may affect current perceptions of past events by increasing the strength or number of negative emotions upon recall.

5 Discussion and Conclusions

Earlier research suggested that high levels of existential anxiety were correlated with increased risk perceptions (Goodwin et al. 2011). Based on that foundation, we hypothesized that direct mortality salience (MS) primes – designed to trigger existential anxiety about human mortality – would increase participants' perceptions of flood risk.

Our statistical analysis of the Toronto data found no significant difference in flood risk perceptions between MS and control groups for all subcategories. In the first analysis we compared MS and control groups with no separation between flood-affected and not-affected individuals; no significant differences were found. The second analysis, in which responses were divided between those with or without previous flood experience, also yielded no significant differences between MS and control groups.

We continue to question why MS primes would influence risk perceptions in some situations (e.g., swine flu, Goodwin et al. 2011), but not in others, such as Toronto's urban flooding. We propose that a critical difference between these two studies is the nature of the risk: swine flu risk and the condemnation of out-groups incorporate a strong social dimension, whereas flooding incorporates little consideration for social connection or interpersonal exchange. This is a logical conclusion because TMT research largely focuses on issues with a strong social dimension — e.g., social status, cultural norms — that are likely to be influenced by worldview defense or out-group condemnation. It may be that existential anxiety only induces statistical changes to risk perceptions when participants' perceptions are influenced by social exchange, the condemnation of out-groups, or worldview defense. Additional testing of different risk scenarios — ones that depend on exogenous social exchange versus others that consider more endogenous or individual risk — should be considered. An example of one such "social" risk scenario is climate change threat, where any viable mitigation or adaptation responses require a concerted societal effort, thus incorporating a strong social dimension.

Fritsche and Hafner (2012) found that climate change threat to life increased authoritarian aggression and intolerance to deviant groups, suggesting that a "default" response to climate change is one of division and dissidence rather than loyalty, peaceful resolution, and pro-environmental behaviour. While flooding is presumably one aspect of climate change that will increase in the Toronto area, perceptions of flooding alone, without a clear link drawn between flooding and climate change, does not seem to be influenced by MS. One possible reason for this difference is that climate change is often portrayed as a global event, in which all actors, be they individual, corporate or governmental, must make a concerted effort to reduce CO₂ emissions and promote environmentalism. Flooding, on the other hand, may not be viewed with such a collective mindset — the responsibility may be seen as falling on municipal government for stormwater control — and may therefore be less affected by MS effects on worldview or condemnation of outgroups.

Flooding can and does incorporate a human dimension at a variety of levels. Flooding creates property damages as well as health and safety issues, and water management decisions produce social responses (Walker et al. 2015). On the causal side of the equation, social decisions: influence design of urban built environment, thereby affecting stormwater infiltration (Goff and Gentry 2006); influence decisions about resource allocation to flood protection infrastructure; and alter personal mitigation behaviour. Emphasis on the social dimension of flooding and the role that non-municipal actors play in reducing flood risk may influence individual flood risk perceptions.

For example, Pyszczynski et al. (1996) have shown that MS increases individuals' estimates of societal consensus on certain culturally relevant issues when the participant's belief was the minority opinion. For environmentally-sensitive participants, this effect could emerge if they are asked about the flood risk perceptions and flood risk mitigation behaviours of other people in the community. When MS is induced, these participants might overestimate the number of people who are concerned about flooding issues and who engage in flood-related

mitigation behaviours, because they would overestimate the number of people who agree with their own worldview. For Toronto, which has been identified as Canada's most vulnerable city in terms of flooding risk (Nirupama et al. 2014), societal beliefs regarding the importance of flooding issues could greatly impact the direction of future flood management strategies. Future research into the effects of existential anxiety on flood risk perceptions should explore more explicitly this social dimension of flooding experiences.

The null result from our research has implications for flood risk communications strategies. In contrast to the literature discussions of MS and more general environmental behaviour, this study indicates that fear of death does not influence perceptions of flooding nor flood preparedness intent. Dickinson (2009) argues that climate change threat should be framed biocentrically to avoid the negative consequences of mortality salience effects on human behaviour, which may lead to increased consumption or changes in environmental norms. Yet flooding, though a critical component of climate change threat, did not seem to be influenced by MS effects, and therefore avoiding framing climate change as a threat to human life is unnecessary in this instance. Flood communication strategies that focus on the anthropogenic impacts of flooding are unlikely to induce negative environmental behaviour and may actually improve awareness or concern for flooding issues. Further research should assess the relative effectiveness of various flood risk communication strategies that either explicitly and implicitly include or exclude direct discussion of the anthropogenic impacts of climate change.

In future efforts, we would enlarge the sample size and diversify the residential arrangement to include more semi- or detached homes, as opposed to high-rise apartments which are less susceptible to flood events. In addition, changes to the survey location might be considered. This survey location – while beneficial for the diversity and number of potential participants – was such that many participants arrived in groups or knew each other. Thus the social setting may have distracted participants from fully engaging with the MS prime article.

This research is a contribution to the research on TMT, social decision-making, environmental stress, and water resources. We showed that it was possible to use the Wilcoxon-Mann-Whitney test to assess mortality salience effects on flood risk perceptions. While our results indicated that MS does not affect individual flood risk perceptions, future research investigating public responses to flooding, drought or other changes due to climatic uncertainty might consider this methodological approach. In addition, future research might further refine the use of MS primes for analysis of public and “expert” responses to proposed or newly implemented programs such as water efficiency mechanisms, governance arrangements or water allocation negotiations.

We also contributed specific knowledge about values and attitudes around water in general. Several researchers have addressed the role of MS in moderating environmental attitudes, but our research builds on the field of risk perceptions to strengthen mitigation behaviour and to decrease flood risks. Increasing knowledge around these issues will help improve flood-related communications to the public, which will be critical for reducing the harm and loss of life caused by extreme weather. Along this line, future research should address the effects of MS on the social dimensions of flood risk perceptions, for example, by exploring individuals' perceptions around public consensus of flood related issues and perceptions of other peoples' mitigation responses within the community.

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Compliance with ethical standards

Conflict of Interest The authors declare that they do not have conflict of interest.

Appendix A – Mortality Salience and Control Primes (news articles)

Mortality Salience Prime *Please read the following excerpt of an article from World News.*

“TACLOBAN, Philippines – With the stench of death hanging over this storm-ravaged city, workers on Thursday began collecting the victims of Typhoon Haiyan for burial, in some cases in mass graves.

Most of the collected bodies have yet to be identified.

On the road to the airport, 51 corpses were loaded onto the back of a truck – a tiny handful of the 2,357 people confirmed to have been killed when the storm's 195-mph-winds and wall of water slammed into the country. Aid workers say the true death toll could be much higher.

(...)

People here are relatively used to seeing bodies: Funeral ceremonies in this predominantly Catholic country are usually preceded by a family gathering around an open casket.

But the sight of victims lying uncollected along roadsides or in the wreckage of homes is adding to a widespread sense of despair.

“There are still so many cadavers in so many areas. It's scary,” Tacloban Mayor Alfred Romualdez told AFP, adding that retrieval teams in the paralyzed city were struggling to cope.

The city government remains paralyzed, with an average of just 70 workers showing up for work, compared to 2,500 normally.

In the city's first mass burial, scores of bodies in leaking black bags were lowered into hillside graves without any prayers being said, The Associated Press reported.

John Cajipe, 31, and three teenage boys who work at the local cemetery placed the first body in the grave's right hand corner. Sweat rolled down their faces in the blistering sun as they carried the body.

The second body followed two minutes later, carefully placed alongside the first. And so on, until scores of bodies — all unidentified — filled the grave, the AP said.

Dozens more bodies were lined up in bags outside the City Hall.

Tacloban City Administrator Tecson John Lim told Reuters that a single mass grave for 1,000 victims was being dug Thursday.

It was a process being repeated across the storm-battered Philippines. South of the capital, Manila, locals in the town of Tanauan said one single mass grave contained 200 bodies.”

Source: Eppler, K. and Jamieson, A. (2013, November 14). Typhoon Haiyan: Hundreds of unidentified victims buried in mass graves. *World News*. Retrieved from http://worldnews.nbcnews.com/_news/2013/11/14/21453110-typhoon-haiyan-hundreds-of-unidentified-victims-buried-in-mass-graves

Control Prime *Please read the following excerpt of an article from The Western Producer.*

“MCBRIDE, B.C. — Stalk upon stalk of wine grapes descend in rows in the mountain town of McBride.

Snow-capped peaks and wine grapes aren't usually companions, but in the Mortensen family's vision, people sip their glass from a patio and remark how McBride wine tastes like California wine did long ago.

At 53.3 degrees latitude, Kelly and Sharon Mortensen are set to become wine pioneers in Canada.

The family has led an elaborate experiment on their small B.C. farm over the last 10 years. Behind their house near the village of about 600 people is the beginning of this dream: two and a half acres of wine grapes, many still juvenile plants.

(...)

The Mortensens are among the entrepreneurial farmers anticipating the changes that will come with climate change. Climatologists predict that wine growing regions will shift significantly in the next 50 years. If they can produce wine, Kelly said theirs will be the northern-most winery using grapes in North America.

“The Okanagan may end up being too hot and dry,” Sharon said.

“Climate change is creeping up the world to the poles, and we’re finding the weather here is quite different from ... when we bought our property.”

The month-to-month temperature differences between McBride and Kelowna in the Okanagan Valley are 3 to 5 °C, with similar extreme highs and lows. A winery near Salmon Arm, B.C., which is two to three degrees in latitude south of McBride, currently claims the title of “most northern (wine grape) vineyard in Canada.”

Greg Jones, a professor and research climatologist at Southern Oregon University who studies wine grape growing, said most people view climate change as a gradual temperature rise over time. It can be more variable than that, which can cause problems for wine grapes.

Climate change hasn’t yet put a damper on B.C. wines. In fact, the number of B.C. wineries has tripled in the last 10 years, mostly in the Okanagan.”

Source: Keil, L. (2013, 14 November). Grapes grow in surprising, cold places. *The Western Producer*. Retrieved from: <http://www.producer.com/2013/11/grapes-grow-in-surprising-cold-places/>

Appendix B

Table 1 The PANAS

1	2	3	4	5
Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested:			Irritable:	
Distressed:			Alert:	
Excited:			Ashamed:	
Upset:			Inspired:	
Strong:			Nervous:	
Guilty:			Determined:	
Scared:			Attentive:	
Hostile:			Jittery:	
Enthusiastic:			Active:	
Proud:			Afraid:	

(Watson et al. 1988)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, at the present moment. Use the following scale to record your answers.

Appendix C

Table 2 Survey questions by subcategory

Belief in climate change	<p>2a) The climate is changing.</p> <p>2b) Climate change will affect future flooding by increasing rainfall.</p> <p>2c) Heavy rainfall occurs more frequently now than in the past.</p>
Trust in flood protection	<p>2d) I have confidence in expert knowledge of flooding risks in my area.</p> <p>2e) I have confidence in the technological skills of flood managers in my area.</p> <p>2f) I am confident that there are sufficient, properly trained people working with water management authorities in my area.</p> <p>2 g) Authorities communicate flood risk information effectively with the public in my area.</p>
Perceptions of control	<p>2i) In case of flooding, I am capable of bringing myself/my loved ones to safety.</p> <p>2j) I have a high amount of control over flood prevention.</p>
Perceptions of the likelihood of future flooding	<p>2 l) It is likely that major flooding will occur in my area over the next 10 years.</p>
Perceptions of flooding consequences	<p>3a) The consequences of a flood will likely have a severe effect on me personally (inconvenience, injury, damage to property).</p> <p>3b) A flood will likely damage my home (owned or rented) or personal belongings.</p> <p>3c) A flood is likely to have severe health consequences for me personally.</p> <p>3f) A flood will likely disrupt my daily life (job and daily routines) for a long time.</p>
Dread risk	<p>2 m) Please indicate the extent to which you experience each of the following emotions when you think of flood risk in your area:</p> <p>a)I feel frightened.</p> <p>b)I feel restless.</p> <p>c)I feel relaxed.</p> <p>d)I feel at ease.</p>
Perceptions of unknown	<p>2 h) I am confident in my own flooding risk knowledge.</p> <p>2 k) Flooding is unpredictable.</p>
Perceptions of exposure	<p>3d) In a flood, there will likely be substantial damage to public property (roads, parks, etc.) in my area.</p> <p>3e) The consequences of a flood will likely affect (inconvenience, injure, damage property of) a large number of people across the city.</p>
Individual preparedness intent	<p>3 g) I am interested in receiving information about flood preparedness from the City of Toronto.</p> <p>3 h) I intend to search for information about flood preparedness, flood consequences, and safety protocols.</p> <p>3i) I intend to assemble an emergency kit (e.g. including food, water, first aid kit, etc.) in case of future flooding.</p>

Appendix D

Table 3 Wilcoxon-Mann-Whitney test results by subcategory

Subcategory	State	Observations	Rank sum	Expected	z-score	Prob > z
Climate change belief	MS	29	982.0	942.5	0.541	0.589
	Control	35	1098.0	1135.7		
Trust in flood protection	MS	29	920.5	942.5	-0.298	0.765
	Control	35	1159.5	1137.5		
Control	MS	29	905.0	942.5	-0.514	0.607
	Control	35	1175.0	1137.5		
Unknown	MS	29	850.5	942.5	-1.265	0.206
	Control	35	1229.5	1137.5		
Flooding likelihood	MS	29	903.0	942.5	0.101	0.919
	Control	35	1113.0	1137.5		
Dread	MS	29	1014.5	942.5	0.976	0.329
	Control	35	1065.5	1137.5		
Consequences	MS	29	931.5	942.5	-0.149	0.881
	Control	35	1148.5	1137.5		
Exposure	MS	29	932.5	942.5	-0.141	0.888
	Control	35	1147.5	1137.5		
Preparedness	MS	29	929.0	942.5	-0.184	0.854

Appendix E

Table 4 Previous flood experience Wilcoxon-Mann-Whitney test results by subcategory

Subcategory	State	Observations	Rank sum	Expected	z-score	Prob > z
Climate change belief	MS	16	268.0	288.0	-0.673	0.501
	Control	19	362.0	342.0		
Trust in flood protection	MS	16	300.0	288.0	0.400	0.689
	Control	19	330.0	342.0		
Control	MS	16	279.0	288.0	-0.303	0.766
	Control	19	351.0	342.0		
Unknown	MS	16	261.0	288.0	-0.908	0.364
	Control	19	369.0	342.0		
Flooding likelihood	MS	15	247.5	262.5	-0.549	0.583
	Control	19	347.5	332.5		
Dread	MS	16	322.0	288.0	1.132	0.258
	Control	19	308.0	342.0		
Consequences	MS	16	264.5	288.0	-0.782	0.434
	Control	19	365.5	342.0		

Table 4 (continued)

Subcategory	State	Observations	Rank sum	Expected	z-score	Prob > z
Exposure	MS	16	269.0	288.0	-0.649	0.517
	Control	19	361.0	342.0		
Preparedness	MS	16	245.0	288.0	-1.442	0.149
	Control	19	385.0	342.0		

Appendix F

Table 5 No previous flood experience Wilcoxon-Mann-Whitney test results by subcategory

Subcategory	State	Observations	Rank sum	Expected	z-score	Prob > z
Climate change belief	MS	13	230.5	195.0	1.584	0.113
	Control	16	204.5	240.0		
Trust in flood protection	MS	13	173.5	195.0	-0.951	0.342
	Control	16	261.5	240.0		
Control	MS	13	189.5	195.0	-0.246	0.806
	Control	16	245.5	240.0		
Unknown	MS	13	176.5	195.0	-0.834	0.404
	Control	16	258.5	240.0		
Flooding likelihood	MS	13	214.5	195.0	0.914	0.361
	Control	16	220.5	240.0		
Dread	MS	13	198.0	195.0	0.133	0.894
	Control	16	237.0	240.0		
Consequences	MS	13	209.5	195.0	0.644	0.520
	Control	16	225.5	240.0		
Exposure	MS	13	204.5	195.0	0.457	0.648
	Control	16	230.5	240.0		
Preparedness	MS	13	223.0	195.0	1.254	0.210
	Control	16	212.0	240.0		

References

- Canada. Environment Canada. Climate Daily Data Report for July 2013. Updated August 8, 2014. Accessed August 20th, 2014: <http://climate.weather.gc.ca/climateData/>
- Arndt J, Allen JJB, Greenberg J (2001) Traces of terror: subliminal death primes and facial electromyographic indices of affect. *Motiv Emot* 25(3):253–277
- Arndt J, Greenberg J, Cook A (2002) Mortality salience and the spreading activation of worldview-relevant constructs: exploring the cognitive architecture of terror management. *J Exp Psychol Gen* 131:307–324
- Arndt J, Solomon S, Kasser T, Sheldon KM (2004) The urge to splurge: a terror management account of materialism and consumer behavior. *J Consum Psychol* 14(3):198–212
- Baldassare M, Katz C (1992) The personal threat of environmental problems as predictor of environmental practices. *Environ Behav* 24(5):602–616
- Ballesteros-Cánovas JA, Sanchez-Silva M, Bodoque JM, Díez-Herrero A (2013) An integrated approach to flood risk management: a case study of Navaluenga (Central Spain). *Water Resour Manag* 27(8):3051–3069
- Becker E (1973) *The denial of death*. Free Press, New York
- Botzen WJW, Aerts JCJH, van den Bergh JCM (2009) Dependence of flood risk perceptions on socioeconomic and objective risk factors. *Water Resour J* 45. doi:10.1029/2009WR007743
- Bubeck P, Botzen WJW, Aerts JCJH (2012) A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Anal* 32(9):1481–1495
- Canadian Broadcasting Corporation. (2013, August 14). Toronto's July Storm Cost Insurers \$850M. *Canadian Broadcasting Corporation News (CBC)*. Retrieved September 15, 2014 from: <http://www.cbc.ca/news/business/toronto-s-july-storm-cost-insurers-850m-1.1363051>
- Correia FN, Fordham M, da Graca Saraiva M, Bernadão F (1998) Flood hazard assessment and management: interface with the public. *Water Resour Manag* 12:209–227
- Dar-Nimrod I (2012) Viewing death on television increases the appeal of advertised products. *J Soc Psychol* 152(2):199–211
- Dickinson JL (2009) The people paradox: self-esteem striving, immortality ideologies, and human response to climate change. *Ecol Soc* 14(1):34
- Florian V, Mikulincer M (1997) Fear of death and the judgement of social transgressions: a multidimensional test of terror management theory. *J Pers Soc Psychol* 73(2):369–380
- Fransen ML, Fennis BM, Pruyn ATH, Das E (2008) Rest in peace? Brand-induced mortality salience and consumer behavior. *J Bus Res* 61:1053–1051
- Frantz C, Mayer FS, Norton C, Rock M (2005) There is no I in nature: the influence of self-awareness on connectedness to nature. *J Environ Psychol* 25(4):427–436
- Fritsche I, Hafner K (2012) The malicious effects of existential threat on motivation to protect the natural environment and the role of environmental identity as a moderator. *Environ Behav* 44(4):570–590
- Fritsche I, Jonas E, Niesta Kayser D, Koranyi N (2010) Existential threat and compliance with pro-environmental norms. *J Environ Psychol* 30:67–79
- Goff KM, Gentry RW (2006) The influence of watershed and development characteristics on the cumulative impacts of stormwater detention ponds. *Water Resour Manag* 20:829–860
- Goodwin R, Haque S, Hassan SBS, Dhanoa A (2011) Representations of swine flu: perspectives from a Malaysian pig farm. *Public Underst Sci* 20(4):477–490
- Greenberg J, Pyszczynski T, Solomon S, Simon L, Breus M (1994) Role of consciousness and accessibility of death-related thoughts in mortality salience effects. *J Pers Soc Psychol* 67(4):627–637
- Greenberg J, Arndt J, Simon L, Pyszczynski T, Solomon S (2000) Proximal and distal defenses in response to reminders of one's mortality: evidence of a temporal sequence. *Soc Personal Soc Psychol* 26(1):91–99
- Harries T (2012) The anticipated emotional consequences of adaptive behaviour—impacts on the take-up of household flood-protection protective measures. *Environ Plan A* 44(3):649–668
- Hegger DLT, Driessen PPJ, Dieperink C, Wiering M, Raadgever GTT, van Rijswijk HFMW (2014) Assessing stability and dynamics in flood risk governance: an empirically illustrated research approach. *Water Resour Manag* 28:4127–4142
- Ho MC, Shaw D, Lin S, Chiu YC (2008) How do disaster characteristics influence risk perception? *Risk Anal* 28(3):635–643
- Insurance Bureau of Canada. (2014). Canada inundated by severe weather in 2013: Insurance companies pay out record-breaking \$3.2 billion to policyholders. Accessed September 13th, 2014: http://www.ibc.ca/en/Media_Centre/News_Releases/2014/January/Canada_inundated_by_severe_weather_in_2013.asp
- Kasser T, Sheldon KM (2000) Of wealth and death: materialism, mortality salience, and consumption behavior. *Psychol Sci* 11:348–351
- Kellens W, Zaalberg R, Neutens T, Vanneville W, De Maeyer P (2011) An analysis of the public perception of flood risk on the Belgian coast. *Risk Anal* 31(7):1055–1068

- Kellens W, Terpstra T, De Maeyer P (2013) Perception and communication of flood risks: a systematic review of empirical research. *Risk Anal* 33(1):24–49. doi:10.1111/j.1539-6924.2012.01844.x
- Keller C, Siegrist M, Gutscher H (2006) The role of the affect and availability heuristics in risk communication. *Risk Anal* 26(3):631–639
- Kinsley D (1995) *Ecology and religion: ecological spirituality in cross-cultural perspective*. Prentice-Hall, Englewood Cliffs
- Koole SL, Van den Berg AE (2005) Lost in the wilderness: terror management, action orientation, and nature evaluation. *J Pers Soc Psychol* 88(6):1014–1028
- Kreibich H, Thieken AH, Petrow T, Müller M, Merz B (2005) Flood loss reduction of private households due to building precautionary measures – lessons learned from the Elbe flood in August 2002. *Nat Hazards Earth Syst Sci* 5:117–126
- Godden L, Kung A (2011) Water law and planning frameworks under climate change variability: systemic and adaptive management of flood risk. *Water Resour Manag* 25:4051–4068
- Makropoulos CK, Butler D (2010) Distributed water infrastructure for sustainable communities. *Water Resour Manag* 24:2795–2816
- Mandel N, Heine SJ (1999) Terror management and marketing: he who dies with the most toys wins. *Adv Consum Res* 26:527–532
- Marris C, Langford I, Saunderson T, O’Riordan T (1997) Exploring the “Psychometric Paradigm”: comparisons between aggregate and individual analyses. *Risk Anal* 17(3):303–312
- Ng R, Rayner S (2010) Integrating psychometric and cultural theory approaches to formulate an alternative measure of risk perception. *Innov Eur J Soc Sci Res* 23(2):85–100
- Nirupama N, Armenakis C, Monpetit M (2014) Is flooding in Toronto a concern? *Nat Hazards* 72:1259–1264. doi:10.1007/s11069-014-1054-2
- Pearson LJ, Coggan A, Proctor W, Smith TF (2010) A sustainable decision support framework for urban water management. *Water Resour Manag* 24:363–376
- Proença de Oliveira R, Saldanha Matos J, Monteiro AJ (2015) Managing the urban water cycle in a changing environment. *Water Util J* 9:3–12
- Pyszczynski T, Wicklund RA, Florescu S, Koch H, Greenberg J (1996) Whistling in the dark: exaggerated consensus estimates in response to incidental reminders of mortality. *Psychol Sci* 7(6):332–336
- Pyszczynski T, Greenberg J, Solomon S (1999) A dual-process model of defense against conscious and unconscious death-related thoughts: an extension of terror management theory. *Psychol Rev* 106(4): 835–845
- Rosenblatt A, Greenberg J, Solomon S, Pyszczynski T, Lyon D (1989) Evidence for terror management theory: I. The effects of mortality salience on reactions to those who violate or uphold cultural values. *J Pers Soc Psychol* 57(4):681–690
- Scannell L, Gifford R (2013) Personally relevant climate change: the role of place attachment and local versus global message framing in engagement. *Environ Behav* 45(1):60–85
- Schnebele E, Cervone G, Kumar S, Waters N (2014) Real time estimation of the Calgary floods using limited remote sensing data. *Water* 6:381–398. doi:10.3390/w6020381
- Siegrist M, Gutscher H (2006) Flooding risks: a comparison of lay people’s perceptions and expert’s assessments in Switzerland. *Risk Anal* 26(4):971–979. doi:10.1111/j.1539-6924.2006.00792.x
- Siegrist M, Gutscher H (2008) Natural hazards and motivation for mitigation behavior: people cannot predict the affect evoked by a severe flood. *Risk Anal* 28(3):771–778
- Siegrist M, Keller C, Kiers HAL (2005) A new look at the psychometric paradigm of perception of hazards. *Risk Anal* 25(1):211–222
- Slovic P, Finucane ML, Peters E, MacGregor DG (2004) Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. *Risk Anal* 24:311–322
- Soane E, Schubert I, Challenor P, Lunn R, Narendran S, Pollard S (2010) Flood perception and mitigation: the role of severity, agency and experience in the purchase of flood protection, and the communication of flood information. *Environ Plan A* 2:3023–3038
- Solomon S, Greenberg J, Pyszczynski T (2004) The cultural animal: twenty years of terror management theory and research. In: Greenberg J, Koole SL, Pyszczynski T (eds) *Handbook of experimental existential psychology*. The Guilford Press, New York, pp 13–34
- Tavakol M, Dennick R (2011) Making sense of Cronbach’s alpha. *Int J Med Educ* 2:53–55
- Terpstra T (2011) Emotions, trust, and perceived risk: affective and cognitive routes to flood preparedness behavior. *Risk Anal* 31(10):1658–1675
- Terpstra T, Lindell MK (2012) Citizens’ perceptions of flood hazard adjustments: an application of the protective action decision model. *Environ Behav* 45(8):993–1018
- Tvedt T (2010) ‘Water systems’, environmental history and the deconstruction of nature. *Environ Hist* 16(2): 143–166

- Vastfjall D, Peters E, Slovic P (2008) Affect, risk perception and future optimism after the tsunami disaster. *Judgment Decis Mak J* 3(1):64–72
- Vess M, Arndt J (2008) The nature of death and the death of nature: the impact of mortality salience on environmental concern. *J Res Pers* 42:1376–1380
- Walker WE, Loucks DP, Carr G (2015) Social responses to water management decisions. *Environ Process* 2(3): 486–509
- Watson D, Clark LA, Tellegen A (1988) Development and validation of brief measures of positive and negative affect: the PANAS scales. *J Pers Soc Psychol* 54(6):1063–1070