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Bringing appraisal theory to environmental risk perception: a review of conceptual approaches of the past 40 years and suggestions for future research

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Bringing appraisal theory to environmental risk perception: a review of conceptual approaches of the past 40 years and suggestions for future research

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An intensive program of 40 years of research has produced various conceptual cognitive and affective approaches to environmental risk perception. In this short review of the most relevant conceptual approaches, appraisal theory is presented as a useful means of integrating cognitive and affective approaches to risk perception. Appraisal theory offers an opportunity to advance our understanding of how environmental risk perception operates in an emotion-specific manner and enables identification of new research directions. Although within other conceptual approaches there are still open research questions, the potential for examining environmental risk perception within appraisal theory has not yet been fully explored. Reviewing current appraisal theoretical models, seven research questions are suggested to structure future research on environmental risk perception.

Keywords: risk perception; review; cognition; affect; emotion; appraisal theory

1. Introduction

Environmental risk perception became a prominent topic of public discussion at the end of the 1960s, primarily due to divisions in scientific and public perception over the risks and benefits of nuclear power. At the same time, differences between expert and lay people's perceptions were observed for other hazards too (Fischhoff, Slovic, and Lichtenstein 1982; Gutteling and Kuttschreuter 2002). The question of how people generally perceive technological, chemical, physical, and natural hazards in their environment gained public and scientific attention. An intensive program of research ensued, producing various conceptual approaches to risk perception. To date, it appears that a comprehensive review of these conceptual approaches to environmental risk perception is still missing.

The aims of the paper are twofold. The first goal is to provide a short overview of a selection of theoretical approaches applied to environmental risk perception

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research in the past 40 years. Rather than discussing all empirical findings related to environmental risk perception, we begin by presenting a selection of influential cognitive and affective research methods and findings.¹ The second goal is to introduce appraisal theory as a possible means of integrating the different approaches to improve understanding of how environmental risk perception operates and to identify new research directions. Here appraisal theory is considered in terms of the specific cognitive and affective processes underlying environmental risk perception. The paper closes with several suggestions with which to structure future research.

The development of the theoretical approaches of the past 40 years can be portrayed from three perspectives (a) the extent to which an approach takes individual differences in environmental risk perception into account, like the examination of the question of why different individuals perceive risk differently; (b) the extent to which the content of the approaches to environmental risk perception is cognitive or affective in nature; and (c) the extent to which the approach describes the process of how environmental risk perception operates. These three perspectives enable us to present similarities and differences between the theoretical approaches and to describe how the different approaches are related to each other.

The development of the psychometric paradigm (presented in Section 2) has yielded beneficial insights into the question of why people perceive different hazards differently (Fischhoff et al. 1978; Slovic 1987). However, early studies analyzed aggregated data and obscured individual differences in the perception of different hazards. Recent research (e.g. Bronfman et al. 2007; Siegrist, Keller, and Kiers 2005), therefore, has utilized new analysis methods to take individual differences in risk perception into account. The psychometric paradigm was the first theoretical approach that examined cognitive and affective aspects of risk perception. Yet, it did not explicitly focus on the specific processes of how risk perception operates. A much closer consideration of perceptual processes was undertaken within a parallel, more cognitive approach that focused on risk judgment and decision-making under uncertainty (presented in Section 3). Cognitive heuristics and biases described the common cognitive processes underlying the risk judgment when individuals are faced with a complex risk lacking complete information (Kahneman, Slovic, and Tversky 1982). They did not explicitly focus on the question of why different individuals respond to risk differently. This question was examined by focusing on cognitive approaches such as individual experience with risk (e.g. Barnett and Breakwell 2001), or mental models of risks (Bostrom et al. 1994); others utilized a cultural theoretical approach (Wildavsky 1984) or world-views (Dake 1991) to explain individual differences in risk perception (for an overview, see Breakwell 2007). Acknowledging that cognitive approaches have ignored affective processes in risk perception and decision-making, approaches focusing on affective processes underlying environmental risk perception were developed (presented in Section 4). The psychometric research and subsequent studies on affect and emotion demonstrated that these are important elements of risk perceptions and determinants of risk preferences (Lerner and Keltner 2001; Loewenstein et al. 2001; Slovic et al. 2007). Relying on affect – a person's positive or negative feelings about specific objects, ideas, images, or stimuli – when evaluating risk is called 'the affect heuristic' (Slovic et al. 2007). A dual-process view of risk perception thus emerged, according to which perceptions of and responses to risk reflect two interacting information-processing systems – the 'analytic' and the 'experiential' systems (Gawronski and Bodenhausen 2006; Slovic et al. 2007; Strack and Deutsch 2004).

Further theoretical developments stated that risk perception may include more complex feelings than positive and negative affect (Peters, Burraston, and Mertz 2004); specific emotions such as fear and anger have been identified as particularly important (Lerner and Keltner 2001). To date, only a few studies have conceptualized environmental risk perception in an emotion-specific manner (Fischhoff et al. 2005), some of which do so within the framework of appraisal theory (Bohm 2003; Bohm and Pfister 2000, 2005; Dohle, Keller, and Siegrist forthcoming; Peters, Burraston, and Mertz 2004). Appraisal theories (presented in Section 5) provide an integrative framework for cognitive and affective approaches to environmental risk perception. A person's evaluation of a personally significant stimulus or risk is assumed to be based on her cognitive and affective appraisals that elicit specific differential emotions and corresponding action tendencies (Scherer 1999). In addition, recent appraisal relational models, in particular (presented in Section 5.2), may specify how individual difference measures influence appraisals and, in turn, emotional responses to risk. Furthermore, the appraisal process model (presented in Section 5.3) may precisely describe how environmental risk perception operates. Basically, appraisal process models (Smith and Neumann 2005) draw on the same processes underlying decision-making under uncertainty as cognitive and affective heuristics.

A wealth of knowledge already exists within the framework of appraisal theory. Further application of this knowledge to the field of environmental risk perception integrates previous approaches and allows a more precise specification of the relationship between cognition, affect, risk perception, and behavior in this field. Going beyond previous approaches, appraisal theories explicitly model how specific emotions mediate the influence of specific appraisals on risk and benefit perception resulting in differentiated action tendencies and behaviors. Furthermore, they specify why different individuals emotionally respond to the same stimulus differently. In sum, by demonstrating how risk perception operates in an emotion-specific way, appraisal theories provide an integrative framework in which to facilitate an in-depth analysis of the differentiated processes underlying environmental risk perception. On the one hand, appraisal theory may enrich our understanding of how to address emotional, perceptual, and behavioral components of environmental risk perception in risk communication (Visschers et al. this issue). On the other hand, appraisal theory development has the added value of opening new research directions by empirically demonstrating appraisal processes in environmental risk perception. Suggestions for future research are presented in Section 6.

In this paper, we review the conceptual approaches to environmental risk perception and corresponding empirical findings of interest to researchers and practitioners in the field of environmental risk perception. We use the term 'environmental risk' to describe any source of hazard that resides in the environment and poses some degree of threat to human beings. Hazards may come from technologies (e.g. nuclear power, biotechnology, nanotechnology, etc.), hazardous substances (e.g. dioxin contamination, asbestos, etc.), or involve natural disasters or geophysical phenomena (e.g. climate change, earthquakes, tornadoes, etc.).

2. The psychometric paradigm

The psychometric paradigm (Fischhoff et al. 1978; Slovic 1987) has been widely applied to study environmental risk perception. In typical psychometric studies,

participants rate a set of hazards on a number of risk attributes (e.g. dread, familiarity, control, catastrophic potential: 18 attributes were used in early studies; (e.g. Fischhoff et al. 1978). These risk attributes tend to correlate with one another such that two or three factors account for most of their variance: how dreaded the risk is, how well known it is, and how many people are exposed to it (Slovic, Fischhoff, and Lichtenstein 1982). Dread, catastrophic potential and worry, which appear to be more affective in nature, tend to load on the first component, commonly labeled 'dread.' Attributes such as how unfamiliar the hazard is to science or to those exposed to the risk tend to load on the second factor, representing how 'unknown' the risk is, or 'unfamiliarity' (Slovic 1987; Slovic et al. 2007). Accordingly, hazards that rated higher on the dread dimension of the psychometric paradigm, such as nuclear power, were recently found to evoke stronger implicit associations with negative affective attributes such as 'atrocious' or 'bad' than did hydroelectric power and home appliances (Dohle, Keller, and Siegrist 2010). Both the 'dread' and the 'unknown' factors of the psychometric paradigm help to explain variance in environmental risk perception (e.g. Fischhoff et al. 1978). It is important to note that the set of risk attribute and benefit questions used in psychometric studies of risks (e.g. Fischhoff et al. 1978) coincide with the appraisals of risk that elicit specific differential emotions and corresponding tendencies. This will have important implications for both appraisal theory and psychometric research (as presented in Section 5.1).

Utilizing two-way principal component analysis to analyze means across individuals, however, obscures individual differences in the perception of different hazards. A psychometric study by Gardner and Gould (1989) examined individual differences by analyzing the data for each hazard separately. More recent studies have suggested a hybrid method to analyze individual differences in risk perception within the framework of the psychometric paradigm (Bronfman et al. 2007; Willis and Dekay 2007; Willis et al. 2005). This method either: (1) uses factor scores derived from ratings averaged across participants prior to analysis and, thus, ignores the variation among participants (Bronfman et al. 2007; Willis and Dekay 2007; Willis et al. 2005), or it (2) uses factor scores derived from ratings averaged over hazards and, thus, ignores variation among hazards (Bronfman, Cifuentes, and Gutierrez 2008). Neither approach accounts for both individual differences and hazard differences simultaneously. Studies using newer statistical methods such as the three-way principal component analysis demonstrate individual differences in the perception of hazards (Siegrist et al. 2005), taking both individual differences and hazard differences into account.

The complexity of interactions in the three-way data analysis of psychometric studies raised the question of the appropriate combination of level of analysis (aggregate vs. disaggregate) and focus of analysis (differences between hazards vs. differences between individuals). Willis and colleagues (2005) suggested a hazard-focused analysis, as used in the traditional psychometric approach, where the primary goal is to differentiate among hazards. They suggested an individual-focused approach to understand the more complex relationships between beliefs, attitudes, and behaviors, with practical benefits, for example, in risk communication to different groups of individuals. An individual-focused approach, in addition, allows the examination of moderating or mediating effects of individual measures and the integration of behavior. Researchers, thus, utilized individual-focused approaches to subsequently examine cognitive processes underlying environmental risk perception.

3. Cognitive approaches to environmental risk perception

Beginning with the earliest psychometric studies (see Slovic, Fischhoff, and Lichtenstein 1982), risk perception researchers have framed risk perception as risk judgment and examined individual differences within the framework of judgment and decision-making under uncertainty. In this vein, research on cognitive heuristics and biases, mental models and social cognition and trust have provided insights into cognitive aspects of individual environmental risk perception.

3.1. Cognitive heuristics and optimistic bias

When people are asked to evaluate the risks of an environmental hazard, they seldom have statistical evidence at hand. In these cases, people use a number of cognitive heuristics that have the advantage of reducing task difficulty or lack of information (Tversky and Kahneman 1974). A relevant heuristic in the field of environmental risk perception is the *availability heuristic*, which posits that people judge an event as more likely in cases where it is relatively easy to imagine or recall instances of similar events (Tversky and Kahneman 1973). Availability can be particularly misleading when events have had an emotional impact, large media coverage, or have occurred recently. People also judge things more likely if these things are typical of their kind, a process encapsulated by the *representativeness heuristic* (Tversky and Kahneman 1983). A large number of studies have compared people's perception of their personal risk with that of others. Results are robust and show that people estimate their personal risk to be lower than that of others, a phenomenon called *optimistic bias* (Weinstein 1982, 1987). Weinstein relates this phenomenon to information-processing errors: individuals might lack experience with the hazard. For example, Helweg-Larsen (1999) showed in the case of a 1994 earthquake that actual experience might reduce optimistic bias. To conclude, risk judgments may be biased in systematic ways; people may over – or underestimate an environmental risk. This, in turn, may result in inappropriately high levels of concern about or disregard for the risk. Measures of precautions may, thus, be overvalued or neglected.

3.2. Mental models

Mental models are internal representations of external realities; they are the engines of inference. The concept of small-scale models that the mind creates to anticipate events can be traced back to Bartlett (1932), Craik's (1943) book *The Nature of Explanation* and Gentner and Stevens's (1983) *Mental Models*. Research on mental models of climate change illustrates their relevance to environmental risk and decision-making. Mental models of climate change vary, and lead to widely divergent action and policy prescriptions. Some people have mental models of climate change that include burning fossil fuels and consequent carbon dioxide emissions as causes of global warming (Reynolds et al. 2010); others have mental models of climate change that include specific causal mechanisms – such as stratospheric ozone depletion (Bostrom et al. 1994; Read et al. 1994) – that are erroneous. In the early 1990s, study participants with stratospheric ozone depletion models of climate change often suggested reducing the use of aerosol sprays as a way of tackling the problem. Many common mental models of climate change conflate or confuse climate change with other environmental risks or processes; some of these are

nonspecific, such as ‘pollution’ (Kempton 1991, 1997) or ‘weather’ (Bostrom and Lashof 2007). Mental model studies of other environmental risks also suggest that analogies between environmental processes often drive causal explanations of environmental risk by lay people (Bostrom 2008; Forbus and Gentner 1997).

3.3. *Trust in risk managers*

For many environmental hazards, people may lack sufficient knowledge to make an informed decision about the risks (Siegrist and Cvetkovich 2000; Siegrist et al. 2007) or may simply be unaware of the issues and yet to form an opinion (e.g. Carbon Capture and Storage, Huijts, Midden, and Meijnders 2007). Under these circumstances, research has reported that perceptions about those in charge of managing the hazards (i.e. risk managers) became a proxy for perceptions of the hazard itself: ‘if you cannot evaluate the risk, evaluate the risk manager’ (Huijts, Midden, and Meijnders 2007, 2788). Generally speaking, trust and, thus, hazard acceptance were likely to be higher if risk managers were perceived to (a) be competent at assessing and managing the risks; (b) share the public’s values (e.g. be concerned about protecting health); and (c) be honest and open with the public (Mayer, Davis, and Schoorman 1995; Peters, Covello, and McCallum 1997; Siegrist, Cvetkovich, and Roth 2000; White and Eiser 2005, 2006).

Clearly, trust in this context did not rely on personal knowledge of the target (Rempel, Holmes, and Zanna 1985) and, as a result, was generally referred to as ‘social’ (Cvetkovich and Löfstedt 1999) or ‘role-based’ (Kramer 1999) trust. It was also a dynamic concept and could be built as well as lost (Slovic 1993). As a result, it was important to appreciate how trust was affected by new information about risk managers’ performances, both good and bad (Eitzinger and Wiedemann 2008; Poortinga and Pidgeon 2004; Savadori et al. 2007; Siegrist, Gutscher, and Keller 2007; White and Eiser 2005, 2006), as well as simply assessing general levels of trust in specific actors and specific risks (Frewer et al. 1996; Jungermann, Pfister, and Fischer 1996; Viklund 2003). This is important because observing changes in trust may well be an important indicator of subsequent shifts in public acceptance levels. If we see public trust in some risk managers falls, for instance, we might expect attitudes toward that hazard subsequently to become more negative.

In conclusion, over the years researchers in the field of cognitive heuristics have pointed to the important role of affect and claimed a dual-process view of thinking and decision-making (e.g. Kahneman 2003). Also, trust researchers started to claim trust to include affective aspects (Visschers and Siegrist 2008).

4. *Affective and associative approaches to environmental risk perception*

In the last decade, an increasing proportion of risk perception research has focused on the influence of affect, a person’s positive or negative feelings about specific objects, ideas, images, or other stimuli. Furthermore, people’s spontaneous and implicit associations with environmental risk have attracted research attention, which have been theorized to link to affect (Spence and Townsend 2008).

4.1. *Affect and risk perception*

An important line of risk-related research focused on the effect of the manipulation of affect on risk judgments. Johnson and Tversky (1983) found that negative affect

(induced by a brief newspaper report on a tragic event such as a tornado or flood) produced a pervasive increase in frequency estimates for many undesirable events, regardless of the similarity between the report and the estimated risk. Similarly, Vastfjall, Peters, and Slovic (2008) showed that eliciting negative affect in people (by asking them to think about a recent major natural disaster such as the 2004 tsunami) influenced judgments not only when the affect was considered relevant (e.g. the perceived risk of traveling to areas affected by the disaster), but also when it was not relevant (e.g. developing gum problems).

Relying on affect when evaluating risk is called 'the affect heuristic' (Slovic et al. 2007). According to dual-process theories, perceptions of and responses to risk typically reflect two interacting information-processing systems (Epstein 1994). The 'analytic' system reflects the slow deliberative analysis of risk and decisions about how to manage hazards. The 'experiential system' reflects fast, intuitive, experiential, and image-based affective reactions to danger. 'Affective reactions' refer to a person's positive or negative feelings about specific objects, ideas, images, or other stimuli. These feelings arise from the experiential mode of thinking and are used as information to guide judgments and decisions (Schwarz and Clore 1988). Affect has been theorized to play an important role in motivating behavior (Damasio 1994; Isen 1997; Kahneman 2003; Zajonc 1980). Feelings generally provide a quicker and easier way to deal with our complex and uncertain world. Positive feelings act like a beacon of incentive, motivating people to reproduce those feelings, whereas negative feelings motivate actions to avoid those feelings. Although for some decision problems, an in-depth analysis is certainly important. Initial experimental evidence for the affect heuristic was provided by Finucane et al. (2000), who found that whereas risk and benefit tended to be positively correlated across hazardous activities in the world, they were negatively correlated in people's judgments. An enormous number of survey studies in various fields of environmental risks provided evidence that affect played an important role in risk perception (Siegrist et al. 2007).

Another line of research examined affective imagery containing spontaneous associations that come to people's minds when they think about a stimulus and people's affective ratings of those associations. The affective imagery was used to examine various topics associated with risks: global warming and climate change (e.g. Leiserowitz 2005; Lorenzoni et al. 2006; Poortinga, Pidgeon, and Lorenzoni 2006), or nuclear power and nuclear waste repositories (Peters and Slovic 1996; Slovic, Flynn, and Layman 1991; Slovic, Layman, and Flynn 1991), or nuclear power plants (Keller, Visschers, and Siegrist forthcoming). In the domain of climate change, a US national survey by Leiserowitz (2005) found that negative affect and affective imagery were significant predictors of global warming risk perceptions. A content analysis of affective imagery associated with 'global warming' revealed that the phrase evoked negative connotations for almost all respondents, but that the most dominant images referred to impacts that were psychologically and/or geographically distant, such as generic increases in temperature or a new environmental problem (Pidgeon, Kasperson, and Slovic 2003).

4.2. Exploring implicit associations within environmental decision-making

Implicit associations refer to automatic spontaneous mental links between a stimulus and an attribute and are typically measured using reaction time tasks, such as the

implicit association task (IAT; Greenwald, McGhee, and Schwartz 1998). These measures are theorized to examine associations within the experiential system of processes outlined in the dual-process models. Initial forms of implicit association measures, often described as implicit attitude measures, focused on examining implicit associations with evaluative categories such as 'pleasant', 'unpleasant', 'good', or 'bad', often described as implicit attitudes. Within the field of environmental risk perception, Spence and Townsend (2006) examined implicit attitudes toward genetically modified (GM) food, discovering that these differed quite substantially from explicit attitudes and, in the sample examined, were positive toward GM food, even though explicit attitudes were negative. Furthermore, implicit attitudes toward GM food could predict behavior toward GM food above and beyond what could be predicted by explicit attitudes pointing to the utility of this method (Spence and Townsend 2007).

Implicit measures of associations are now frequently developed and modified to examine associations with other mental constructs. For example, a couple of different methodological variants have focused on measuring risk associations. Siegrist, Keller, and Cousin (2006) examined associations between a specific risk issue, nuclear power, and risk, whilst Ronay and Kim (2006) examined individual differences in preference for risk by examining associations among the attributes of 'gain' and 'loss' and risk.

Notably, implicit attitudes are defined very similarly to the construct of the affect heuristic, with both being related to associational processing, spontaneous responding, and affect (Spence and Townsend 2008). To date, there remains little evidence for an empirical link, however, and indeed the description of implicit attitudes as affective in nature remains controversial. Interestingly, there have been some efforts to develop implicit measures in order to evaluate associations with specific emotions. For example, IATs have been modified to examine fear associations with particular anxiety-provoking stimuli, such as snakes and spiders (Teachman, Gregg, and Woody 2001). Importantly, fear-focused measures were found to discriminate between groups of people, even when differences on standard implicit attitude tasks were accounted for, indicating that something further is being explained by these tasks.

Implicit association approaches may have a valuable contribution to make to the study of environmental risk perception. The currently low utilization of this approach is likely due to various continued conceptual and methodological issues and controversies within the field (Fazio and Olson 2003), but as the field is developed further, it is becoming increasingly fruitful. Note, in particular, that recent developments mean that it may be possible to examine implicit associations with a variety of cognitions and discrete emotions, enabling a more specific targeted examination of mental associations.

5. Appraisal theoretical approaches to environmental risk perception

Some researchers have begun to investigate environmental risk perception in an emotion-specific manner. Their studies suggest that risk perception might include more complex feelings than simply good or bad affect (Peters, Burraston, and Mertz 2004); specific emotions, such as fear and anger, have been identified as particularly important in risk perception (Lerner and Keltner 2001). Appraisal theory is the most prominent psychological approach to study-specific emotions (Moors 2009). During

the last decade, a few studies have applied this approach to environmental risk perception (Bohm 2003; Bohm and Pfister 2000; Dohle, Keller, and Siegrist forthcoming; Peters, Burraston, and Mertz 2004). Currently, three different models are distinguished – structural, process, and relational (Smith and Kirby 2000, 2009). They are promising in opening new research directions in the field of environmental risk perception and deserve brief acknowledgment below.

5.1. *The relationship between appraisals and emotions*

Structural models are the most dominant appraisal theoretical models. They delineate the relation between appraisal and emotions (Frijda 1986; Scherer 1984, 1999; Smith and Ellsworth 1985). The basic assumption is that specific emotions, such as fear and anger, are elicited and differentiated based on a person's evaluation of a personally significant stimulus or event on a small number of appraisal dimensions. The number of appraisals varies, depending on the authors (for overviews see Scherer 1999; Watson and Spence 2007). The appraisals currently proposed can be summarized as outcome desirability (evaluative and motivational processes), agency (responsibility and controllability), fairness, certainty, and coping potential.² There is considerable empirical evidence that the experience of particular emotions is systematically related to these specific appraisals (Smith and Kirby 2009). For example, when something relevant happens to an individual that has a direct implication on his or her goals, values, and general well-being, and this relevant event is appraised as undesirable and unpleasant, the individual feels an emotion such as fear, anger, or guilt. Which of these emotions will be experienced depends on the additional appraisal of responsibility or blame. This also means that based on the evaluation with regard to outcome desirability (positive/negative evaluation) and based on the involvement of further appraisal dimension(s), the affective positive/negative evaluation (outcome desirability) results in a specific emotional response, illustrating that appraisal is an important part of affect. Anger, for example, is experienced when someone else is blamed; guilt, when one blames oneself. Fear also involves an evaluation of the situation as undesirable, but in addition, it involves uncertainty as to whether one can adequately cope with or adjust to the undesirable aspect of the situation (Smith and Kirby 2000). There is divergence among appraisal theorists about the order of activation of the appraisals (Moors 2009).³ However, most appraisal theorists view emotions as causing action tendencies (Ellsworth and Scherer 2003; Frijda 1986; Scherer 2009b). Fear, for example, is viewed as preparing to avoid, whereas anger is viewed as preparing to approach. Emotion is viewed as preparing for action, but not as a sufficient condition for its execution (Frijda 2007). We note that emotion is not the only important factor, and even in the case of highly emotional behavior, such as aggression or flight, the actual execution is determined by multiple factors (Scherer 2009a, 2009b).

Notably, the set of risk attribute and benefit questions used in psychometric studies of risks (e.g. Fischhoff et al. 1978) largely cover and parallel the appraisals discussed above (e.g. agency – including responsibility and controllability, fairness, certainty, and outcome desirability, from Watson and Spence 2007). This has implications for both appraisal theory and psychometric research. It follows from the factor structure found in psychometric studies that these appraisals are likely not completely independent of one another. More importantly, although appraisals may directly affect perceptions, structural appraisal modeling differs from and goes

beyond earlier psychometrics by explicitly modeling how specific emotions mediate the influence of specific appraisals on risk and benefit perceptions. Structural appraisal models, thus, facilitate an in-depth analysis of how the different appraisals interact with each other and how different appraisals influence different specific emotions and corresponding action tendencies.

Only a few studies have yet examined environmental risk perception from an appraisal theoretical approach, and most of these have utilized structural appraisal models. Lerner and Keltner (2000, 2001) examined the influence of *incidental* emotions (preexisting emotions held by the individuals) on risk perception within an appraisal theoretical approach. They found that appraisals of certainty and individual control defined anger and appraisals of uncertainty and situational control defined fear. Anger, in turn, evoked optimistic risk estimates and risk-seeking choices, whereas fear provoked avoidance decisions and pessimistic risk estimates.

Bohm and Pfister (Bohm 2003; Bohm and Pfister 2000) further distinguished between consequentialist vs. ethical evaluation; their studies provided evidence that the mental model(s) held by a person determined his or her evaluative focus (e.g. Bohm 2003; Bohm and Pfister 2005), which in turn triggered emotional responses. Specifically, consequence-based emotions included both prospective emotions, such as fear, as well as retrospective emotions, such as sadness; ethics-based emotions could be self-related, such as guilt, or other-related, such as anger. They treated the psychometric dimension of dread (e.g. as studied in Fischhoff et al. 1978) as a prospective consequence-based emotion like fear and found that, with regard to environmental risks, prospective consequence-based emotions, like fear, appeared to be most intense. Bohm and Pfister (2000) also examined action tendencies in the field of global environmental risks, such as help/prevention, aggression/retaliation, and escape/avoidance or self-focus.

Dohle and colleagues (forthcoming) examined the appraisal dimensions of controllability and fairness. Controllability was defined as the perspective that one's own actions could modify the course of events as an aspect of the coping potential (Frijda 1986; Scherer 1999). Fairness was assumed to be relevant to appraisals of responsibility: if another person was responsible for a certain event or situation (Smith and Ellsworth 1985), it was seen as less fair than if the person him/herself was responsible. Dohle and colleagues found that the influence of the appraisals' controllability and fairness on risk perception and acceptance was mediated by the integral (integral to the risk being judged) emotions of fear and anger toward mobile phone base stations. Notably, fear more strongly influenced risk perception of mobile phone base stations, while anger more strongly influenced benefit perceptions and the acceptance of mobile phone base stations.

Most recently, structural models were used to examine risk perception-related constructs, such as trust, exploring how appraisal theory could help us to explain public trust in risk managers. White, Cohrs, and Görtz (2011) presented people with scenarios about the accuracy of a doctor's cancer diagnosis. They monitored people's appraisals of the outcomes in terms of costs and benefits and emotional reactions toward the doctor who made the decision. Supporting structural equation modeling showed that the effect of the cognitive appraisal on trust in the doctors was almost fully mediated by the emotional reactions (e.g. anxiety and sympathy) toward the doctors. However, cognitions were not the only thing influencing these emotional reactions since prior levels of general trust were also important. People felt more sympathy toward doctors if (a) they felt errors had relatively low costs

and (b) they tended to trust doctors originally. Although further research is needed, trust is a classic approach/avoidance behavior and, thus, ideally suited to exploration from an appraisal theory approach.

5.2. Individual differences in emotional responses

Recently, *relational appraisal theoretical models* have begun to focus on individual differences in emotional responses (Scherer 2009a; Smith and Kirby 2009). They examine the question of why different individuals emotionally respond to the same stimulus differently. Appraisals are assumed not to be a simple function of either the stimulus characteristics or the individual's dispositional characteristics. Instead, the appraisals reflect an evaluation of what the stimulus implies for the person's well-being in relation to the individual's dispositional goals, needs, resources, abilities, and values (Smith and Kirby 2009). As different individuals bring different combinations of needs, goals, abilities, and values to each situation, they are assumed to appraise the same circumstances differently and, hence, react with different emotions to the same circumstances. Thus, relational models predict individual differences in appraisal and in emotional responses (Smith and Kirby 2009).⁴

It appears that, at present in the field of environmental risk perception, only one study has applied relational appraisal models in combination with structural models. Peters and colleagues (2004) found that individual differences in negative affective reactivity (being worried about making mistakes or being criticized by someone else) and in cognitive worldviews (generalized attitudes toward the world and its social organization) were associated with the strength of affective and cognitive appraisals (affect, predictability, causation, coping and importance) of various radiation sources. The influence of these appraisals on risk perception and stigmatization of the radiation sources were, in turn, mediated by the specific emotions of fear and anger.

5.3. Processes of emotion elicitation

Process models of appraisal theory delineate the processes by which the appraisals are elicited (Barrett, Ochsner, and Gross 2007; Smith and Kirby 2000; Smith and Neumann 2005). Although appraisal theorists described the appraisals as cognitive, the appraisals are not thought to be a result solely of a process of analytical evaluation. Instead, this evaluation is assumed to include cognitive and affective appraisals occurring intuitively and automatically, or as a result of analytical evaluation. In fact, appraisal theoretical process models of emotion elicitation draw on the same dual-process models (Epstein 1994) as the affect heuristic (Slovic et al. 2007). In addition, they also refer to newer dual-process models (Strack and Deutsch 2004) to clarify the link between emotion and action tendencies and overt behavior (Smith and Neumann 2005). Like most dual-process models, they suggest two distinct process modes of emotion elicitation: the *associative* operating automatically and the *rule-based*, rather thoughtful and reflective processing. Different types of cues have the potential to activate various experiential, physiological, and behavioral components of emotion such as appraisals, specific emotion, or action tendencies (Smith and Neumann 2005), as they are assumed to be closely linked. Through effortful control, it is possible to engage in action that is opposite to these automatic

behavioral tendencies (Smith and Neumann 2005; Strack and Deutsch 2004). Appraisal theoretical process models appear not to have been examined in the field of environmental risk perception to date.

6. Suggestions for future research

Although within other conceptual approaches there are still open research questions, the potential for examining environmental risk perception within appraisal theory appears to be not fully explored yet. Appraisal theory offers an opportunity to advance our understanding of how environmental risk perception operates in an emotion-specific manner. This is not to advocate that emotions always play an exclusive role in risk perception and related action; indeed, we acknowledge that actual perception or action is determined by multiple factors (e.g. Scherer 2009a, 2009b). However, within environmental risks in particular, emotions often do play a significant role, especially given the complexities and uncertainties involved with topics of interest.

Structural, relational, and process models of appraisal theory are beneficial means of integrating existing cognitive and affective approaches to environmental risk perception and of opening future research directions. Previous empirical studies (Bohm 2003; Bohm and Pfister 2000, 2005; Dohle, Keller, and Siegrist forthcoming; Peters, Burraston, and Mertz 2004) provided empirical evidence for the relationship between particular appraisals and specific emotions (structural appraisal processes). However, a comprehensive structural appraisal model that might be applied to a large variety of environmental risks has not been developed yet. Based on a comprehensive review of appraisal theories, Watson and Spence (2007) suggested a revisited appraisal theoretical model of consumer behavior. Independent of a stimulus event, the four appraisals of outcome desirability (evaluative and motivational processes), agency (responsibility and controllability), fairness, and certainty are claimed to influence emotion and consumer behavior directly and indirectly. We used an adapted version (see Figure 1) to structure our suggestions for future research on environmental risk perception. As in the field of environmental risk perception, the appraisal-coping potential was found to be an antecedent of emotion (Peters, Burraston, and Mertz 2004); we include it in the model as well. This is in contrast to Watson and Spence (2007), who proposed the exclusion of coping potential due to a lack of empirical evidence, but it is in line with the suggestion of most appraisal theorists (see, e.g. Scherer 1999).

From this model, we derived seven research questions to structure future research as part of the present review of conceptual approaches to environmental risk perception.

R1: What are the relevant characteristics of a particular environmental risk?

The first step of research within the structural appraisal theoretical model requires a detailed description of the characteristics of the examined risk. Bohm and Pfister (2000) distinguished four types of environmental risks according to the causal structure of human and environmental factors (caused by human activities vs. natural causation and consequences for humans vs. those for the natural environment). They identified characteristics such as the social dilemma structure or delayed and geographically far-reaching consequences. Their set of characteristics may be validated and possibly extended to further risks such as risks related to new technologies (e.g. nanotechnology).

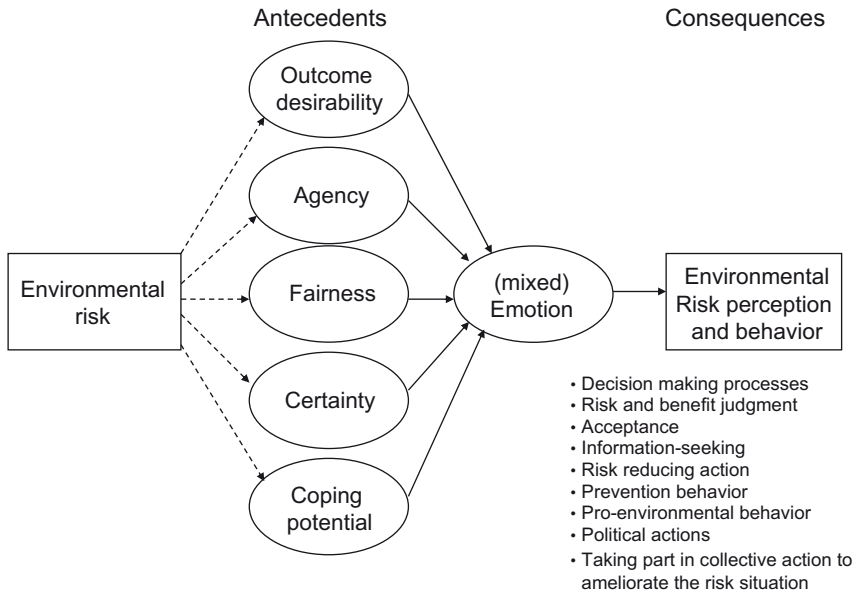


Figure 1. Model of appraisal theory in the context of environmental risk, adapted and developed from the model by Watson and Spence (2007).

R2: What are the relevant appraisals and how do they influence specific emotions in the context of a particular environmental risk?

In the model depicted in Figure 1, we suggest the five dimensions of outcome desirability, agency, fairness, certainty, and coping potential as relevant in the field of environmental risk perception. However, the set of relevant appraisals may differ between various risks such as climate change or nanotechnological applications. Furthermore, the *combined* effect of various appraisals on emotions should be examined. This may provide useful insights into the differentiation of emotions. For example, Watson and Spence (2007) propose that undesirable self-caused events will lead to guilt, whereas undesirable other-caused events will lead to anger.

R3: What are the relevant, specific emotions in the context of a particular environmental risk?

The specific emotions of fear and anger have been identified as particularly important in risk perception (Lerner and Keltner 2001). Emotional indices consisting of various specific emotions have also been examined (Bohm 2003). Different risks may evoke different emotional responses. For example, mobile phones (but not mobile phone base stations) may elicit the specific emotion of joy, as the need for communication and being connected with other people may be associated with mobile phones. This may also apply to particular applications of nanotechnology. However, the same risk may evoke different emotional responses (mixed emotions); this may be especially prevalent in the context of environmental risks. Indeed, it is also possible that one or more of the underlying appraisals of a situation could provoke more than one emotional response to a particular stimulus and these may prime different action tendencies (Watson and Spence 2007).

R4: What are the consequences of specific emotions for decision-making and behavior in the context of a particular environmental risk?

A further line of research may examine the questions (a) of what motivational orientations and action tendencies are evoked by what emotional responses and (b) under what conditions what overt environmental behavior is performed. With respect to behavior, one can think of (1) engaging in some kind of protective action, either to reduce the risks or to reduce the consequences; (2) seeking information and/or communicating with others about the hazard; (3) taking part in some collective action to draw attention to the situation or to remedy the situation; or (4) ignoring the threat and continuing a daily routine. Bohm and Pfister (2000) examined various action tendencies in the field of environmentally friendly behavior such as help/prevention, aggression/retaliation and escape/avoidance, or self-focus.

R5: What are the direct and indirect effects of appraisals on emotions, decision-making and behavior in the context of a particular environmental risk?

As emotions were found to mediate the influences of cognitive and affective appraisals on decision-making, the direct and indirect effects of appraisal combinations need to be isolated (Watson and Spence 2007). This has potential to improve understanding of the relative influence that direct cognition vs. cognition mediated by emotion has on decision-making and behavior in the field of environmental risk.

R6: How do individual dispositions and representations influence the appraisals of particular environmental risks?

It may, for example, be assumed that *mental models about climate change* (Bostrom and Lashof 2007; Bostrom et al. 1994) held by a person are mental representations about causes and consequences of climate change that determine his or her evaluative focus and specific emotions, which, in turn, trigger emotional responses to climate change. This assumed relationship may also be examined for other environmental risks. Relational appraisal models may also shed light on the affective and cognitive processes underlying *trust in risk managers*. As value similarity is an important determinant of trust (Siegrist, Cvetkovich, and Roth 2000), it may be hypothesized that trust influences risk and benefit judgments via the appraisal of the moral appropriateness of a risk. For example, high value similarity with risk managers and corresponding high levels of trust may lead to more positive evaluation of the moral appropriateness of how risk managers deal with risk (e.g. fairness) and may thus decrease feelings of fear or anger. Another hypothesis might be that the individual's general *self-efficacy* may influence the individual's risk perception via the appraisal of the coping potential related to a particular risk.

R7: How do the associative and the rule-based reflexive systems of appraisal and emotion elicitation operate and interact in the context of a particular environmental risk?

A combination of various research methods might provide more insights into this question. In addition, recent developments in the field of implicit measures may facilitate the examination of implicit associations with a variety of cognitions and discrete emotions, enabling a more specifically targeted examination of mental associations.

7. Conclusions

A variety of conceptual approaches applied in the past 40 years of research has provided beneficial insights into cognitive and affective processes underlying environmental risk perception. Appraisal theoretical models enable the formulation and examination of an expanded list of research propositions and, thus, make transparent the relationship between cognition and affect in decision-making processes as well as the relative dominance of each in a particular context (Watson and Spence 2007). Appraisal theory, thus, provides an integrative perspective of affect and cognition in environmental risk perception. Furthermore, individual differences in emotional responses to risk may be explained in more detail. Finally, the operation and interaction of the processes involved in appraisal and emotion elicitation may be examined more deeply. This paper suggests seven research questions that may structure future research, providing an opportunity to move toward a consistent and comprehensive understanding of how risk perception operates in an emotion-specific manner across a wide range of environmental risks.

Notes

1. Some approaches that aim to explain individual differences in risk perception, such as cultural theory or the examination of worldviews and other individual dispositions or demographics (e.g. gender) are not presented in detail. The role of these variables in risk perception may be mediated by cognition and affect and is, thus, partially discussed in the presentation of affective and cognitive approaches. Theoretically interesting approaches that have not initiated a clear line of empirical research in the field of environmental risk perception, such as the social representation theory (Joffe 2003), are not presented either; for a detailed overview of these approaches, see, for example, Breakwell (2007).
2. Definitions (Scherer 1999; Watson and Spence 2007): Outcome desirability encompasses the overall evaluation of how positive or negative (desirable/undesirable) a situation is relative to a personal benchmark, whether it be driven by goals or a more general evaluation of pleasantness. Agency includes the evaluation whether control is by oneself, others or chance). Certainty represents the perceived likelihood of a particular event. Fairness deals with how morally appropriate one perceives an event to be. Coping potential is the evaluation of the ability to cope with consequences to be expected. Due to a lack of empirical evidence, Watson and Spence proposed ignoring coping potential as an antecedent of emotion. This is in contrast to the suggestion of most appraisal theorists (see, e.g. Scherer 1999) who proposed including coping potential with respect to an event. However, in the context of environmental risk, coping potential with a risk was empirically demonstrated to be a relevant determinant of emotion (Peters, Burraston, and Mertz 2004).
3. Some appraisal theorists view the components of emotion as being ordered in a sequential process, starting with an evaluation of whether or not the stimulus is good or bad, pleasant or unpleasant and followed by more complex appraisals (Ellsworth and Scherer 2003; Scherer 2009a, 2009b). This component process model (Scherer 2009a, 2009b) delineates a very complex sequence of appraising and elicitation of emotion and action tendencies with cycles of reappraising. We believe that in the context of environmental risk perception, it is more important to have knowledge about the relevant emotional components (e.g. what appraisals elicit what specific emotions and what action tendency) rather than to know the true sequence of the activation of these components.
4. It should be noted that there is also a different approach to understanding individual differences in emotion through appraisal. Relational models assume that the specific links between particular appraisals and the experience of particular emotions, as specified in the structural models, are general across all individuals. There are a few authors who assume that individuals may differ in the specific appraisal patterns (for a short overview, see Smith and Kirby 2009).

References

- Barnett, J., and G.M. Breakwell. 2001. Risk perception and experience: Hazard personality profiles and individual differences. *Risk Analysis* 21, no. 1: 171–8.
- Barrett, L.F., K.N. Ochsner, and J.J. Gross. 2007. On the automaticity of emotion. In *Social psychology and the unconscious: The automaticity of higher mental processes*, ed. J. Bargh, 173–217. New York, NY: Psychology Press.
- Bartlett, F.C. 1932. *Remembering: A study in experimental and social psychology*. London: Cambridge University Press.
- Bohm, G. 2003. Emotional reactions to environmental risks: Consequentialist versus ethical evaluation. *Journal of Environmental Psychology* 23, no. 2: 199–212.
- Bohm, G., and H.R. Pfister. 2000. Action tendencies and characteristics of environmental risks. *Acta Psychologica* 104, no. 3: 317–37.
- Bohm, G., and H.R. Pfister. 2005. Consequences, morality, and time in environmental risk evaluation. *Journal of Risk Research* 8, no. 6: 461–79.
- Bostrom, A. 2008. Lead is like mercury: Risk comparisons, analogies and mental models. *Journal of Risk Research* 11, nos. 1–2: 99–117.
- Bostrom, A., and D. Lashof. 2007. Weather it's climate change. In *Creating climate for change: Communicating climate change and facilitating social change*, ed. S. Moser and L. Dilling, 31–43. New York, NY: Cambridge University Press.
- Bostrom, A., M.G. Morgan, B. Fischhoff, and D. Read. 1994. What do people know about global climate-change? 1. Mental models *Risk Analysis* 14, no. 6: 959–70.
- Breakwell, G. M. 2007. *The psychology of risk*. Cambridge: Cambridge University Press.
- Bronfman, N.C., L.A. Cifuentes, M.L. Dekay, and H.H. Willis. 2007. Accounting for variation in the explanatory power of the psychometric paradigm: The effects of aggregation and focus. *Journal of Risk Research* 10, no. 4: 527–54.
- Bronfman, N.C., L.A. Cifuentes, and V.V. Gutierrez. 2008. Participant-focused analysis: Explanatory power of the classic psychometric paradigm in risk perception. *Journal of Risk Research* 11, no. 6: 735–53.
- Craik, K.J.W. 1943. *The nature of explanation*. Cambridge: Cambridge University Press.
- Cvetkovich, G., and R.E. Löfstedt. 1999. *Social trust and the management of risk*. London: Earthscan.
- Dake, K. 1991. Orienting dispositions in the perception of risk: An analysis of contemporary worldviews and cultural biases. *Journal of Cross-Cultural Psychology* 22, no. 1: 61–82.
- Damasio, A.R. 1994. *Descartes' error: Emotion, reason, and the human brain*. New York, NY: Avon.
- Dohle, S., C. Keller, and M. Siegrist. 2010. Examining the relationship between affect and implicit associations: Implications for risk perception. *Risk Analysis* 30, no. 7: 1116–28.
- Dohle, S., C. Keller, and M. Siegrist. Forthcoming. Fear and anger: Antecedents and consequences of emotional responses to mobile communication. *Journal of Risk Research*.
- Eitzinger, C., and P.M. Wiedemann. 2008. Trust in the safety of tourist destinations: Hard to gain, easy to lose? New insights on the asymmetry principle. *Risk Analysis* 28, no. 4: 843–53.
- Ellsworth, P.C., and K.R. Scherer. 2003. Appraisal processes in emotion. In *Handbook of the affective sciences*, ed. R.J. Davidson, H. Goldsmith, and K.R. Scherer, 572–95. New York, NY: Oxford University Press.
- Epstein, S. 1994. Integration of the cognitive and the psychodynamic unconscious. *American Psychologist* 49, no. 8: 709–24.
- Fazio, R.H., and M.A. Olson. 2003. Implicit measures in social cognition research: Their meaning and use. *Annual Review of Psychology* 54: 297–327.
- Finucane, M.L., A. Alhakami, P. Slovic, and S.M. Johnson. 2000. The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making* 13, no. 1: 1–17.
- Fischhoff, B., R.A. Gonzalez, J.S. Lerner, and D.A. Small. 2005. Evolving judgments of terror risks: Foresight, hindsight, and emotion. *Journal of Experimental Psychology-Applied* 11, no. 2: 124–39.
- Fischhoff, B., P. Slovic, and S. Lichtenstein. 1982. Lay foibles and expert fables in judgments about risk. *American Statistician* 36, no. 3: 240–55.

- Fischhoff, B., P. Slovic, S. Lichtenstein, S. Read, and B. Combs. 1978. How safe is safe enough – psychometric study of attitudes towards technological risks and benefits. *Policy Sciences* 9, no. 2: 127–52.
- Forbus, K., and D. Gentner. 1997. ‘Qualitative mental models: Simulations or memories?’. Paper presented at the Proceedings of the Eleventh International Workshop on Qualitative Reasoning, 97–104. June 3–6, in Cortona, Italy.
- Frewer, L.J., C. Howard, D. Hedderley, and R. Shepherd. 1996. What determines trust in information about food-related risks? Underlying psychological constructs. *Risk Analysis* 16, no. 4: 473–86.
- Frijda, N.H. 1986. *The emotions*. Cambridge: Cambridge University Press.
- Frijda, N.H. 2007. *The law of emotion*. Mahwah, NJ: Lawrence Erlbaum.
- Gardner, G.T., and L.C. Gould. 1989. Public perceptions of the risks and benefits of technology. *Risk Analysis* 9, no. 2: 225–42.
- Gawronski, B., and G.V. Bodenhausen. 2006. Associative and propositional processes in evaluation: Conceptual, empirical, and metatheoretical issues: Reply to Albarracin, Hart, and McCulloch (2006), Kruglanski and Dechesne (2006), and Petty and Brinol (2006). *Psychological Bulletin* 132, no. 5: 745–50.
- Gentner, D., and A.L. Stevens. 1983. *Mental Models*. Hillsdale, NJ: Lawrence Erlbaum.
- Greenwald, A.G., D.E. McGhee, and J.L.K. Schwartz. 1998. Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology* 74, no. 6: 1464–80.
- Gutteling, J.M., and M. Kuttischreuter. 2002. The role of expertise in risk communication: Lay people’s and expert’s perception of the millennium bug risk in the Netherlands. *Journal of Risk Research* 5: 35–47.
- Helweg-Larsen, M. 1999. (The lack of) optimistic biases in response to the 1994 Northridge earthquake: The role of personal experience. *Basic and Applied Social Psychology* 21, no. 2: 119–29.
- Huijts, N.M.A., C.J.H. Midden, and A.L. Meijnders. 2007. Social acceptance of carbon dioxide storage. *Energy Policy* 35, no. 5: 2780–9.
- Isen, A.M. 1997. Positive affect and decision making. In *Research on judgment and decision making: Currents, connections, and controversies*, ed. W.M. Goldstein and R.M. Hogarth, 509–34. New York, NY: Cambridge University.
- Joffe, H. 2003. Risk: From perception to social representation. *British Journal of Social Psychology* 42: 55–73.
- Johnson, E.J., and A. Tversky. 1983. Affect, generalization, and the perception of risk. *Journal of Personality and Social Psychology* 45, no. 1: 20–31.
- Jungermann, H., H.R. Pfister, and K. Fischer. 1996. Credibility, information preferences, and information interests. *Risk Analysis* 16, no. 2: 251–61.
- Kahneman, D. 2003. A perspective on judgment and choice – mapping bounded rationality. *American Psychologist* 58, no. 9: 697–720.
- Kahneman, D., P. Slovic, and A. Tversky. 1982. *Judgment under uncertainty: Heuristics and biases*. New York, NY: Cambridge University Press.
- Keller, C., V. Visschers, and M. Siegrist. Forthcoming. Affective imagery and acceptance of replacing nuclear power plants. *Risk Analysis*.
- Kempton, W. 1991. Lay perspectives on global climate change. *Global Environmental Change-Human and Policy Dimensions* 1, no. 3: 183–208.
- Kempton, W. 1997. How the public views climate change. *Environment* 39, no. 9: 12–21.
- Kramer, R.M. 1999. Trust and distrust in organizations: Emerging perspectives, enduring questions. *Annual Review of Psychology* 50: 569–98.
- Leiserowitz, A.A. 2005. American risk perceptions: Is climate change dangerous? *Risk Analysis* 25, no. 6: 1433–42.
- Lerner, J.S., and D. Keltner. 2000. Beyond valence: Toward a model of emotion-specific influences on judgment and choice. *Cognition & Emotion* 14, no. 4: 473–93.
- Lerner, J.S., and D. Keltner. 2001. Fear, anger, and risk. *Journal of Personality and Social Psychology* 81, no. 1: 146–59.
- Loewenstein, G.F., E.U. Weber, C.K. Hsee, and N. Welch. 2001. Risk as feelings. *Psychological Bulletin* 127, no. 2: 267–86.

- Lorenzoni, I., A. Leiserowitz, M.D. Doria, W. Poortinga, and N.F. Pidgeon. 2006. Cross-national comparisons of image associations with 'global warming' and 'climate change' among laypeople in the United States of America and Great Britain. *Journal of Risk Research* 9, no. 3: 265–81.
- Mayer, R.C., J.H. Davis, and F.D. Schoorman. 1995. An integrative model of organizational trust. *Academy of Management Review* 20, no. 3: 709–34.
- Moors, A. 2009. Theories of emotion causation: A review. *Cognition & Emotion* 23, no. 4: 625–62.
- Peters, E.M., B. Burraston, and C.K. Mertz. 2004. An emotion-based model of risk perception and stigma susceptibility: Cognitive appraisals of emotion, affective reactivity, worldviews, and risk perceptions in the generation of technological stigma. *Risk Analysis* 24, no. 5: 1349–67.
- Peters, R.G., V.T. Covello, and D.B. McCallum. 1997. The determinants of trust and credibility in environmental risk communication: An empirical study. *Risk Analysis* 17, no. 1: 43–54.
- Peters, E., and P. Slovic. 1996. The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power. *Journal of Applied Social Psychology* 26, no. 16: 1427–53.
- Pidgeon, N., R. Kasperson, and P. Slovic. 2003. *The social amplification of risk*. Cambridge: Cambridge University Press.
- Poortinga, W., and N.F. Pidgeon. 2004. Trust, the asymmetry principle, and the role of prior beliefs. *Risk Analysis* 24, no. 6: 1475–86.
- Poortinga, W., N. Pidgeon, and I. Lorenzoni. 2006. Public perceptions of nuclear power, climate change and energy options in Britain; Summary findings of survey conducted during October and November 2005. Understanding risk Working Paper 06-02, School of Environmental Sciences University of East Anglia.
- Read, D., A. Bostrom, M.G. Morgan, B. Fischhoff, and T. Smuts. 1994. What do people know about global climate-change? 2. Survey studies of educated laypeople. *Risk Analysis* 14, no. 6: 971–82.
- Rempel, J.K., J.G. Holmes, and M.P. Zanna. 1985. Trust in close relationships. *Journal of Personality and Social Psychology* 49, no. 1: 95–112.
- Reynolds, T., A. Bostrom, D. Read, and M.G. Morgan. 2010. Now what do people know about climate change? Survey studies of educated laypeople. *Risk Analysis* 30, no. 10: 1520–38.
- Ronay, R., and D.Y. Kim. 2006. Gender differences in explicit and implicit risk attitudes: A socially facilitated phenomenon. *British Journal of Social Psychology* 45: 397–419.
- Savadori, L., M. Graffeo, N. Bonini, L. Lombardi, K. Tentori, and R. Rumiati. 2007. Rebuilding consumer trust in the context of a food crisis. In *Trust in cooperative risk management: Uncertainty and skepticism in the public mind*, ed. M. Siegrist, T.C. Earle, and H. Gutscher, 159–71. London: Earthscan.
- Scherer, K.R. 1984. On the nature and function of emotion: A component process approach. In *Approaches to emotions*, ed. K.R. Scherer and P. Ekman, 293–318. Hillsdale, NJ: Erlbaum.
- Scherer, K.R. 1999. Appraisal theory. In *Handbook of cognition and emotion*, ed. T. Dalgleish and M. Power, 637–63. New York, NY: Wiley.
- Scherer, K.R. 2009a. The dynamic architecture of emotion: Evidence for the component process model. *Cognition & Emotion* 23, no. 7: 1307–51.
- Scherer, K.R. 2009b. Emotions are emergent processes: They require a dynamic computational architecture. *Philosophical Transactions of the Royal Society* 364: 3459–74.
- Schwarz, N., and G.L. Clore. 1988. How do I feel about it? Informative functions of affective states. In *Affect, cognition, and social behavior*, ed. K. Fiedler and J.P. Forgas, 44–62. Toronto: Hogrefe International.
- Siegrist, M., M.E. Cousin, H. Kastenholz, and A. Wiek. 2007. Public acceptance of nanotechnology foods and food packaging: The influence of affect and trust. *Appetite* 49: 459–66.
- Siegrist, M., and G. Cvetkovich. 2000. Perception of hazards: The role of social trust and knowledge. *Risk Analysis* 20, no. 5: 713–9.
- Siegrist, M., G. Cvetkovich, and C. Roth. 2000. Salient value similarity, social trust, and risk/benefit perception. *Risk Analysis* 20, no. 3: 353–62.

- Siegrist, M., H. Gutscher, and C. Keller. 2007. Trust and confidence in crisis communication: Three case studies. In *Trust in cooperative risk management: Uncertainty and skepticism in the public mind*, ed. M. Siegrist, T.C. Earle, and H. Gutscher, 267–86. London: Earthscan.
- Siegrist, M., C. Keller, and M.E. Cousin. 2006. Implicit attitudes toward nuclear power and mobile phone base stations: Support for the affect heuristic. *Risk Analysis* 26, no. 4: 1021–9.
- Siegrist, M., C. Keller, and H.A.L. Kiers. 2005. A new look at the psychometric paradigm of perception of hazards. *Risk Analysis* 25, no. 1: 211–22.
- Slovic, P. 1987. Perception of risk. *Science* 236, no. 4799: 280–5.
- Slovic, P. 1993. Perceived risk, trust, and democracy. *Risk Analysis* 13, no. 6: 675–82.
- Slovic, P., M.L. Finucane, E. Peters, and D.G. MacGregor. 2007. The affect heuristic. *European Journal of Operational Research* 177, no. 3: 1333–52.
- Slovic, P., B. Fischhoff, and S. Lichtenstein. 1982. Why study risk perception? *Risk Analysis* 2, no. 2: 83–93.
- Slovic, P., J.H. Flynn, and M. Layman. 1991. Perceived risk, trust, and the politics of nuclear waste. *Science* 254, no. 5038: 1603–7.
- Slovic, P., M. Layman, and J.H. Flynn. 1991. Risk perception, trust, and nuclear waste – lessons from Yucca mountain. *Environment* 33, no. 3: 6–11.
- Smith, C.A., and P.C. Ellsworth. 1985. Patterns of cognitive appraisal in emotion. *Journal of Personality and Social Psychology* 48, no. 4: 813–38.
- Smith, C.A., and L.D. Kirby. 2000. Consequences require antecedents. Toward a process model of emotion elicitation. In *Feeling and thinking. The role of affect in social cognition*, ed. J.P. Forgas, 83–106. New York, NY: Cambridge University Press.
- Smith, C.A., and L.D. Kirby. 2009. Putting appraisal in context: Toward a relational model of appraisal and emotion. *Cognition & Emotion* 23, no. 7: 1352–72.
- Smith, C.A., and R. Neumann. 2005. Emotion processes considered from the perspective of dual process models. In *The unconscious in emotion*, ed. P. Niedenthal, L. Feldman-Barrett, and P. Winkielman, 287–311. New York, NY: Guilford Press.
- Spence, A., and E. Townsend. 2006. Implicit attitudes towards genetically modified (GM) foods: A comparison of context-free and context-dependent evaluations. *Appetite* 46, no. 1: 67–74.
- Spence, A., and E. Townsend. 2007. Predicting behaviour towards genetically modified food using implicit and explicit attitudes. *British Journal of Social Psychology* 46: 437–57.
- Spence, A., and E. Townsend. 2008. Spontaneous evaluations: Similarities and differences between the affect heuristic and implicit attitudes. *Cognition & Emotion* 22, no. 1: 83–93.
- Strack, F., and R. Deutsch. 2004. Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review* 8, no. 3: 220–47.
- Teachman, B.A., A.P. Gregg, and S.R. Woody. 2001. Implicit associations for fear-relevant stimuli among individuals with snake and spider fears. *Journal of Abnormal Psychology* 110, no. 2: 226–35.
- Tversky, A., and D. Kahneman. 1973. Availability – heuristic for judging frequency and probability. *Cognitive Psychology* 5, no. 2: 207–32.
- Tversky, A., and D. Kahneman. 1974. Judgment under uncertainty – heuristics and biases. *Science* 185, no. 4157: 1124–31.
- Tversky, A., and D. Kahneman. 1983. Extensional versus intuitive reasoning – the conjunction fallacy in probability judgment. *Psychological Review* 90, no. 4: 293–315.
- Vastfjall, D., E. Peters, and P. Slovic. 2008. Affect, risk perception and future optimism after the tsunami disaster. *Judgment and Decision Making Journal* 3, no. 1: 64–72.
- Viklund, M.J. 2003. Trust and risk perception in Western Europe: A cross-national study. *Risk Analysis* 23, no. 4: 727–38.
- Vischers, V.H.M., and M. Siegrist. 2008. Exploring the triangular relationship between trust, affect, and risk perception: A review of the literature. *Risk Management* 10: 156–67.
- Vischers, V.H.M., P.M. Wiedemann, H. Gutscher, S. Kurzenhäuser, R. Seidl, C.G. Jardine, and D.R.M. Timmermans. This issue. Affect-inducing risk communication: Current knowledge and future directions. *Journal of Risk Research*.

- Watson, L., and M.T. Spence. 2007. Causes and consequences of emotions on consumer behaviour – a review and integrative cognitive appraisal theory. *European Journal of Marketing* 41, no. 5–6: 487–511.
- Weinstein, N.D. 1982. Unrealistic optimism about susceptibility to health-problems. *Journal of Behavioral Medicine* 5, no. 4: 441–60.
- Weinstein, N.D. 1987. Unrealistic optimism about susceptibility to health-problems – conclusions from a community-wide sample. *Journal of Behavioral Medicine* 10, no. 5: 481–500.
- White, M.P., J.C. Cohrs, and A. S. Göritz. 2011. Dynamics of trust in medical decision making: An experimental investigation into underlying processes. *Medical Decision Making* 31: 710–20.
- White, M.P., and J.R. Eiser. 2005. Information specificity and hazard risk potential as moderators of trust asymmetry. *Risk Analysis* 25, no. 5: 1187–98.
- White, M.P., and J.R. Eiser. 2006. Marginal trust in risk managers: Building and losing trust following decisions under uncertainty. *Risk Analysis* 26, no. 5: 1187–203.
- Wildavsky, A. 1984. A cultural theory of risk. *Bulletin of the British Psychological Society* 37, no. February: A24.
- Willis, H.H., and M.L. Dekay. 2007. The roles of group membership, beliefs, and norms in ecological risk perception. *Risk Analysis* 27, no. 5: 1365–80.
- Willis, H.H., M.L. DeKay, B. Fischhoff, and M. G. Morgan. 2005. Aggregate, disaggregate, and hybrid analyses of ecological risk perceptions. *Risk Analysis* 25, no. 2: 405–28.
- Zajonc, R.B. 1980. Feeling and thinking – preferences need no inferences. *American Psychologist* 35, no. 2: 151–75.