Gut feeling versus common sense : associative and cognitive processes in risk perception and communication

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Gut Feeling versus Common Sense:

**Associative and Cognitive Processes in Risk Perception and
Communication**

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**Associative and Cognitive Processes in Risk Perception and
Communication**

PROEFSCHRIFT

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Chapter 1

Associative and Cognitive Processes in Risk Perception and Communication: An Overview of the Dissertation

Many people might recognize the following situation. One night, you suddenly wake up because you hear a strange noise in your house. Your first thought is that an intruder has entered the house, as the strange noise immediately evoked a feeling of fear. What should you do? Have a look to see what caused the noise or call the police right away? To make this decision, you rely on the feeling you experience at that moment and on the information and knowledge you have about it (cognition), e.g. the burglary rate in your neighbourhood. This example illustrates that people appraise the risks they encounter in daily life to decide whether and how they should cope with them, i.e. they engage in *risk perception*. This thesis examines how risk perception can be affected by information in a message about such a risk, i.e. *risk communication*. Moreover, it proposes that people perceive risks by means of two types of processes: one based on gut feeling, the other on cognitive processes.

Since the early 1970s, many scholars and policy makers have been interested in how 'ordinary' people (i.e. the general public) perceive risks (e.g. Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Kahneman & Tversky, 1972; Starr, 1969). They became especially interested when the general public appeared to reject new technological developments that were thought to be very useful by experts and policy makers, such as nuclear energy. Many studies have so far provided interesting insights into the way people perceive risks and the determinants that can influence this evaluation. However, these studies mainly focused on the *cognitive* processes that affect risk perception, as they tried to reveal what information people have explicitly in mind when they evaluate risks. Little attention has been given to the *associative* processes that determine how people perceive risks. Associative processes are quick evaluations of, for example, objects, people or situations and are based on impulse and intuition, analogy or heuristics. The research project presented in this dissertation is among the first to focus on the associative processes that underlie risk perception. Thus, it assumes risk perception to be the result of both cognitive and associative processes.

Associative processes occur automatically and are mainly based on so-called gut feeling, but also on heuristics, previous experience and evaluations of other risks. These associations result in a quick evaluation of whether a risk can be approached or avoided. This type of reaction may be a fundamental part of risk perception because it has survival value for people. For example, when people encounter a lion in the wild, they should be able to determine immediately whether to fight it or run away, as the lion might otherwise attack them. People have always needed such a quick approach–avoidance evaluation to survive situations in which an immediate reaction can save their lives. Therefore, associative processes must be anchored in a basic, intuitive system, which has developed earlier in human evolution than the cognitive processes (cf. Zajonc, 1980). On the other hand, when people are in a zoo and are asked whether they want to feed the lions, there is no immediate threat. Hence, they have the opportunity to evaluate elaborately what the possible risks are before responding. Thus, the cognitive processes take much longer to produce a risk evaluation, so that they would appear to be less important for survival and must have developed later in evolution.

To study the role of associations in risk perception, we¹ used an indirect test. This type of test measures an immediate, associative evaluation of a stimulus and does not allow conscious control. This indirect test is new in risk perception research. It was adopted from social cognition research and adapted to our purposes. To complement this, we applied a self-report questionnaire, which is a direct test, to reveal the cognitive processes

of risk perception.

Besides risk perception, this thesis also examines the way in which evaluations of risks can be influenced by communication about them. Risk communication as we examined it was defined in a narrow sense as it includes single risk messages that are distributed from communicator to the general public, because we were mainly interested in the effect of risk messages. Their effect on risk perception was studied by various methods, such as interviews, surveys and indirect tests, in explorative and experimental studies.

Risk is described here as a source of danger; a possibility of incurring loss or misfortune (WordNet 2.1, 2005). This thesis focuses on risks that can affect people's health or the environment. Further, our studies related to risks that are relatively new to most people because they have not yet or at least not often been discussed in the popular media. Such risks were chosen to avoid participants already having a strong opinion about them, which would make it hard to change them by risk communication. Examples of new health or environmental risks are deoxynivalenol in wheat products, the transport of chlorine by train in the Netherlands, nanotechnology and avian influenza.

The remaining part of this overview starts with an outline of the theoretical and research background of risk perception. This leads to a description of our dual process view of risk perception. Next, we explain the indirect method that we used in our experimental studies, after which we introduce risk communication research. The six studies that are reported on in this thesis are then briefly presented. Lastly, the main findings and the methodology of the studies are discussed. The overview ends with the main conclusions.

Risk Perception

People evaluate potentially hazardous situations they encounter in daily life. Different people may have different perceptions of the same risk, which may result in different levels of concern about this risk and different responses to it. Moreover, the general public's perception may differ from objective standards or from evaluations by experts. Various factors can affect people's risk perception, such as qualitative characteristics of the risk, individual differences, the setting, society, the information provided and the way the risk is processed.

This dissertation focuses on the mental processes that lead to risk perception. We discuss three theoretical approaches here: qualitative characteristics as measured by the psychometric paradigm, heuristics and dual process theories. Many theories and concepts have been developed to explain risk perceptions. These theories concern aspects like individual differences (e.g. Barnett & Breakwell, 2001; Bromiley & Curly, 1992; Lion & Meertens, 2001), people's information preferences about a risk (Huber, Wider, & Huber, 1997; Lion, Meertens, & Bot, 2002) and sources outside the individual, such as culture, society, institutions (Kasperson et al., 1988), society's history (Douglas & Wildavsky, 1982), modernization and globalization (Beck, 1992). A comprehensive discussion of this literature is beyond the scope of this dissertation. We therefore only focus on theories and concepts about the mental processes that underlie risk perception.

Risk perception research about cognitive processes started in the early 1970s with the work by Starr (1969), who suggested a quantitative method to determine which characteristics of a new technology determine whether people will accept it. Starr's ideas led to the development of the psychometric paradigm of risk perception; a method

to reveal the public's perception of a risk by measuring its qualitative characteristics (Fischhoff et al., 1978; Slovic, 1987). At the same time, Tversky and Kahneman (1974) showed that people often use rules of thumb (heuristics) in judgments, risk perception and decision making. It appeared that the general public do not usually evaluate risks by multiplying probability (the chance of a risk occurring) by valence (the size or severity of its effect). People often do not have sufficient information, ability or opportunity for such calculations. Instead, they apply heuristics, which require less cognitive effort and capacity. More recently, dual process theories have been developed to explain risk perception (e.g. Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, Finucane, Peters, & MacGregor, 2004). These theories differentiate between an immediate route and a more deliberate route of persuasion, information processing and risk perception, and describe determinants of the way risk information is processed.

In short, this thesis concentrates on how people process risk information and form a perception of the risk. Therefore, the psychometric paradigm, heuristics and dual process theories are discussed in more detail below, resulting in a description of our own dual process view.

Qualitative Risk Characteristics and the Psychometric Paradigm

The psychometric paradigm of risk perception aims to form a quantitative representation of the way lay people perceive risks, using the qualitative characteristics of these risks (Fischhoff et al., 1978; Slovic, 1987; Slovic, Fischhoff, & Lichtenstein, 1984). The method “assumes [that] risk is subjectively defined by individuals who may be influenced by a wide array of psychological, social, institutional and cultural factors” (p. xxiii, Slovic, 2000). The psychometric paradigm assumes that risk perception is determined by inherent (although subjectively evaluated) characteristics of the risk and of the respondents. Examples of these qualitative characteristics are voluntariness, dread, trust, controllability, benefits to people or society, severity of the consequences and knowledge of respondents about the risk. Respondents are asked to rate a particular hazard in terms of these characteristics, each characteristic on a separate scale, e.g. from 1 to 7. Next, these ratings are analysed (usually by factor analysis) to determine whether more general categories can be identified of the characteristics that underlie the perception of the risk and whether the characteristics can predict a holistic evaluation (e.g. Fischhoff et al., 1978; Slovic, 1987).

Several studies that applied the psychometric paradigm to people's ratings of various risks have identified two factors among the qualitative characteristics that apparently underlie risk perception, namely *dread* and *unknown/unfamiliar* (Slovic, 1987; Slovic, Fischhoff, & Lichtenstein, 1982; Slovic et al., 1984). The *dread* factor involves a sense of uncontrollability of the risk, the possibility of a global catastrophe, high risk to future generations, risks not being easily reduced and involuntariness. The *unknown* factor is characterized by risks not being observable, new to the people exposed, and knowledge about the risk (Slovic et al., 1984). According to Slovic (1987), a third factor can be identified, labelled *number of people exposed to the hazard*. Other researchers who used the psychometric paradigm have identified still other factors, including *technological risk* and *severity* (Fischhoff et al., 1978), *size of potential accident* and *degree of organized safety* (Vlek & Stallen, 1981), and *tampering with nature* (Sjöberg, 2000b). The psychometric paradigm has often been criticized for its use of aggregated data (group averages instead of individual ratings), which artificially increases the explained variance of the factors (Marris, Langford, Saunderson, & O'Riordan, 1997; Sjöberg, 2000a). Nevertheless, the

method's underlying assumption that risk perception can be explained by the qualitative characteristics of the risk rather than its quantitative details remains of great value to this field of research.

Heuristics

People frequently use rules of thumb or cognitive shortcuts, so called heuristics, to judge the probability and severity of the possible consequences of a situation (i.e. a risky situation) (Tversky & Kahneman, 1974). Heuristics are relatively simple mental strategies that reduce the cognitive workload for decision makers, as it is often impossible or unnecessary to process all (or all available) information about a subject (Slovic et al., 1982; Tversky & Kahneman, 1974). Sometimes, however, heuristics can lead to interpretations of the probability or severity of a hazard that differ from those made by risk experts would, because not all of the necessary information is considered, or because it is not fully used. Several heuristics can be applied to the way people perceive risks: the representativeness heuristic, availability heuristic, simulation heuristic, anchoring and adjustment heuristic, and affect heuristic (Finucane, Alhakami, Slovic, & Johnson, 2000; Kahneman & Tversky, 1972; 1973; 1982; Tversky & Kahneman, 1973).

People implicitly or explicitly apply the representativeness heuristic when they estimate the probability or severity of a situation by the degree to which it is characteristic of situations that are retrieved from memory. The degree of representativeness of the new situation to the retrieved situations determines the estimation or perception of the new situation (Kahneman & Tversky, 1973). An example of this heuristic may be that people perceive the risk of food irradiation as low when they regard it as representing a food safety strategy. However, people might perceive food irradiation as risky when they relate it to nuclear radiation.

The availability heuristic means that people estimate the probability or severity of a situation based on the ease with which similar situations are recalled from memory (Tversky & Kahneman, 1973). Situations that are frequently stored in memory, because they were often experienced (directly or indirectly), are easily recalled and are therefore estimated to be likely in real life. However, availability is also influenced by factors unrelated to the actual frequency of experience, such as mental rehearsal, recent activation in memory, the conspicuousness (e.g. vividness) of the situation and ample treatment of the situation in the media. Furthermore, a person's memory may be biased, so that a situation is remembered as more common than it actually is (Slovic et al., 1982). A heuristic that is related to the availability heuristic is the simulation heuristic, in which people judge the probability or severity of a unique situation by the ease with which they can mentally simulate the occurrence of that situation. The ease of simulation influences the probability and severity estimation of the situation (Kahneman & Tversky, 1982).

Anchoring means that the starting point of people's probability estimate (in numerical terms) determines their final probability judgment (Tversky & Kahneman, 1974). This starting point or anchor may be mentioned in the risk information, e.g. low vs. high frequency estimate of the probability of the risk, or may be retrieved from other sources (memory, co-incidental exposures). The interpretation of this anchor may need to be adjusted to the current setting, although in practice, people often do not sufficiently adjust this value. The anchoring and adjustment heuristic has been examined, for example, in probability judgments of nuclear war (Plous, 1989). In this study, the anchor was provided in the questionnaire item that asked respondents to estimate the probability of the hazard.

Respondents who were asked whether the chance of a nuclear war was greater or smaller than 1% estimated a probability that was only half as high as that estimated by respondents who were asked whether this chance was greater or smaller than 90%.

Finally, in the affect heuristic, people judge a hazard by accessing a pool of positive feelings (benefits) and negative feelings (danger) that are associated with the hazard in memory (Finucane et al., 2000). The positive and negative feelings or evaluations about a hazard have opposite relations with risk perception. This implies that when a generally positive evaluation about a hazard dominates in memory, for example “nuclear energy is good”, people do not perceive it as risky. In contrast, when people associate the hazard mainly with a generally negative evaluation, for example “nuclear energy is bad”, they perceive it as risky. In other words, perceived riskiness is based on general affective reactions to an object or stimulus.

In short, heuristics can be useful strategies for people to evaluate risks, as they reduce cognitive workload and mostly lead to satisfactory decisions and estimations. Unfortunately, they also have shortcomings when people do not consider all information that is necessary to make a judgment.

Dual Process Theories

Dual process theories approach risk perception by distinguishing an analytical, central and systematic process from an experiential, peripheral or heuristic process of information processing and persuasion (e.g. Chaiken, Liberman, & Eagly, 1989; Epstein, 1994; Petty & Cacioppo, 1986; Slovic et al., 2004; Strack & Deutsch, 2004). Information can be handled by one of the two processes, which are actually the extremes of a continuum from systematic to heuristic. Although people can apply both processes to perceive the same risk, one process will dominate the other (Loewenstein et al., 2001). The central, analytical or systematic process leads to a deliberative evaluation and takes more time and effort, whereas the peripheral, experiential or heuristic system is relatively shallow and quick, and requires little effort. An important contribution of the dual process theories relates to the identification of determinants of the information processing mode that people apply in particular situations. Conditions such as time, opportunity, self-efficacy and motivation determine which process is mainly used (Chaiken et al., 1989). For instance, if people have sufficient time and resources, and are motivated to evaluate something extensively, they will apply central, analytic and systematic processing to the information.

Dual process theories were originally developed to explain information processing and attitude change. Recently, several scholars have specified and tested dual processes to explain risk perception (e.g. Loewenstein et al., 2001; Slovic et al., 2004; Trumbo, 1999). An example of a dual process theory that has been applied to risk perception is the Heuristic–Systematic Information Processing Model (HSM, Trumbo, 1999). In this theory, systematic processing (in-depth information processing) and heuristic processing (schemata or heuristics like those described above) are assumed to underlie risk perception. Other dual process theories contrast analysis, logic and cognition with experience and affect to explain how people perceive risks (Loewenstein et al., 2001; Slovic et al., 2004). The analytic system is conscious and deliberative, based on logic and ratio, whereas the experiential system is intuitive and spontaneous, and based on affect and associations.

The Primary Evaluative and Secondary Evaluative Processes of Risk Perception

We support the idea that two types of processes can explain how people perceive risks. However, we label these two processes differently and call them the primary evaluative process and the secondary evaluative process. We first explain these processes more thoroughly. Then, we describe the way they correspond and contrast to the associative and cognitive processes, and to previously-published dual processes.

The primary evaluative process forms the first, spontaneous reaction to a risk, functions automatically and is founded on a global approach–avoidance association, gut feeling or prior experience (see Table 1.1). Its definition is based on affective primacy, which conceptualizes that affect is primary, fundamental, inescapable and independent of, though not unrelated to, cognition (Zajonc, 1980). Similarly, the primary evaluative process is considered to be a fundamental and basic process because it offers evolutionary advantage. The decision as to whether something or somebody is dangerous or not should be made fast and not be based on deliberative conscious processing, because this takes precious time, which might limit the chances of survival (Zajonc, 1980). The first reaction to a risk should be anchored in an intuitive, associative process for it to be quick. Furthermore, the primary evaluative process should be fundamental because it is found among various animal species (cf. Elliot, 2006). Prior associations between the risk and its evaluations are assumed to play a part in the primary evaluative process, as these associations can be activated automatically (cf. Strack & Deutsch, 2004).

Although some of the risks people experience today are too ‘modern’ to have influenced the evolution of the primary evaluative process, people still use this process when they perceive modern risks. It has been suggested that people automatically and preconsciously evaluate stimuli on an approach–avoidance dimension before a more conscious evaluation occurs (Bargh, 1997), which may imply that a primary evaluative process always occurs before a more deliberate evaluation. This does not mean that the *outcomes* of the primary evaluative process concerning modern risks (e.g. nuclear power stations) are similar to those concerning ‘old-fashioned’ risks (e.g. snakes).

Table 1.1 Characteristics of the primary and secondary evaluative processes of risk perception

Primary evaluative process	Secondary evaluative process
- fundamental associative processes, gut feeling	- specific associative processes and cognitive processes
- first, spontaneous reaction	- operates at a later stage
- intuitive, immediate, automatic associations	- more deliberate, conscious and controlled; heuristics and affect
- anchored early in evolution: approach–avoidance response, affective primacy (Zajonc, 1980)	- developed later in evolution
- easily activated, determines risk perception except when overruled by the secondary evaluative process	- only present if the situation allows it (i.e. sufficient time and opportunity) and the primary evaluative process motivates it.

In the secondary evaluative process, information is processed more or less elaborately and extensively (see Table 1.1). It is more under conscious control and follows at a later stage than the primary evaluative process. This process is only active when there

is sufficient motivation and the situation allows elaboration. The secondary evaluative process can also be influenced by heuristics, specific associations and affect if these form part of or are stimulated by the relevant information.

The outcomes of the primary evaluative process (e.g. “danger!”) may motivate the secondary evaluative process (Strack & Deutsch, 2004). In addition, the latter process may sometimes overrule the primary evaluative process. In that case, the outcomes of the primary evaluative process can still be incorporated in the ultimate perception, as it is a motivator of the secondary evaluative process. Often, the outcomes of the two processes are related in the perception of the risk. In other situations, the outcomes of the processes do not appear to be related and may exist separately because the two processes are stimulated by different sources and methods. For example, when people encounter food that looks unnatural (e.g. purple spaghetti), their first reaction may be that they want to avoid this and that the food has gone off. However, when they are given time to find out what kind of food it actually is, they may realize that someone has added a natural colouring agent to the food and that this is harmless.

The primary and secondary evaluative processes relate in the following way to the associative and cognitive processes described in the Introduction. Associative and cognitive processes are the two extremes on a continuum that describes risk perception. The primary evaluative process is located on the extreme left of this continuum (fundamental associations) as it is only based on global and quick associations: approach versus avoidance of the risk. The secondary evaluative process includes both associative and cognitive processes. It therefore ranges from the left side in relation to the centre (specific associations), to the extreme right side of the continuum (meta-cognitions). In other words, associations that are used in the secondary evaluative process are more specific than those in the primary evaluative process, such as heuristics.

Similarly, although the primary and secondary evaluative processes of risk perception have some characteristics in common with the dual processes that were discussed in the previous section, they also differ in some respects. As with the previous dual processes, we assume that situation (time, capacity, opportunity) and motivation determine whether and to what extent people use the more elaborate process to evaluate a hazard after the quick, shallow process. Our primary and secondary evaluative processes of risk perception differ from other dual process theories in the timing of the two processes. The primary evaluative process always occurs first and may activate the secondary evaluative process a bit later. Other dual process theories are not explicit about whether one process precedes the other, and if so which one. Furthermore, our two processes of risk perception are different from those used in other dual process approaches in the level of elaboration that can occur in the first, shallow process. Since the primary evaluative process is fundamental and primarily associative, a minimum level of elaboration is required in this process (cf. Strack & Deutsch, 2004). Heuristics are therefore considered to be part of the secondary evaluative process. Other dual process theories, such as HSM and the Elaboration Likelihood Model (Chaiken et al., 1989; Petty & Cacioppo, 1986), seem to classify heuristics as the ‘quick’ process (heuristic or peripheral processing). Indeed, heuristics are relatively quick and shallow forms of processing and are situated more to the left on the associative–cognitive continuum compared to full-blown cognitive elaboration. They are, however, slow and involve more cognitive activity than primary affective reactions.

The primary evaluative process has been given this narrow definition for theoretical

and methodological reasons. Firstly, the definition resembles the most fundamental approach—avoidance reaction to risks on which this process is based. Secondly, this definition is most similar to the outcomes of indirect tests. This allowed us to test the distinction between the two processes empirically.

Although the primary evaluative process is based on fundamental, quick associations, we expected that risk communication could affect the primary evaluative process in two ways. Firstly, it could prime associations that people already (implicitly) hold but that are usually overruled by the secondary evaluative process. Secondly, the risk message could be so striking that people form new, fundamental associations after receiving the message only once.

To summarize, it is proposed in this thesis that people perceive risks by means of two processes: a primary and a secondary evaluative process. The former is the result of fundamental associative processes, while the latter includes both specific associative and cognitive processes. These two processes are interrelated but may also result in different outcomes. Whereas the primary evaluative process is always active, the secondary evaluative process can only be evoked by the primary evaluative process or by the situation (e.g. time and opportunity).

Indirect Measure

Risk perception has often been measured by self-report questionnaires using items such as severity estimation, probability estimation, acceptance, willingness to pay, qualitative characteristics and affect. A self-report questionnaire is a direct test, as it assesses someone's final evaluation or interpretation directly. This makes this type of test suitable to measure the secondary evaluative process. The primary evaluative process, however, requires a test that assesses the instantaneous association with a risk. A measurement instrument like a questionnaire cannot reveal this fundamental association. Moreover, a direct measure gives respondents the opportunity to deliberate about the risk, which activates the secondary evaluative process and overrules the primary evaluative process. An indirect test is therefore needed, since this can measure the strength of the association between an object and its evaluation, which is an indicator of automatic appraisal. Above all, interference by conscious processing will hardly affect the results of such a test.

The indirect measure we applied is new in risk perception research, although others have recently suggested the possible value of such a measure for risk perception research (Montijn-Dorgelo & Midden, 2004; Siegrist, Keller, & Cousin, 2006). The indirect measure was adopted from social cognition research, in which it is assumed that attitudes, stereotypes and self-esteem have an explicit and an implicit form (Greenwald & Banaji, 1995). Whereas the explicit form can be directly reported, e.g. in a questionnaire, the implicit form is unconsciously present and cannot be reported directly, although people may be aware that they have this attitude (Fazio & Olson, 2003). For example, white people often state explicitly that they do not have a stereotypical image of black people, whereas their implicit reactions might show the opposite. To measure people's implicit attitudes, various indirect tests have been developed, which all are based on the same principle. Attitude objects (e.g. names that are especially common among black people) are paired with two contradicting affective evaluations (e.g. good vs. bad) (see De Houwer, 2003; Greenwald, McGhee, & Schwartz, 1998). If people have a strong implicit

association between an attitude object and one of the evaluations, their responses to this attitude–evaluation combination will be facilitated in the test. If the attitude object and evaluation are related in the opposite direction, this will cause interference in the responses to this combination. For example, white people were found to respond more easily to the combination white–pleasant than to black–pleasant, which may indicate that they implicitly had a relatively positive association with whites, and a relatively negative one with black people (Greenwald et al., 1998).

We selected the Extrinsic Affective Simon Task (EAST, de Houwer, 2003) as an indirect test for our experiments. The EAST is a computer task that measures association strength between one object and two contrasting evaluations. The association strength is determined by the reaction times and the numbers of errors that respondents make regarding the combinations of an object (e.g. flower) with its evaluations (e.g. positive vs. negative). In the original EAST, respondents have to classify evaluation words based on their intrinsic valences (e.g. positive word: press left, negative word: press right) and object words based on their extrinsic valences (e.g. colour; blue flower word: press left, green flower word: press right). It is then expected that the intrinsic valence of the object words interferes with the responses based on the extrinsic valence. As a result, if respondents have a negative association with flowers, they will respond faster to flower words that require the same response as the negative evaluation words (i.e. green flowers) than to flower words that require the same response as the positive evaluation words (i.e. blue flowers). In case the respondents have a positive association with the attitude object, the facilitation effect is reversed.

The EAST was chosen for our studies because it has the advantage that it can measure the strength of the association with one object, whereas other indirect tests often require two opposing objects so that the association strength of one of the objects has to be interpreted in relation to that of the other object. Another reason to select the EAST was that participants do not have to respond to the intrinsic valences (i.e. meanings) of both object words and evaluation words, as is required in other tests. Double intrinsic valences may result in recoding of the meaning of the object words into that of the evaluation words, which interferes with the reaction to the object words. In order to prevent this interference, the EAST asks participants to respond to the intrinsic valences of the evaluation words and to the extrinsic valences (appearance, e.g. colour) of the object words.

Since we wanted to use the EAST to measure risk perception, the test had to be adapted in two ways. Firstly, the intrinsic valences were changed from those reflecting general affect to those reflecting risk perception: dangerous–harmless or unhealthy–healthy. Secondly, we used pictures instead of words to present the intrinsic valences and stimuli (risks), because pictures could ‘describe’ the risk object better than words. Moreover, previous studies that presented pictures in the EAST showed that the response times were shorter than when words were used (Callan & Ellard, 2003; Huijding & de Jong, 2005). These two adjustments may appear opportunistic, as we changed both object and method in the EAST, which may complicate the interpretation of our results. These changes were, however, needed to allow us to specify the assessment with the EAST from general affect to perceived riskiness.

Risk Communication

Besides studying how people perceive risks by means of the primary and secondary evaluative processes, we examined how people can be informed about risks (through risk communication) and how this can influence the two processes of risk perception. Risk communication may have several aims, such as (1) to inform people about a risk, (2) to encourage them to make an informed decision as to whether to take action to prevent a risk or how to deal with it (National Research Council, 1989; Rohrmann, 1992), (3) to warn people in case of disasters and emergencies, (4) to encourage joint problem solving and conflict resolution (Covello, von Winterfeldt, & Slovic, 1986) and (5) to prevent panic and outrage (Sandman, 1987).

For our purposes, we defined risk communication in a narrow sense, by only including risk messages that are sent from risk managers (e.g. risk producers and governmental organizations) to the public to inform them about a new or unknown risk. We used this narrow definition because we were interested in investigating how risk communication can affect the two processes of risk perception within people. The messages provide information about the risk and how to deal with it, and they reflect a one-way process. Examples of risk messages are warning messages on products (e.g. Visschers, Ruiter, Kools, & Meertens, 2004), brochures about a specific risk (e.g. radon, Johnson & Fisher, 1989) and newspaper articles (see Golding, Krinsky, & Plough, 1992).

Risk communication as studied in our research is based on the findings of a risk assessment, which is part of a dynamic process between risk experts, producers and managers, people-at-risk or those involved, and policy makers (e.g. Health Council of the Netherlands, 1996). A risk assessment provides information about the characteristics of a hazard; the relation between exposure levels to the hazard and its health effects; the magnitude, duration, schedule and route of exposure; the vulnerability and size of the populations at risk; and the probability and severity of the risk (Renn, 2005). These details form the basic information in a risk communication.

We are aware that risk communication is generally given a much broader definition, including everything from the development of the first message to ways of involving and responding to the public (National Research Council, 1983). Based on this description, several authors and organizations have published recommendations for the way risks should be communicated to people (e.g. Covello et al., 1986; Fischhoff & Downs, 1997; Health Council of the Netherlands, 2001c; National Research Council, 1989). An example of a recommendation is to use two-way communication, in which the public are immediately involved in the risk communication process and their concerns are taken seriously (National Research Council, 1989; Sandman, 1994).

Several studies have examined the effects of risk messages on risk perception. In these studies, one or several elements of the message were varied and presented to respondents in experimental or field settings. In addition to examining the effects of the messages on risk perception, their effects were assessed on variables such as trust, attitude, understanding and behaviour. Examples are studies comparing the use of frequencies and percentages when indicating the probability of mortality from a particular hazard (e.g. "1 in 10" vs. "10%" per year), verbal versus numerical expressions of probability (e.g. "very unlikely" vs. "1 in 10"), scenario information, graphs, tone of the message, framing (highlighting positive vs. negative information), uncertainty information, type of risk message (e.g. video, article, brochure), controversial information about the risk manager or information

source and risk comparisons (e.g. Armstrong, Schwartz, Fitzgerald, Putt, & Ubel, 2002; Bruine de Bruin, Fischhoff, Millstein, & Halpern-Felsher, 2000; Connelly & Knuth, 1998; Downs et al., 2004; Hendrickx, Vlek, & Oppewal, 1989; Johnson & Slovic, 1995; Roth, Morgan, Fischhoff, Lave, & Bostrom, 1990; Stone, Yates, & Parker, 1997; Yamagishi, 1997). These studies have covered many different risk message elements in various contexts (e.g. medical vs. environmental, field vs. laboratory). We discuss several of these elements and their effects in a literature review in Chapter 2. Chapters 4 to 6 examine risk communication in relation to the primary and secondary evaluative processes of risk perception.

Overview of the Studies

In total, six studies are described in this thesis: two qualitative and four quantitative studies. The qualitative studies were a literature review and an interview study, while the quantitative studies consisted of a survey and three experimental studies. In all studies, we had two main aims. The first was to investigate the roles of the associative and cognitive processes in the way people interpret risks and risk communication. Moreover, we wanted to examine the impact of the primary and secondary evaluative processes on risk perception. As we explained before, these two processes are related, though not identical, to the associative and cognitive processes. The second goal was to examine whether and how risk communication can affect the primary and secondary evaluative processes of risk perception. Three types of risk communication were explored for their impact on risk perception: text, audiovisual materials and active risk communication.

To achieve these two goals, we used a new test to measure the primary evaluative process of risk perception, namely the indirect EAST test described above, as well as a direct test (questionnaire). More specifically, to pursue the first aim, we conducted interview studies about the way the general public form perceptions of unknown risks and a survey to explore whether and how people use associations in risk perception. The second goal was covered by a literature review about the effects of various presentation formats in risk messages on risk perception. In addition, three experimental studies were set up in which risk messages were varied in terms of cognitive and affective elements, to study their effects on the primary and secondary evaluative processes of risk perception.

Chapter 2. Probability information in risk communication research: A review of the research literature

A literature study was conducted to review what is already known about the effects of probability information in risk communication on risk perception, understanding, acceptance etc. Many studies have examined how people perceive probability information and how this information in risk communication can influence risk perception. However, their results had so far not been reviewed in an article considering both health and environmental risks. In this review paper, we discuss where risk communication research about probability information stands at the moment and what remains to be examined. Furthermore, we attempt to clarify the various effects of presentation formats of probability information on risk perception by heuristic and systematic processing, and offer several recommendations for practitioners in the risk communication field and suggestions for further research.

Using the literature databases PsycINFO, Medline, Social Science Index and Eric, and the snowball method, 1,077 hits were identified about probability information in risk perception and communication, 57 of which are discussed in this review. The review focuses on frequencies, percentages, base rates and proportions, cumulative risk information, absolute vs. relative risk information, verbal information, numerical vs. verbal information, graphs and risk ladders.

The review led to several recommendations for practitioners in the field, which are all based on the findings from previous studies. These recommendations are presented in Box 2.1 and 2.2. In these boxes, we categorized the recommendations in two groups: recommendations about the general use of a presentation format and those about the way the format should be used. In addition, we indicate the quality of the evidence for the recommendations.

The following three examples illustrate how the recommendations were created and on what findings they were based. First, it appeared that people easily misinterpret frequency information (e.g. 34 out of 1,000 people) because they only look at the first number (divisor) of the frequency and neglect the base rate (denominator) (Yamagishi, 1997). Similarly, people have difficulty understanding proportions (e.g. 1 out of 333 people) compared to rates (e.g. 3 per 1,000 people) because people seem to neglect the base rate, which changes in proportions. We therefore recommend applying the same denominator in probability information throughout risk messages that include several probabilities, so that people can compare the divisors, for example, 34 out of 1,000 people per year become ill by X, whereas 966 out of 1,000 people do not become ill by X.

Second, several studies showed that people think that a relative risk reduction (e.g. "The percentage of people who die of disease A each year is relatively reduced by 10% thanks to medicine Y compared to medicine X.") describes a larger risk reduction than an absolute risk reduction (e.g. "The percentage of people who died of disease A decreased by 0.5 thanks to medicine Y compared to medicine X."), as the RRR provides the highest number (e.g. Chao et al., 2003; e.g. Forrow, Taylor, & Arnold, 1992; Hembroff, Holmes-Rovner, & Wills, 2004; Malenka, Baron, Johansen, Wahrenberger, & Ross, 1993; Misselbrook & Armstrong, 2001; Studts et al., 2005). This may be problematic as RRR can lead to misunderstandings. Therefore, we recommend that RRR should be used with care in risk communication.

Third, people have indicated that they prefer to receive numerical information and to use verbal information to express a risk (Erev & Cohen, 1990; Lion & Meertens, 2001; Mazur, Hickam, & Mazur, 1999; Shaw & Dear, 1990). Furthermore, numerical information was trusted more (Gurmankin, Baron, & Armstrong, 2004a), was regarded as more satisfactory (Berry, Raynor, Knapp, & Bersellini, 2004), and was better understood than verbal information (Knapp, Raynor, & Berry, 2004; Marteau et al., 2000). Also, the probability of an event expressed in verbal information was often overestimated (Knapp et al., 2004). Consequently, it is advisable to present both in risk communication.

It was not always possible to give clear recommendations on the basis of the effects reported in the studies, because the studies were conducted in various contexts, using different groups of respondents and measuring different dependent variables, e.g. risk perception, acceptance or intention to change behaviour. In addition, there is a theoretical explanation for the various effects of presentation formats: as stated before, people may process risks in a systematic and in a heuristic way (see Heuristic-Systematic Information Processing Model, Chaiken, Liberman, & Eagly, 1989; Trumbo, 1999). Heuristic

information processing entails that people use schemata or simple inferential rules to come to an evaluation of a risk. The systematic processing represents in-depth processing of the information, and is more deliberate and time consuming.

The situation in which a presentation format is used (e.g. amount of time, motivation and cognitive capacity of respondents) can stimulate either heuristic or systematic processing of the probability information. When people have sufficient time, motivation or cognitive capacity, they apply systematic processing. In such situations, they search and reorganize the information about the risk themselves so that the probability's format does not matter. However, people who do not have sufficient motivation or opportunity to deliberate, rely on heuristic processing to interpret probability information. It seems likely that under these conditions, presentation format has more impact on how the risk is processed and, thus, perceived, understood or accepted, than under the former conditions. Thus, the recommendations suggested in this paper may be especially valuable when the receivers of a risk message are expected to process the risk information heuristically.

Overall, this review suggests that trying to find 'magic bullets' to communicate probability information is insufficient. The situation in which the probability information is provided should be considered when communicating this type of risk information, as this context seems to determine which type of processing people use and how this may affect their perception of the risk.

Chapter 3: How do the general public evaluate risk information? The impact of associations with other risks

As we reported in the section about risk perception, previous research and theories had already described how people are influenced by heuristics and qualitative risk characteristics in the way they perceive risks (e.g. Slovic, 1987; Tversky & Kahneman, 1974). However, it has not yet been clarified how people are affected by prior knowledge in this respect. We studied the way people use prior knowledge about known risks (i.e. risk associations) to interpret new or unknown risks, in a qualitative (focus group and in-depth interviews) and a quantitative study (survey). Theories and concepts that suggest the importance of prior knowledge in risk perception and communication are the construction–integration theory (Kintsch & van Dijk, 1978), the mental models approach (Morgan, Fischhoff, Bostrom, & Atman, 2002) and the representativeness heuristic (Kahneman & Tversky, 1972).

Study 3a. Focus group and in-depth interviews

We conducted 7 focus group interviews and 11 in-depth interviews to examine what information and risk characteristics are used to evaluate a risk. More specifically, we wanted to investigate whether people use specific associations between risks to interpret unknown risks, and how and why this is done. During the interviews, the respondents read four newspaper articles about unknown risks, and they were asked after each article how they evaluated the risk, what kind of information they had used from the article to interpret this risk and whether they associated any known risk with this unknown risk. Six different risk articles were used, discussing (1) acrylamide in food, (2) deoxynivalenol (DON) in wheat products, (3) nuisance caused by artificial light in the outdoor environment, (4) the burning of chemical weapons near a village, (5) phthalates in cosmetics and (6) medicine residues that are released into the environment. It was assumed that these risks were unknown to most people, which was confirmed by our interview findings. The interviews were transcribed and coded.

The results showed that specific risk associations had a prominent position in the evaluation of unknown risks. They were often mentioned spontaneously. The risk associations were based on personal experience, media coverage and general knowledge. In addition, they were mentioned because they shared some characteristics with the unknown risk. As a result, the mental map of the known risk seemed to be applied to the unknown risk, e.g. respondents only related fat food (known risk) to acrylamide (unknown risk), and because the former contained fat, which is unhealthy, acrylamide was also considered to be bad for health. In some cases, respondents applied the mental map of a known risk that had one characteristic in common with the unknown risk, but was dissimilar in all other characteristics, so that the association might seem far-fetched.

Respondents seemed to use specific associations between unknown and known risks for the following four reasons. First, respondents referred to known risks to demonstrate the possible severity and consequences of the unknown risk. Second, specific associations with known risks were used to show that people had already tolerated many similar risks before, although these were known to cause harm. Third, the associations were used to indicate that the unknown risk also had certain benefits, just like known risks. Fourth, the interviewees associated the unknown risk with a known risk to indicate that a solution would also be found for the unknown risk.

Thus, respondents often spontaneously used known risks to interpret unknown risks. As a result, the general evaluation and the salient characteristics of the known risk influenced the perception of the unknown risk. Also, the associated mental model narrowed the focus to a limited amount of information about the unknown risk. Our results could be clarified by the mental models approach, as these models offered a good representation of the respondents' knowledge propositions about a risk. In addition, the construction–integration theory proved to be useful to explain our findings, since respondents referred to their existing mental models to understand the unknown risks and linked the content of these schemes to the new information.

Study 3b. Survey

The second study was set up to pursue three aims. The first aim was to find out whether the perception of associated risks was related to the perception of unknown risks. Secondly, we wanted to examine how people associated known risks with unknown risks; i.e. what information they used to choose an associated risk. Thirdly, we investigated whether these associations were personal, as this would complicate the use of associated risks in risk communication.

Respondents evaluated four different risks in four successive questionnaires: an unknown risk, a risk that they themselves associated with the unknown risk (*self-associated risk*), a risk associated by others and an unrelated risk. Respondents were members of an Internet research panel. The sample was representative of the population of the Netherlands. The respondents were asked to answer items about risk perception and the qualitative characteristics of the risk, and (only in the first questionnaire) to mention a risk of which the unknown risk reminded them. There were approximately one-week intervals between successive questionnaires. The respondents judged three unknown risks in the first questionnaire (food irradiation, avian influenza and chlorine transport by train in the Netherlands), on which the risks in the three later questionnaires were based. We checked whether people were familiar with the risks mentioned in the first questionnaire, which did not appear to be the case. The results were analysed by computing correlations

between the risk perceptions of the four types of risk evaluation and by comparing these correlations using Steiger's $Z1bar^*$ (Steiger, 1980).

To answer our second question, *how* risks were associated, we explored three possible association methods. First, we evaluated whether the unknown risks and the self-associated risks shared a semantic connection, that is, whether the wording of the unknown risks was used to find a related risk. Second, we analysed the similarity between the risk perceptions of the unknown risks and the self-associated risks. Third, we tested whether the respondents used certain qualitative characteristics to choose the self-associated risks. Hence, we analysed whether the evaluations of some qualitative characteristics were similar for the unknown and self-associated risks.

According to our findings, the perceptions of the unknown risks were strongly related to the perceptions of the self-associated risks. Associations between two risks were not purely personal, since risks associated by others correlated with the unknown risks in the same way as the self-associated risks. Furthermore, the association appeared not to be caused by a third factor, such as risk aversion.

The risk associations seemed to be based on a semantic connection and salient characteristics between the unknown and the self-associated risks. For example, the risk of food irradiation was most often associated with other food risks or with radiation risks. Thus, the semantic network theory seemed to be able to explain the choice of associated risk. The perceived riskiness and the qualitative characteristics could not explain the choice of the risk associations.

Our findings may have the following implications for risk communication. They indicate that it is not necessary to provide individuals with their own personal risk association in a risk communication, because a risk associated by others can also be linked to the unknown risk. In addition, we recommend using the mental models approach to reveal what the target audience already knows about the unknown risk and which associations they use to interpret it (Morgan et al., 2002). Finally, before using associated risks in risk communication it is suggested to study the effects of associated risks on risk perception empirically.

In short, the qualitative study and the survey study were the first to reveal the role of risk associations in risk perception. This may be interesting to apply in risk communication.

Chapter 4. An associative approach to risk perception: Measuring the effects of risk communications directly and indirectly

In this experiment, we measured the respondents' risk perception by means of a direct and an indirect measure, which were intended to reveal the secondary evaluative and primary evaluative processes of risk perception, respectively. We wanted to investigate whether these two measures were sensitive to variations in risk messages. We created three different articles describing risks: a high-risk article (emphasizing negative consequences), a low-risk article (emphasizing benefits or lack of association between hazard and negative consequences) and a control article (containing no risk information). The articles discussed (the risk of living near) high-voltage power lines. This hazard was considered to be unknown to most respondents.

The questionnaire (direct measure) included items about demographic characteristics, risk perception and the qualitative characteristics of the risk. In addition, we used the adjusted EAST (indirect measure) to measure people's first, spontaneous association with

the risk.

According to the EAST results, the respondents associated power lines more strongly with unhealthy than with healthy, which may reflect the outcomes of the primary evaluative process. The questionnaire results did not reveal such a negative evaluation of this risk. There was no effect of the variation between the three articles on the EAST results, whereas the self-reported risk perception (questionnaire) did appear to be affected by this variation. The respondents who had read the high-risk article reported a higher perceived riskiness (in the questionnaire) than the respondents who had read the low-risk or control article. The two measures of risk perception were not related. This may indicate that the two measurement methods (creating different situations) evoked separate processes and outcomes of risk perception among the respondents.

We regard the findings of this study as an indication that the EAST may be valuable for studying risk perception. The EAST reveals the first, spontaneous response to a risk, which may resemble the primary evaluative process, while a questionnaire may uncover a different perception of the same risk. Therefore, this indirect method may be used to complement a direct method, to obtain an overall picture of the perception of a risk.

The variation between the risk articles did not appear to affect the primary evaluative process in this study. Perhaps our risk messages were not extreme enough to change the primary evaluative process, because this process is influenced by affective and situational cues. Instead, a text that is made more salient by highlighting these cues may affect the primary evaluative process. It should be examined whether risk communication that includes these cues can affect both the primary and secondary evaluative processes.

Despite the promising results obtained with the EAST, we should mention that it is not self-evident that this indirect method actually measures risk perception, rather than a general affective evaluation, as is the purpose of the original EAST. All the same, the EAST seems to be a valuable tool to measure risk perception in addition to a questionnaire, as it may provide additional information about the way people perceive risks.

Chapter 5. Audiovisual risk communication unravelled: Effects on gut feelings and cognitive processes

In the fifth study, we built on the results of the previous experimental study (Chapter 4). We designed an experiment to investigate how audiovisual risk communication can influence both the primary and secondary evaluative processes of risk perception. We used video as the medium because this is more vivid and more likely to affect the primary evaluative process than textual information only. Textual information may mainly affect the secondary evaluative process. Also, the videos included both images and text, which is beneficial for recall (Dual Coding Theory, Clark & Paivio, 1991). The effects of the videos were measured by the adjusted EAST and a questionnaire.

This study departed from three hypotheses. Firstly, we expected that the two main elements of a video (sound/footage versus text) would affect the two processes of risk perception differently. In particular, we hypothesized that the sound/footage would influence the primary evaluative process because this type of video is vivid and includes affective elements (e.g. images, Slovic et al., 2004). On the other hand, the text of a video was assumed have an effect on the secondary evaluative process. The second hypothesis was that sound/footage videos would have a more lasting impact on risk perception than text videos. The multi-modality of video information may affect risk perception after a

delay period, because it is stored in memory better than, for example, textual information alone. Thirdly, we hypothesized that the respondents would associate the hazard presented in this study more strongly with danger than with harmlessness, as measured by the EAST. In addition, we examined whether the results of the EAST and the questionnaire were related.

Four videos were tested in this study in a 2 (sound/footage: present vs. not present) x 2 (text: present vs. not present) design: text and sound/footage video, text video without sound/footage, sound/footage video without text and control video (no text and no sound/footage). The videos were about nanotechnology and addressed its benefits, risks and uncertainties.

The EAST included pictures and the evaluative valences were harmless–dangerous. The questionnaire considered demographic characteristics, risk perception, affect and video characteristics (only in Measurement 1). After watching one of the videos, the respondents completed the EAST and filled in the questionnaire (Measurement 1). Two weeks later, the respondents were invited back to the laboratory and completed the same EAST and questionnaire (Measurement 2).

The results showed that the sound/footage videos (i.e. the text and sound/footage video and the sound/footage video without text) were perceived as more vivid than the videos without sound/footage (the text video without sound/footage and the control video). At both measurements, the EAST results showed that respondents associated nanotechnology more strongly with danger than with harmlessness, supporting our third hypothesis. However, such a negative perception was not found in the questionnaire results, as the respondents evaluated nanotechnology around the midpoint of the risk perception scale at both measurements.

At Measurement 1, neither the text nor the sound/footage videos seemed to influence the EAST results. At the second measurement, the sound/footage videos caused a stronger association between nanotechnology and danger (EAST) than between nanotechnology and harmlessness, compared to the no-sound/footage videos.

The questionnaire results showed that the text videos influenced some risk perception and affect items at the first measurement, whereas sound/footage had no effect on these items. The type of video barely influenced the self-reported risk perception or affect items at the second measurement. Further, the effects of text on the questionnaire items had decreased between the two measurements. Thus, the first hypothesis was partly confirmed, in that sound/footage videos seemed to affect the primary evaluative process after a delay period, whereas text videos appeared to influence the secondary evaluative process immediately after the video was viewed. The support for the second hypothesis (the long-term effects of the video elements) was not as obvious. First, the effect of sound/footage videos on the primary evaluative process only appeared after a delay period, but there was no clear effect of time on this process. Second, the effect of text videos seemed to decrease somewhat over time. Moreover, the two processes of risk perception seemed to operate in parallel, since the EAST and questionnaire results at both measurements hardly correlated.

The delayed effect of the footage videos may have been caused by a so-called sleeper effect: at first, the persuasive effect of the footage as measured by the indirect test may have been suppressed because the respondents may have experienced the end of the footage video as manipulating, which undermined the credibility of the video. This discounting cue may have suppressed the outcomes of the indirect test. After a delay period, the

respondents had forgotten about this discounting cue. Consequently, the persuasive effect of the footage only appeared at the second measurement: nanotechnology was associated with danger.

In sum, this study showed that video may be a useful medium for risk communication. Its sound/footage seemed to influence the primary evaluative process of risk perception, whereas its text appeared to have an immediate effect on the secondary evaluative process. The EAST may be valuable for risk perception research, as it reveals additional information about the way people perceive a risk, complementing the findings from a questionnaire. Both processes seem to be important in risk perception and to be affected differently by risk messages. It would be interesting to examine how risk communication can influence both processes without a delay and with long-lasting effects.

Chapter 6. The effect of active risk communication on the relation between associative and cognitive processes

Risk communication does not always seem to affect people's perception or understanding of a risk the way it is intended to. An explanation for this phenomenon may be that people stick to their first impression (primary evaluative process) and do not change this when they receive information about the risk (secondary evaluative process). Perhaps risk communication can establish a relation between these two processes, so that people form an integrated and consistent perception of and reaction to a risk. We hypothesized in this study that this integration might be accomplished by active risk communication. Active risk communication would stimulate cognitive elaboration of information, so that it is processed at a deeper level than passive risk communication. As a result, several strong associations are activated between the risk and its evaluation in the two processes of risk perception.

In this study, we examined the effects of active, passive and no risk communication about pedestrians' risks in traffic situations. The format we used was scenario information, which is a vivid and step-by-step description of how a risky event can end dramatically (Hendrickx et al., 1989). In the active risk communication condition, the respondents wrote a scenario, for example, how a pedestrian was hit by a car. The passive risk communication included reading a scenario about how a pedestrian got involved in a traffic accident. In the control condition, the respondents were asked to write a scenario about an irrelevant event. The active task of writing a scenario was expected to stimulate both deliberative processing of the risk information (secondary evaluative process) and mental simulation of the risky event (primary evaluative process). Since the same information source activated both risk perception processes, the resulting associations within each of the two processes should be in agreement.

We used a questionnaire and the EAST to assess the effects of the risk communications and the control task on the primary and secondary evaluative processes of risk perception. The respondents were randomly assigned to one of the tasks, after which they completed the EAST and filled in the questionnaire.

The EAST results indicated that, overall, the respondents seemed to associate being a pedestrian in traffic situations with danger (lower percentage of errors than the association between pedestrian traffic situations and harmlessness). The questionnaire results also revealed that the respondents perceived being a pedestrian in traffic situations as risky (i.e. the average score on the risk perception scale lay above its midpoint), independent of the type of risk communication. The type of risk communication did not affect the two processes

of risk perception. Moreover, the results of the indirect and direct measures seemed to be related in the active risk communication condition. Thus, active risk communication may have brought the two processes of risk perception into line. We assumed that active risk communication only influenced the two processes of risk perception at individual level but not at condition level, since this type of communication appeared to relate the two processes but the outcomes of the two processes did not differ between conditions.

These results confirmed our hypothesis that active risk communication triggers more associations with the risk in both processes, so that it is more likely that similar associations are activated in the two processes. Researchers in the field of social cognition have described the relation between dual processes in the light of several moderators (see Hofmann, Gschwender, Nosek, & Schmitt, 2005). Moderators that explain the *translation* between the two processes may be particularly interesting in explaining our findings, such as the representational strength of people's risk perception and their awareness of the two processes.

Our final study thus showed that when active risk communication is used, the two processes of risk perception seem to be related, unlike what we found when using passive or no risk communication. Thus, the concept measured by the EAST may be in line with self-reported risk perception under certain conditions. This study also showed that it is important to take both processes into account when measuring risk perception, in the design of risk communication and in the assessment of its effects.

General Discussion

In this thesis, it is hypothesized that not only cognitive processes but also associative processes are important in risk perception. So far, research about the way people perceive risks has paid little attention to associative processes, to primary evaluative processes, or to associations with other risks and other knowledge. The studies reported on here concerned both cognitive and associative processes in risk perception and risk communication. In the following discussion, we consider the main findings of our studies, the indirect test we used to measure risk perception and an evaluation of the methods used.

Main Findings and their Relation to the Associative and Cognitive Processes

Two main findings stand out in our research: the role of associative processes in risk perception and the difficulty of influencing risk perception by risk messages. We now discuss these findings in detail.

Impact of associative processes

Our results consistently suggest that associative processes are important in the way people perceive risks. This is supported by two outcomes. First, the interview study and survey (Chapter 3) showed that people associate new or unknown risks with known risks to interpret the former (i.e. specific associations). Second, the experiments (Chapters 4, 5 and 6) revealed that our respondents appeared to have a strong, spontaneous association with a risk and that assessing this association yielded a more comprehensive picture of the way the risks were perceived.

We studied the impact of associative processes in risk perception in various contexts. That is, associative reactions were found for different risks, such as health risks (e.g.

phthalates in cosmetics), environmental risks (e.g. medicine residues released into the environment), insidious risks (e.g. living near power lines), catastrophic accidents (e.g. chlorine transport by train), risks to children (e.g. deoxynivalenol in wheat products) and general safety risks (e.g. being a pedestrian in traffic situations). Associative processes were also revealed in various samples of respondents, namely students and the general population, as well as in qualitative and quantitative studies and in direct (self-report questionnaires) and indirect tests (EASTs). In all of these contexts, associative associations consistently appeared to play a part in risk perception, either because we found EAST effects even for unknown risks or because people appeared to associate the unknown risk with a known risk. Thus, associations were revealed in both primary and secondary evaluative processes.

So far, associative processes have not received much attention in risk perception and communication research. Although several researchers have suggested that associative processes are important in risk perception and decision making (Sloman, 1996; Slovic et al., 2004; Strack & Deutsch, 2004), studies in this field have only looked at associative processes in specific areas, for example, the role of *affective* associations in risk perception (which we would describe as the result of the primary evaluative process) (Finucane et al., 2000; Kobbeltveld, Brun, Johsen, & Eid, 2005; Rundmo, 2002) and the role of associative processing in probability estimations (Windschitl & Weber, 1999). We were interested in both general and specific associations, because these were both included in our definition of associative processes. General associations are based on an approach–avoidance reaction, that is, a fundamental and immediate evaluation of whether something is dangerous or harmless (i.e. the result of the primary evaluative process). Specific associations are the result of semantic similarity or similarity in salient characteristics between two risks, which link an unknown risk and a known risk based on specific characteristics (i.e. the outcome of the secondary evaluative process).

Associative processes in risk perception may have developed because they offer some evolutionary advantage (see Elliot, 2006), in that the immediate approach–avoidance response to a risk increases the chances of survival. A quick association between a risk and its evaluation can help people avoid danger. Another reason why associative processes are used is that they save cognitive workload in risk perceptions. In other words, they function as a heuristic: the perceived riskiness of a known risk serves as an indicator of the perceived riskiness of the new or unknown risk, if the known and new or unknown risks share salient characteristics or have a semantic relation.

People appear to have at least four reasons to associate new or unknown risks with known risks. The known risks serve to demonstrate (1) the possible severity and consequences of the new or unknown risks, (2) the fact that people have already tolerated many similar risks before even though they know that these known risks may cause harm, (3) the benefits of some risky activities, and (4) the fact that unknown risks can be remedied.

It should be noted that associative and cognitive processes are considered to be fundamental determinants of risk perception within individuals. We do acknowledge the influence of other factors outside individuals, such as social and cultural factors. These external factors are supposed to determine which associations and cognitions are used, and may have an effect on the outcomes and content of these two processes. In addition, external factors are believed to influence the effect of risk perception on behaviour. This implies that people's perception of a risk, which results from associative and cognitive

processes, does not straightforwardly predict their behaviour towards that risk.

Overall, we believe that these findings indicate that associative processes should be taken into account in risk perception and risk communication research, in addition to cognitive processes. Since the two types of processes can complement each other in risk perception, the inclusion of associative processes may lead to a better understanding of the way people perceive risks. In addition, risk communication that is based on both associative and cognitive processes of risk perception may better be able to anticipate how people perceive a risk than risk communication that is only based on cognitive processes.

Risk communication effects

The second main finding of our studies is that it turned out to be difficult to influence the way people evaluate risks by means of risk messages. The primary evaluative process in particular appeared hard to influence. So far, our findings seem to indicate that the textual information in a risk message may be able to influence the secondary evaluative process in the short term. For now, we tentatively suggest that if one wants to influence the primary evaluative process, moving images may be better able to accomplish this, in time.

It may be that it takes more than a single message to influence spontaneous associations with risks. Perhaps other strategies, such as repeated exposure or conditioning, are needed to influence the primary evaluative process, that is, a risk should be associated repeatedly and consistently with stimuli that indicate danger or safety. Another option is to make a single message extreme and memorable in order to establish a spontaneous association with a risk. Of course, this should remain within the boundaries of what is ethically acceptable.

The results of our final study indicated that active risk communication by having respondents write a risk scenario results in a link between the primary and secondary evaluative processes of risk perception. Thus, this type of communication seems to be a good starting point to bring these two processes into line, which may be useful because the results of our experimental studies often indicated that these two were not related. At the same time, it should be noted that active risk communication only related the two processes but did not influence how participants perceived the risk.

In addition, we would like to remark that the primary and secondary evaluative processes might be able to explain the discrepancies in risk perception between the general public and experts, and even why some risk communications were found to be ineffective. Perhaps the general public's risk perception is determined mainly by the first, spontaneous association with a risk, whereas the risk perception of experts is dominated by the secondary evaluative process. Once again, this demonstrates that both processes should be considered in risk perception and communication.

The Indirect Method

To our knowledge, the experiments presented in this thesis were the first to use the (adjusted) Extrinsic Affective Simon Task (EAST) to measure risk perception. We consider the adjusted EAST to be valuable in risk perception and communication research for two reasons. Firstly, because our experiments revealed strong EAST effects: the respondents consistently appeared to have a strong association between the risk and one of the two evaluations. In our case, they associated the risk with 'unhealthy' or 'dangerous'. EAST effects are not self-evident, since respondents could also not have shown a strong

association between the risk and either one of the two evaluations; they would then seem ambivalent about the risk.

Secondly, the EAST may be valuable because it seems to measure a different aspect of risk perception than a questionnaire. Since we hardly found correlations between the EAST and the questionnaire results, the EAST may provide additional information about the way people perceive risks, complementing the results of a direct method. It reveals people's gut feeling about a risk, which can be different from their deliberate evaluation. Also, the results of the EAST may resemble people's reaction in spontaneous or pressurized situations, as it evokes the first reaction to a risk before extensive elaboration can possibly start.

However, it is still not fully clear whether our adjusted EAST measured risk perception or a more general affective evaluation, as the original EAST does (De Houwer, 2003). This may be problematic when people's affective evaluation is different from their risk perception of the same situation. For instance, some people relate bungee jumping with a positive affect ("the kick") and at the same time associate it with riskiness. If our EAST measures an affective evaluation instead of risk perception, and these two appraisals are contradictory for certain objects (e.g. positive and dangerous), this may lead to incorrect interpretations of the way people spontaneously perceive these objects.

Alternatively, it may be that the EAST actually assesses the primary evaluative process of risk perception but that people are not influenced by this process in real life. In other words, whereas this indirect test may reveal the primary evaluative process, people may not pay attention to the outcome of this process in daily life. In that case, the primary evaluative process will not affect people's overall perception of a risk.

Nonetheless, we believe that the outcomes of our adjusted EAST are based on risk perception rather than on an affective evaluation, and that people automatically use the outcomes of the primary evaluative process in their risk perception. We argue that the affective evaluation is founded on an approach–avoidance distinction (i.e. risk perception) rather than the other way around, namely that risk perception is based on an affective evaluation. Our rationale for this is that the approach–avoidance distinction has more evolutionary survival value than the positive–negative evaluation.

Even if it appears that the EAST measures a general affective evaluation instead of (more specific) risk perception, this test remains valuable for risk perception and communication research, as the function of the EAST remains the same. If we assume that this test measures the first, spontaneous reaction to an object in real-life situations, then apparently, this type of reaction is based on a general affective evaluation, which may influence how people perceive risks. It has been suggested that the affective evaluation is the "core evaluative dimension of approach–avoidance motivation" (p. 112 Elliot, 2006) and that the context determines the precise meaning of this dimension; e.g., in some situations, this may be a dangerous–harmless evaluation.

Therefore, our adjusted EAST should be validated further, and it should be investigated how the outcomes of the test relate to people's responses to risks in real life. A perfect way to do this would be to relate the results of our adjusted EAST to people's spontaneous behavioural reaction to a risk. Several studies have already demonstrated that indirect tests could predict people's habitual behaviour in relation to the stimulus assessed (Maison, Greenwald, & Bruin, 2004, Study 3). These tests also appeared to reveal people's behaviour preferences (De Houwer & De Bruycker, in press; Maison et al., 2004; Swanson, Rudman, & Greenwald, 2001). For example, the EAST was capable of categorizing vegetarians

and non-vegetarians on the basis of their vegetable and meat preferences (De Houwer & De Bruycker, in press). In addition, the Implicit Association Task (IAT) proved capable of predicting consumers' taste recognition of cola brands and cola brand preference (Maison et al., 2004). Furthermore, the Approach–Avoidance Task showed that a stimulus (e.g. risk) automatically activates an approach movement or an avoidance movement (Chen & Bargh, 1999). Thus, these studies imply that our adjusted EAST may be able to predict actual behaviour and behavioural preferences.

Another option would be to relate the results of our adjusted EAST to a physiological measure that is known to assess primary reactions to risks (e.g. arousal). However, this measure does not indicate whether people experience this physiological activation as danger (risk perception) or as something else (e.g. anger).

Evaluation of the Methods used

Our research used various methods: a literature review, focus group and in-depth interviews, a survey and experimental studies. We started with in-depth and focus group interviews to get a handle on the way people interpret unknown risks and risk messages. Based on this work and the literature review, we conducted several experimental studies. The advantage of the experimental studies in the laboratory was that the effects of the risk messages could be assessed in isolation, as some important confounding variables could be controlled and the respondents were not bothered by distracters, e.g. noise in the communication channel.

As was mentioned above, various types of risk were used in the experimental studies. This may be an advantage as well as a disadvantage. The advantage is that it provides some evidence that the results do not pertain to one risk only but may be generalized to some extent. For example, the EAST was applied to various risks and was able to reveal that the respondents had a preferred association with these risks. Thus, the EAST may also be capable of measuring the association strength of other risks. On the other hand, the use of different risks can also be regarded as a disadvantage, because it complicates straightforward conclusions about the results of our experimental studies. If we had used the same risk(s) in all experimental studies, we might have been more convincing when recommending the type of risk message that would be effective in influencing risk perception. However, it would still not be clear whether these recommendations could be generalized to other risks.

Another limitation may be that the respondents in the experimental studies were students. Students may be a special group of respondents because most of them are young and still lead sheltered lives. They may perceive risks more light-heartedly and as personally irrelevant than people in general. However, there is no reason to assume that the fundamental processes by which people evaluate risks (primary and secondary evaluative processes) differ between students and the general public. Nevertheless, the outcomes and relative contributions of the two processes may differ substantially between students and the general public. In this respect, it should also be mentioned that the respondents in the interview and survey studies were members of the general public.

Finally, we want to stress again that the way risk communication was studied in the research underlying this thesis does not imply that we equate risk communication with short messages about risks. Of course, we acknowledge that in practice, risk communication includes many factors, such as trust, two-sided communication and various interested parties. A risk message is a small but essential part of this procedure.

Conclusions and Implications

This dissertation is the first to show empirically that associative processes are prominent features of the way people perceive risks. People seem to use associations with known risks to evaluate new or unknown risks (secondary evaluative process), and they rely on their gut feeling in a spontaneous, immediate reaction to a risk (primary evaluative process). Therefore, we suggest that both associative and cognitive processes should be considered when trying to find out how people perceive a risk. Furthermore, it may be valuable to take both processes into account when developing and evaluating risk communication.

We also studied the associative and cognitive processes in more detail, i.e. the influence of the primary and secondary evaluative processes in risk perception and communication. This led to the conclusion that it may be difficult to develop a risk message that influences both the primary and secondary evaluative processes of risk perception. The primary process in particular was not easily affected by our messages. This process may require a communication method that establishes automatic associations between a risk and its evaluation. Helpful strategies in this respect might include conditioning or repeated simultaneous exposure to the risk and stimuli indicating danger or safety. More research is needed to find out how both processes of risk perception can be influenced by risk communication so that people respond to a risk in the same way regardless of the process they rely on.

To our knowledge, the experiments reported in this thesis were the first in which the EAST was applied to measure risk perception. We consider this indirect measure to be valuable because it may provide additional information to complement the results of a direct test. The EAST seems to reveal people's first association with a risk. Therefore, we suggest using an indirect method, in addition to a direct method, in pre-test or evaluation research to measure how people perceive a risk and to assess the effects of risk communication. This would generate a more complete picture of the way people perceive risks.

Overall, we believe that the way risks are evaluated, namely by using associative as well as cognitive processes, is fundamental to humans. However, we do acknowledge that other factors, such as the type and characteristics of the risk, the context, society and an individual's personality, may influence the outcomes of these two processes and hence the perception of a risk. Both associative and cognitive processes should be taken into account in the development of risk communication and in the evaluation of its effects. In the end, this may result in a comprehensive view of the way people perceive risks and the way risk communication can be optimized.

Chapter 2

Probability Information in Risk Communication: A Review of the Research Literature

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Abstract

Communicating probability information about risks to the public is more difficult than might be expected. Although many studies have examined this subject, their resulting recommendations are scattered over various publications, diverse research fields, and are about different presentation formats. An integration of empirical findings in one review seems worthwhile to describe the evidence-base for communication about probability information and to present the recommendations that can be made so far. The studies are categorized in the following formats: frequencies, percentages, base rates and proportions, cumulative risk information, absolute and relative risk information, verbal risk information, numerical versus verbal risk information, graphs and risk ladders. These formats are organized around several main recommendations. Based on the results we argue that the effects of presentation format not only depend on the format, but also on the context in which it is used. Furthermore, we argue that the presentation format may have the strongest effect when the receiver processes probability information heuristically instead of systematically. It is concluded that future research and risk communication practitioners should not only concentrate a presentation format that is adequate in general ('magic bullets'), but also on the situation in which the probability information is presented as this may predict how people process the information and in what way this may influence their interpretation of the risk.

Introduction

Communicating the results of risk analyses to people is important to inform them about risks (Covello, von Winterfeldt, & Slovic, 1987; Fischhoff, 1995; Keeney & von Winterfeldt, 1986). The risk's probability is one of the outcomes of a risk analysis, in addition to, for example, details about the people at risk and the exposure level (National Research Council, 1983; Renn, 2005). Numerous studies have been conducted about how (i.e. in which format) to present the probability of a risk to the general public. The studies are reported in many publications, are from different research fields and examine various presentation formats. As a result, there is no overall picture of the way that these various presentation formats affect risk perception and other factors, such as understanding, attitude and behaviour. Therefore, it seemed worthwhile to review the research literature about the communication of probability information. The purpose of this review is to come to general recommendations about the presentation of probability information in risk communication, which should be particularly useful for practitioners involved in risk communication.

Probability information can be communicated in several ways, using various presentation formats, such as frequencies, percentages, rates and verbal expressions. Several studies have tried to clarify which presentation formats of probability information can facilitate comprehension and interpretation (e.g. Covello et al., 1987; Fischhoff, 1995; Hendrickx et al., 1989; Shapira, Nattinger, & McHorney, 2001; Slovic, Monahan, & MacGregor, 2000; Stone, Yates, & Parker, 1994). Also, some reviews have already been published about probability information in risk communication. However, these were either in the medical field, focusing on doctor-patient communication (e.g. Adams & Smith, 2001; Edwards, Unigwe, Elwyn, & Hood, 2003; Epstein, Alper, & Quill, 2004; Ghosh & Ghosh, 2005; Julian-Reynier, Welkenhuysen, Hagoel, Decruyenaere, & Hopwood, 2003; Thomson, Edwards, & Grey, 2005), covered only a limited number of presentation formats (e.g. Gigerenzer, 2003; Rothman & Kiviniemi, 1999; Weinstein, 1999), or were not based on empirical evidence but on conceptual analysis (e.g. Covello et al., 1986; Fischhoff & Downs, 1997; Paling, 2003). In this review, we not only include medical and health risks, but also technological risks and accidents. The review covers studies about what kind of probability information people prefer and about the effects of different presentation formats on risk perception, or related measures (e.g. willingness to pay), and on comprehension.

The review is limited in three ways. First, it does not focus on recommendations that are based on practical cases that caused public outrage, as these recommendations have been summarized elsewhere (Barnett & Breakwell, 2003; Jardine, 2003; Smith & Desvousges, 1990; Van der Pligt & Midden, 1990). Instead of such a practice-based approach, we chose an evidence-based approach by reviewing mainly quantitative research and sometimes qualitative research. Second, we use a narrow definition of *risk communication*; we only examine risk messages and the way people perceive them. As a result, we do not discuss broader issues that may be involved in risk communication such as context, policy and two-way risk communication. Third, we chose one main subject of risk communication to review, that is probability information, although we acknowledge that many other factors of a risk communication may influence the way people perceive a risk, such as the framing of risk information, the role of trust, risk comparisons and the qualitative content of messages.

We start this review by explaining the method of the literature search. Then we discuss studies that concerned probability information in risk perception and/or communication. These are arranged under the following headings: (1) frequencies, percentages, base rates and proportions, (2) cumulative risk information, (3) absolute and relative risk information, (4) verbal risk information, (5) numerical versus verbal risk information, (6) graphs and (7) risk ladders. Because the design, aims and research fields often vary between the studies, we further organize the review by presenting recommendations. We first state a recommendation and then explain the studies it is based on. This way, the reader can easily evaluate the empirical basis of a certain recommendation and see which empirical evidence is still lacking. Some recommendations describe the *general use* of probability information whereas others suggest *how* to present probability information (i.e. presentation format). The recommendations also differ on details, whether they include certain conditions, and the amount and quality of the evidence from the studies reviewed. We therefore categorized the recommendations in Box 2.1 and 2.2. Box 2.1 provides general recommendations about the use of probability information in risk communication and Box 2.2 presents recommendations about the way to present probability information. We also indicated the quality of the evidence by means of stars in both boxes.

Search Method

The topics that we looked for in the PsycINFO, Medline, Eric and the International Bibliography of Social Sciences literature databases are mentioned in Table 2.1. These were all conjunctive searches. This search resulted in 1,058 hits. **Seventy two relevant** articles remained after removing double entries, and after evaluating the title and abstract. In addition, we used the snowball method, that is, 'new' studies were found by looking up interesting references of 'old' studies. This resulted in the further selection of 19 articles using the same criteria.

We applied the following criteria in the title and abstract selection: the manuscript should (1) be a research article in a scientific journal or a book, or be presented at a conference, (2) be about a risk or other uncertain event (e.g. a game of chance), (3) be studied among laypeople (i.e. the general public), and (4) include a description of method, procedure, sample size, dependent variables and independent variables. After reviewing the 91 articles more thoroughly, 57 were selected for this review.

The details of the studies discussed in the next section are summarized in tables about each of the topics, as referred to in the text. In these tables, details are given about the design of the study, sample size, type of respondents (e.g. students, general public), dependent and independent variables and subject of the risk communications ('risk').

Frequencies, Percentages, Base Rates and Proportions

First, we discuss one qualitative and three quantitative studies about the effects of frequency and percentage information on risk perception and understanding. In addition, we discuss a study that investigated the effects of rates and proportions. Last, three studies about base rates are reviewed.

The probability of a risk is often expressed in frequencies² or percentages. The layout of

these two formats may determine the understanding and perception of risks. In addition, risks expressed in frequencies may be differently understood or interpreted than risks expressed in percentages.

Table 2.1 Items of literature search

Main items	In combination with	In combination with
Risk communication	Probability	
Risk information	Percentage	
Risk message	Frequency	
Risk perception	Natural frequency	
	Mortality rate	
	Survival rate	
	Numerical and/or verbal	Risk estimate, probability, chance, risk, format, description, or frequency
	Relative and/or absolute	Presentation, risk, or risk reduction
	Number needed to treat	
	Number needed to screen	
	Odds ratio	
	Cumulative risk	
	Conjunctive and/or disjunctive	Estimate, risk, or probability
	Graph	Line, bar, chart, histogram, stick figure, or pie chart
	Graphical display	
	Risk ladder	Paling Perspective Scale
	Risk scale	
	Visual tool	
	Survival and/or mortality	Curve, display, chart

Recommendation 1. Present the same denominator in probability information throughout the risk message, so that people can compare the probability information when they neglect the denominator.

Yamagishi (1997) investigated the effects of several frequency formats on risk perception. In his study, respondents estimated the risk of 11 well-known causes of death, which varied on two probability dimensions: small versus large divisors (12.86 and 24.14 vs. 1,286 and 2,414) combined with large vs. small denominators (100 vs. 10,000). This resulted in four frequency formats (see Table 2.2). For 9 of the 11 causes of death, the respondents based their risk perception on the divisor, without sufficiently considering the denominator. Consequently, respondents thought that a mortality of “1,286 out of 10,000” represented a higher risk than a mortality of “24.14 out of 100”. It seems that respondents used the divisor (number of deaths) as an anchor to estimate the risk and neglected the denominator (sample size) of the risk in the population. The larger the first number of the probability estimate, the more risky the hazard was perceived to be. Thus, the frequency format should be used with care. It is recommended to apply the same denominator throughout a risk message that includes several probabilities so that people can still compare the frequency information if they ignore the denominator.

Table 2.2 Characteristics of studies about numerical probabilities: frequencies vs. percentages, cumulative risk information and base rates.

Authors	Study Design	Respondents	N	Dependent variables	Independent Variables	Risk
Yamagishi (1997)	1 experiment	students	52	risk perception	2 (divisor: high vs. low) x 2 (denominator: 100 vs. 1,000), resulting in: 2.414 per 10,000; 1,286 per 10,000; 24.14 per 100; 12.86 per 100	well-known causes of death (e.g. heart diseases, cancer)
Grimes & Snively (1999)	2 experiment	students	41	risk perception	two formats of mortality information (frequency and range)	see Study 1
	experiment	women	633	comparison between two probabilities	2 (proportions: 1 in 384 vs. 1 in 112) x 2 (rates: 2.6 per 1000 vs. 8.9 per 1000)	bladder infection
	1 experiment	students	60	use of Bayesian reasoning	frequency vs. probability information, either in shortened or standard description.	15 topics, e.g. breast cancer, AIDS, being an active feminist
	1 experiment	students	160	probability estimate	2 (information format: chances vs. frequencies) x 2 (question format: two-steps vs. single-step) x 2 (task domain: probability vs. frequency)	disease problem and admission problem
	2 experiment	students	32	probability estimate	question format: single-step vs. single-step with explicit question for the expected frequency	disease problem and admission problem
Gigerenzer & Hoffrage (1995)	3 experiment	students	40	probability estimate (the chance of a true positive)	information format: chance vs. frequency	disease problem and admission problem
	4 experiment	students	80	probability estimate	2 (information format: chances vs. frequencies) x 2 (question format: distributive chance vs. distr. frequency)	disease problem and admission problem
	5 experiment	students	40	probability estimate	2 (frequency problems: standard vs. defective version: chance of uninfected, not-positive people) x 1 (standard frequency question)	disease problem and admission problem

Table 2.2 Continued.

Authors	Study	Design	Respondents	N	Dependent variables	Independent Variables	Risk
	6	experiment	students	40	probability estimate	2 (frequency format: percentages vs. multiple sample) x 1 (standard frequency question)	disease problem and admission problem
	7	experiment	students	108	probability estimate	3 frequency formats: 1-50 condition, 1-2 condition, 100-200 condition	disease problem
Schapira et al. (2001)		focus groups	women	41	communication preference	frequency vs. percentage, stick figure, bar graphs, time frame	breast cancer
Greening et al. (2005)	1	experiment	students and mothers	2 x 131	chance, worry, action	5 scenarios: general base rate vs. conditional base rate (high vs. low)	medical and traffic risks
Gigerenzer et al. (1988)	2	experiment	students	225	see Study 1	see Study 1	see Study 1
	1	experiment	students	97	numerical probability estimate	2 (base rates: low vs. high) x 2 (reality of sampling process: verbally asserted vs. visually observed)	engineer-lawyer paradigm of Kahneman & Tversky (1973)
	2a	experiment	students	48	see Study 1	3 (half time results: pos., neutral, or negative) x 4 (base rates: 7, 10, 15, or 19), WS	soccer
	2b	experiment	students	144	see Study 1	3 (half time results: pos., draw or negative)	soccer
Gigerenzer, et al. (2005)		survey	general public	750	understanding, intention	30% chance of rain tomorrow, 5 cities	weather forecast

Recommendation 1 is also supported by a study that compared rates and proportions (Grimes & Snively, 1999). In rates, the number of people affected by the risk (divisor) changes while the unit of population exposed or the denominator is a round, constant number (e.g. 3 per 1,000 people). In proportions, the divisor is kept constant and the denominator changes (e.g. 1 per 333 people). Both formats were examined among women using the probability of contracting a bladder infection (see Table 2.2). The participants received two proportions simultaneously (a high and a low) and were asked to indicate which chance of bladder infection was more probable (e.g. 1 in 112 vs. 1 in 384). A similar procedure was used for rates. The high and low proportions corresponded to the high and low rates, respectively. As expected, it was easier to indicate which rate was higher than which proportion, although many women did not understand either format.

Recommendation 2. Natural frequencies or a presentation format with the same elements are recommended for probability information that includes false positives (e.g. test results) because these are easily understood and are likely to result in adequate risk estimates.

Gigerenzer and Hoffrage (1995) studied whether frequency and percentage formats could stimulate the use of Bayesian reasoning (see Table 2.2). Bayesian reasoning can be applied to calculate probabilities and is assumed to lead to a better understanding of a probability problem. Gigerenzer and Hoffrage call the frequencies used in their studies 'natural frequencies' because they argue that these represent probability information as it is encountered in real life. For example, the probability that someone has disease X is related to the number of people who suffer from the disease *and* have the symptoms (e.g. 7 people). This is then divided by the number of people in the population who experience the symptoms of the disease (without necessarily having the disease) (e.g., 7 plus 79 people). Thus, the probability that someone who has the symptoms of the disease and is infected, is $7/(7 + 79) = .08$. In this study, respondents were presented with either natural frequencies or percentages about the probability of 15 problems (7 of which were risks). The respondents had to estimate the probability that one person would experience the specific problem. In addition, they had to explain their estimate by 'writing aloud'. More respondents in the natural frequency conditions than in the percentage conditions appeared to apply Bayesian reasoning. Gigerenzer and Hoffrage (1995) suggested several explanations for the favourable effects of the natural frequency format. First, natural frequencies require fewer cognitive operations than percentages, as this type of information is presented in the same way as it is encountered in daily life. Second, natural frequencies are easier to use than percentages because the base rate can be neglected in natural frequencies, which is not possible in percentage information.

Giroto and Gonzalez (2001; 2002) refuted the special status of natural frequencies as compared to percentages in relation to Bayesian reasoning. They argued and showed that percentage information can also activate Bayesian reasoning as long as the question format and structure of the problem facilitate this (see Table 2.2). Probability information is easily understood when it is asked in two steps (e.g. first the chance estimate of a positive test result and then the chance estimate of being infected) and when it is explicitly represented as a conjunctive event (i.e. the base rate and the positive test results). Hoffrage, Gigerenzer, Krauss and Martignon (2002) responded by stating that Giroto and Gonzalez actually used natural frequencies disguised as percentages.

According to a focus group study by Shapira, Nattinger and McHorney (2001) women thought that frequency information was easy to interpret and that it provides a human context. Percentages were associated with personal relevant risk information and with

mathematics. Respondents were doubtful about frequencies with small denominators: they thought that the sample size was too small. In addition, they seemed to show an optimistic bias when presented with frequencies, because they attributed risks based on this format to other people. For example, some respondents seemed to associate themselves with one of the 9 people not affected by a risk that was presented as '1 out of 10 people will be affected'.

Another way to express probability information is by means of base rates: the number or proportion of people that experiences certain negative consequences in the population at hand. Base rates are frequently misunderstood or neglected when people perceive risks (e.g. Gigerenzer, Hertwig, van den Broek, Fasolo, & Katsikopoulos, 2005; Gigerenzer & Hoffrage, 1995). We found one study about the effects of base rates in risk communication on understanding and risk perception (Greening, Chandler, Stoppelbein, & Robison, 2005) and two studies that examined the effects of base rates related to the engineer-lawyer paradigm, gambles or weather forecasts (see Table 2.2, Gigerenzer, Hell, & Blank, 1988; Gigerenzer et al., 2005).

Recommendation 3a. Tailored base rates, such as conditional base rates, are recommended in risk communication to people with small risk factors.

Greening et al. (2005) compared people's interpretation of general base rates (GBRs) to that of conditional base rates (CBRs) of medical and traffic risks. CBRs are base rates tailored to a special group, e.g. a high-risk group. In Study 1, two CBRs were presented in one risk communication: one of a high-risk group and one of a low-risk group (see Table 2.2); participants in the other condition received a GBR. In Study 2, the respondents received a high-risk CBR or a low-risk CBR or a GBR. In both studies, the size of the GBR was in between the low-risk and the high-risk CBRs. The respondents who received both low-risk and high-risk CBRs (Study 1) or only a low-risk CBR (Study 2) gave correspondingly low personal risk estimates. Respondents who only received the high-risk CBR (Study 2) or who only received the GBR (both studies) estimated their risk even lower than the low-risk CBR. Apparently, respondents who received a low-risk CBR, agreed that they have unfavourable characteristics that put them a bit at risk, in accordance with the objective risk estimate (e.g. some people with a normal weight may agree that because they do little exercise, they might be at risk for overweight over time), so that they consented with the base rate. On the other hand, respondents with high risk factors and those who received general probability information seemed to underestimate their risk, compared to objective risk estimates and compared to the people with low risk factors.

Thus, CBRs tailored to people with small risk factors may lead to more accurate risk perceptions than GBRs or CBRs adapted to considerable risk factors. These latter two seem to cause an optimistic bias; people think that they are not at risk, perhaps because they take precautionary measures (e.g. they only smoke when they are at home), which other people at risk actually take as well (Weinstein & Klein, 1996). It is unclear whether and how people high at risk can be persuaded that they are actually at risk.

Recommendation 3b. Comprehension of base rate information may be improved by notification of a random sampling method, the absence of stereotypical information and the inclusion of a reference class.

A study about base rates in no-risk situations (Table 2.2) showed that base rates were more accurately interpreted when the respondents were aware of a random sampling method and when the description of the chance event was not stereotypical but more realistic (Gigerenzer et al., 1988). Furthermore, base rates were acknowledged when the

reference class of the event was included, e.g. “a 30% chance of rain tomorrow...means that in 3 out of 10 times when meteorologists make this prediction, there will be at least a trace of rain the next day,” (Gigerenzer et al., 2005, p. 629). Thus, additional information in the risk message may facilitate understanding of base rates, for example, information about a random sampling method, no stereotypical information and notification of a reference class.

In short, frequency information and proportions often seemed to be misinterpreted. Rates are more easily understood than proportions. Probabilities expressed in natural frequencies or formats with similar elements are adequately understood. However, although people consider frequency information as easy to understand, they may not regard it as personally relevant information.

Cumulative Risk Information

So far, we have discussed probabilities of single risk events, meaning that people are exposed to one hazard at a time. People can come into contact with cumulative risks when they are exposed to the same hazard repeatedly over a longer period or to multiple hazards simultaneously. The probability that a hazard actually results in negative (health) consequences increases when people are exposed to the hazard over a certain time period or by multiple hazards. For example, the probability of a pregnancy while using the birth control pill for one year is 0,1% on average; whereas if one considers this probability when the birth control pill is used for 10 years, it has increased to almost 1% in total. Cumulative risk information should be presented in risk communication when people may ignore the long-term effects of a risk because they consider its short-term effects to be small (Keller, Siegrist, & Gutscher, 2006).

Recommendation 4a. Provide cumulative risk information directly to people in stead of letting them calculate this change in probability based on a single exposure.

People often do not take into account that they are exposed to the same risk factors over a longer time period or that they are exposed to several risk factors (e.g. both smoking and radon) simultaneously. Research has shown that people rather consider each hazard or exposure moment as a single, independent exposure (Knäuper, Kornik, Atkinson, Guberman, & Aydin, 2005). Consequently, when they have to compute the cumulative risk themselves, this may lead to overestimation (Knäuper et al., 2005) or underestimation of the risk (Fuller, Dudley, & Blacktop, 2004). Although several researchers give recommendations about how cumulative risk can be communicated, there is no empirical evidence available that proofs the effectiveness of these recommendations (Fuller et al., 2004; Knäuper et al., 2005). Two experiments by Keller et al. (2006) showed that probability information in a cumulative format increases perceived riskiness compared to probability presented as a single event (percentage, see Table 2.3).

Recommendation 4b. Disjunctive probabilities (chance that a harmful event happens at least once) of cumulative information are recommended over conjunctive probabilities (chance that a harmful event never happens) to make cumulative risks easier to understand.

Doyle (1997) presented adolescents with disjunctive and conjunctive probabilities about single risk events and examined whether they could estimate their long-term (cumulative) probabilities. A conjunctive probability is the chance that an event will never

Table 2.3 Characteristics of studies about cumulative risk information.

Authors	Study Design	Respondents	N	Dependent variables	Independent Variables	Risk
Keller et al. (2006)	1 experiment	students	170	risk perception	frequency, percentage 1 year, percentage 40 years, percentage 80 years	flooding around house
Fuller et al. (2004)	2 experiment survey	general public elderly	1,598 81	risk perception understanding risk probability after 5 and 10 years	2 (time period: 1 year vs. 30 years) x 2 (format: pie chart vs. percentage) cumulative risk information in stick figure	flooding around house arterial fibrillation and ischemic stroke
Knäuper et al. (2005)	1 experiment	students	63	probability estimation, context questions, behavioural intention	number of sexual partners, cumulative risk of partner (15% vs. 20%), relationship appeal (high vs. low), attractiveness of partner	STD
	2 experiment	students	61	personal probability estimation	positive feelings about present partner	see Study 1
Doyle (1997)	1 experiment	students	128	risk estimation, preferred strategy	6 (single-year probabilities) x 6 (time modes) x 2 (hazards) x 2 (conjunctive vs. disjunctive probabilities) x 2 (order)	contraceptive risk and natural hazards
	2 experiment	students	87	see Study 1	disjunctive probability, 3 time periods, 2 single-year probabilities	contraceptive risk and natural hazards
	3 experiment	students	40	see Study 1	information about normative range vs. examples of probabilities; see Study 1	contraceptive risk and natural hazards
	4 think aloud	students	12	strategy used	see Study 1	contraceptive risk and natural hazards

happen, whereas a disjunctive probability represents the chance that a risk will happen at least once (see Table 2.3). Conjunctive probabilities were assumed to be overestimated over time and disjunctive probabilities were expected to be underestimated over time because people do not sufficiently adjust the starting point of their estimation (never vs. the single event probability, respectively) to the cumulative exposure. The results indicated that most respondents understood that these disjunctive probabilities increased over time. However, they did not take into account that the conjunctive probability (chance that the risk will never happen) became smaller over time. Nevertheless, participants were bad in estimating the cumulative risks of both probability types.

In sum, most people have trouble understanding and estimating cumulative risks. It is recommended to present cumulative risk information directly to people and to use disjunctive instead of conjunctive probabilities.

Absolute versus Relative Risk Reduction

The effectiveness of risk prevention methods is often presented as absolute risk reduction (ARR) or relative risk reduction (RRR). An example of ARR is: "If all car drivers and passengers would wear seat belts in the Netherlands, the probability of dying in a traffic situation due to a car accident would decrease by 8%" (see Brouwer, Blokpoel, van Kampen, & Roszach, 1996). This is the absolute difference between the percentage of people dying from car accidents when this preventive measure would succeed and the corresponding percentage in the current situation. The RRR describes the absolute risk reduction divided by the percentage of people dying from car accidents when all car drivers and passengers would wear seat belts: "If all car drivers and passengers would wear seat belts in the Netherlands, the relative probability of dying in a traffic situation due to a car accident would decrease by 17%."

Recommendation 5a. Be careful with mentioning RRR as this may be mistaken for ARR.

Most of the 12 studies we found (see Table 2.4) reported that RRR increased the *willingness to get or to advice treatment* and the *willingness to pay* compared to ARR or other presentation formats (Chao et al., 2003; Forrow et al., 1992; Gyrd-Hansen, Kristiansen, Nexøe, & Nielsen, 2003; Hembroff et al., 2004; Malenka et al., 1993; Misselbrook & Armstrong, 2001; Stone et al., 1994; Studts et al., 2005). For example, the study by Malenka et al. (1993) showed that when patients received information about RRR, e.g. presenting the risk reduction caused by medicine X in relative format, this led to greater compliance with the recommendations of the risk information than when they received information about ARR. Thus, respondents who read the RRR information were more inclined to avoid the risk by taking the medicine than those who received ARR information. Respondents may think that the RRR is larger than the ARR for two reasons. The first is that the wordings of the RRR and ARR are almost identical. Secondly, the RRR is presented in larger numbers than the ARR.

Two studies that measured the effects of RRR and ARR on *comprehension* found no differences of RRR and ARR on this dependent variable (Table 2.4, Marteau, Senior, & Sasieni, 2001; Sheridan, Pignone, & Lewis, 2003). Studts et al. (2005) showed that participants who were interviewed about their interpretation of RRR, ARR, NNT and absolute survival benefits, associated RRR with inaccurate understanding. They also mentioned that RRR was more influential on willingness to get treatment than the other

formats. Another qualitative study revealed that respondents preferred to receive ARR rather than RRR to understand the risk (Fortin, Hirota, Bond, O'Connor, & Col, 2001). According to these interviewees, RRR was "too alarming because the risk appeared bigger". In the study by Gyrd-Hansen et al. (2003) respondents explicitly received RRR or had to compute the RRR themselves based on the ARR, which both groups received. Based on the information they received or computed, the respondents chose one of two treatment options. Respondents who explicitly received RRR, preferred the treatment option with high RRR and low ARR, whereas the respondents of the other conditions chose the treatment option with low RRR and high ARR. Respondents with less than 10 years of education appeared to neglect ARR, which might indicate that they did not understand ARR.

Recommendation 5b. RRR may be useful to present small risks that have serious consequences and are otherwise neglected as RRR promotes more risk aversion than ARR.

Stone et al. (1994) found an effect of the risk's actual probability on the interpretation of RRR and ARR. When RRR was presented for a risk with a very small probability (e.g. getting a tire blow out), this resulted in more willingness to pay for risk reduction than when ARR was presented for this risk. There was no difference between the interpretation of the RRR and ARR related to a risk with medium probability (Study 1). The authors suggested that respondents "edited" the ARR of a small risk to nil, while they considered the ARR of a medium risk as small but existing. The RRR of a small risk was perceived as significant, so that this latter format increased the willingness to pay for the small risk compared to when its ARR was presented. Stone et al. tested this hypothesis in Study 2 by varying the presentation format (RRR vs. ARR), the risk's actual probability (low vs. high) and the amount of media attention about the risk (low vs. high), which resulted in four different risk reductions presented as either RRR or ARR. The hypothesis was confirmed: respondents were willing to pay more to prevent low risks when the advantages were presented as a RRR than when they were presented as an ARR. This effect was not found for the high risks, nor was it influenced by the amount of media attention. Stone et al. concluded that RRR might be more persuasive for a small risk that may otherwise be neglected, than ARR because a small risk's ARR may be transformed to nil and thus be ignored.

Recommendation 6. The probability of a risk is better understood when it is compared to the probability of another risk or to another group of people.

Apart from describing the reduction of a risk, its probability can be expressed relative to another group of people or to another situation. A study by Emmons et al. (2004) used computer-tailored risk communication to compare personal absolute risk information with personal absolute *and* personal relative risk information, and with general risk information about colorectal cancer (Table 2.4). They calculated the personal absolute risk information using an average individual's risk of developing the disease over a 20-year time period, specified by age and sex. This resulted in a frequency, e.g. "40 in 1,000 people". The relative risk information was based on a comparison between the individual's risk factors (e.g. diet) and the average risk of the US population. This was described verbally, e.g. "very much above average". Respondents who received personal absolute risk information or personal absolute *and* relative risk information had a more accurate risk perception (i.e. corresponding to the experts' conclusions) than respondents who received the general risk information. The risk perception based on the personal absolute risk information

Table 2.4 Characteristics of studies about absolute and relative risk reduction, number needed to treat and benefit information.

Authors	Study Design	Respondents	N	Dependent variables	Independent variables	Risk
Forrow et al. (1992)	survey	physicians	235	treatment advise	ARR vs. RRR (within subjects) and type of disease (between subjects)	hypertension and hypercholesterolemia
Misselbrook & Armstrong (2001)	survey	hyper- and normotensive patients	89 + 187	willingness to treat	RRR, ARR, NNT and personal probability of benefit	hypertension
Hembroff et al. (2004)	experiment	general population	952	willingness to recommend treatment	subsequently: baseline info, higher risk of breast cancer, lower risk of heart disease (RRR vs. ARR)	breast cancer, heart disease
Studs et al. (2005)	experiment	medical students	203	confusion, confidence, helpfulness, influence, qualitative description	RRR, ARR, absolute survival benefit, and number needed to treat	breast cancer
Malenka et al. (1993)	quasi-experiment	students	470	choice of medication	RRR vs. ARR	benefits of medicines
Chao et al. (2003)	experiment	students	203	willingness to recommend, confidence, confusion	RRR, ARR, NNT and absolute survival benefit (ASB)	breast cancer
Stone et al. (1994)	1 experiment	students	108	willingness to pay	RRR vs. incident rate (absolute risk) of improved product and standard product	tires vs. toothpaste
	2 experiment	students	227	willingness to pay	2 (display format: relative risk vs. incidence rate) x 2 (actual risk level: high vs. low) x 2 (media exposure: high vs. low)	burglaries of rental houses, chain saw accidents, airplane accidents, amusement park ride accidents
Emmons et al. (2004)	experiment	students	353	Risk perception	ARR, ARR with RRR, or no information, personalized information	colorectal cancer
Gyrd-Hansen et al. (2003)	interviews	general public	3,201	choice of health intervention	9 (scenarios: different base-line risks and ARRs) x 2 (framing: social vs. individual) x 2 (RRR wording: explicit vs. implicit)	an illness

Table 2.4 Continued.

Authors	Study	Design	Respondents	N	Dependent variables	Independent variables	Risk
Sheridan et al. (2003)		experiment	patients	357	understanding	NNT, RRR, ARR or combination of all three	hypothetical disease
Marteau et al. (2001)	2	experiment	women 20-64 year	722	comprehension	ARR vs. RRR, with/without additional info	smear result after screening
Fortin et al. (2001)		focus group peri- & in-depth interviews	post-menopausal women	25	preferences	bar -, line -, thermometer graph, stick figure, vs. survival curve; 10-year, 20-year, vs. lifetime time horizons; 1 disease in 3 time horizons vs. 3 diseases in multiple clinical outcomes; and ARR, RRR, vs. NNT	coronary heart disease, hip fracture, breast cancer, with and without hormone replacement therapy

did not differ significantly from the risk perception based on the personal absolute *and* relative information. Thus, when personal risk information is used to communicate a risk, relative risk information does not seem to have added value to absolute risk information. However, it is unclear what caused the difference in risk perception in this study because its conditions differed on more than just absolute and relative risk information; tailored information and verbal vs. numerical risk information were also varied.

The number needed to treat (NNT) and benefit information were often examined in addition to RRR and ARR (Table 2.4, Chao et al., 2003; Fortin et al., 2001; Misselbrook & Armstrong, 2001; Sheridan et al., 2003; Studts et al., 2005). The NNT describes the average number of people that needs to be treated to cure one patient. Benefit information was, for example, presented as the absolute survival benefit (ASB) (Chao et al., 2003; Studts et al., 2005), or the personal probability of benefit (PPB) (Misselbrook & Armstrong, 2001). *Recommendation 7.* Information about the number needed to treat (NNT) should be used with care because people evaluate it negatively and have difficulty understanding it.

NNT did not appear to result in more patients willing to get treatment, in case this was necessary, than ARR, RRR or benefit information (Misselbrook & Armstrong, 2001). Also, respondents had mixed opinions about the influence of NNT (because it has a negative frame) and about its helpfulness to make a decision about treatment (Studts et al., 2005). Finally, respondents considered NNT as confusing (Chao et al., 2003).

ASB is defined as the absolute number of people of a certain sample that avoids an adverse event or is cured due to treatment. Respondents preferred ASB to RRR, ARR and NNT because it was considered as of help to understanding the risk information, as more influential than the other formats, as a positive frame, and as clear (Studts et al., 2005). Chao et al. (2003) also found that ASB resulted in better understanding of the treatment's effects than RRR, ARR or NNT.

The PPB is the probability for one person that the treatment succeeds compared to the probability that it fails. A study by Misselbrook and Armstrong (2001) showed that patients presented with this format were more likely to refuse treatment than those presented with RRR, ARR or NNT.

In sum, RRR seems to be more persuasive than ARR, NNT and benefit information. It should be noted that it depends on the risk communication's goal whether RRR and NNT are valuable, as both presentation formats may be misleading compared to the results of a risk assessment. RRR may be useful to small, severe risks that are otherwise neglected. ASB seems to be better comprehended than the other formats. More research is needed about the effects of benefit information as this seems to have promising effects. Most studies concerned presenting risk *reduction*; it is unclear whether similar effects are found when these formats describe a risk *increase*.

Verbal Information

People tend to use qualitative information about risks instead of and in addition to quantitative information (Fischhoff, Slovic, & Lichtenstein, 1981; Johnson & Slovic, 1998; Slovic et al., 1982). A risk that is communicated in verbal expressions may therefore increase its understanding among people, for example "the risk is very unlikely to happen". Table 2.5 presents several studies about the effects of verbal expressions on several dependent variables. First, we discuss studies that considered people's understanding

and numerical ratings of verbal expressions. Then, we review studies that examined the interpretation of several opposite verbal expressions, the effect of personalized verbal expressions on understanding, and the effect of context in which the verbal expression is used on its interpretation. Last, we report a study about the way verbal expressions may affect behaviour.

Recommendation 8a. Verbal expressions should only be presented in individual risk communication, because then they can be tailored to the individual's lexicon.

Several studies focused on people's understanding of verbal expressions and which numerical probability or risk perception they associated with each verbal expression (Brun & Teigen, 1988; Shaw & Dear, 1990; Teigen & Brun, 2003; Weber & Hilton, 1990; Wogalter, Young, Brelsford, & Barlow, 1999). For example, Brun and Teigen (1988) let their respondents judge compound verbal expressions (e.g. "small chance"), single-word expressions (e.g. "chance"), or single-word expressions in a natural context (i.e. sentences). Their and others' studies revealed that there are large differences between individuals and between studies in the numerical ratings that were associated with the same verbal expressions (see Table 2.5, Brun & Teigen, 1988; Shaw & Dear, 1990; Theil, 2002). The numerical ratings of verbal expressions appeared to be consistent within individuals and were ranked according to their verbal meaning (Brun & Teigen, 1988; Reagan, Mosteller, & Youtz, 1989). It was also shown that the numerical ratings of verbal expressions differed between experts (e.g. physicians) and the general public (Shaw & Dear, 1990). Further, only few opposite verbal expressions appeared to have a symmetrical pattern of their numerical estimations, within subjects (Reagan et al., 1989). For example, the numerical interpretations of "low chance" and "high chance" appeared symmetrical to each other; while the numerical interpretation of "unlikely" was not symmetrical to that of "likely". In addition, respondents evaluated positive verbal expressions closer to the numerical probability of 50% chance than the negative expressions.

Because the within-individuals variability of the interpretation of verbal expressions is smaller than the between-individuals variability, Karelitz and Budesco (2004) suggested to convert verbal expressions in risk messages to each recipient's lexicon; a sort of tailoring. To create a personal lexicon, the recipients had to report which verbal expressions they used in daily life and their corresponding numerical probability. The researchers demonstrated in several experiments that a personal lexicon can be useful in a risk message as the recipients' judgments of events expressed in the personal verbal expressions appeared to be just as accurate as their judgments of events expressed as numerical expressions (Table 2.5).

Recommendation 8b. Take the context of the risk communication into account when selecting appropriate verbal expressions for a risk message.

The context in which a verbal expression is reported was found to influence its interpretation (Brun & Teigen, 1988; Weber & Hilton, 1990). Study 2 of Brun and Teigen showed that a medical treatment context reduced the numerical estimates of verbal expressions compared to when no context was added (Table 2.5). In their third study, the context was made more realistic by using TV news sequences. Identical verbal expressions were used in various TV fragments. The respondents' numerical estimates of the verbal expressions differed to a great extent between different contexts. Therefore, these researchers concluded that the meaning of a verbal expression should always be considered in the context in which the expression is applied. In three studies, Weber and Hilton (1990) showed that these context effects may partly be explained by variations in

Table 2.5 Characteristics of studies about verbal information.

Authors	Study Design	Respondents	N	Dependent variables	Independent variables	Risk
Brun & Teigen (1988)	1	experiment students	64	numerical estimate of self and others	verbal expression: long list, compound expressions, or short list, single words, or short list with natural context	no specific risk
	2	experiment experts, general public, lay people	66 + 64 + 24	numerical estimate (7-point scale)	verbal expressions in sentence in medical scenario or no context	new influenza vaccine
	3	experiment students	47	numerical estimate	context (video) vs. no context, verbal probability expression	news sequences incl. verbal probability expressions various risks
Theil (2002)	meta-analysis	studies	10	similarity of verbal expressions in numerical estimates	10 studies, 106 different verbal expressions	various risks
Shaw & Dear (1990)	1	survey	100 + 22 + 28	numerical estimate	8 verbal expressions, general public vs. experts	health issues of baby
Reagan et al. (1989)	survey	mothers, doctors and medical students	115	frequency distribution, word-to-number acceptability, number-to-word acceptability	18 verbal expressions, 19 multiples of 5%	none
Karelitz & Budesco (2004)	1	experiment students/employees university	18	selection and rank order of verbal expressions, numerical probability of verbal expressions, numerical probability of events	personal verbal expressions and predetermined phrases, uncertainty events	none
	2	experiment students/employees	31	probability of events see Study 1	personal verbal expressions, uncertainty events	none
	3	experiment students and employees	35	see Study 1 and spontaneous translation native language-English	numerical descriptions, verbal descriptions	none

Table 2.5 Continued.

Authors	Study Design	Respondents	N	Dependent variables	Independent variables	Risk
Weber & Hilton (1990)	1 experiment	students	85	perceived personal base rate, perceived severity, probability estimates	4 medical scenarios differing in base diseases rates and severity	
	2 experiment	students	71	see Study 1 and perceived base rate of others	see Study 1	see Study 1
	3 experiment	students	41	base rate estimate, severity estimate, probability word estimate	2 (base rate: rare vs. common) x 2 (severity: mild vs. severe) x 3 (medical conditions) x 2 (probability expressions: likely vs. chance)	see Study 1
Teigen & Brun (2003)	1 experiment	students	163	optimism, correctness, surprise, numerical probability	positive vs. negative verbal expression	exam
	2 experiment	students	173	see Study 1	see Study 1	see Study 1
	3 experiment	students	115	numerical probability, estimated number of tests, verbal expression	frequency expressions (e.g. "some")	polycystic syndrome
Wogalter et al. (1999)	4 experiment	students	270	numerical probability, choice of numerical probability	frequency expression (negative vs. positive), verbal expression	various uncertain situations
	3 experiment	students	46	risk perception	injury severity (high vs. low), likelihood (high vs. low), control condition	consumer products
	4 experiment	students	79	behaviour change	see Study 1	chemical substances in lab

perceived severity and perceived base rate of the risky event (Table 2.5). Other unidentified factors may also influence the interpretation of verbal expressions.

Wogalter et al. (1999) examined the effects of verbal statements (in warnings) about a risk's probability (high vs. low) and severity (high vs. low) and of no verbal statement on the risk perception of 10 products (Study 3) and on precautionary behaviour (Study 4, Table 2.5). All verbal statements increased perceived riskiness and behavioural compliance in both studies compared to no verbal statement. In Study 3, a high severity warning caused more perceived riskiness than a low severity warning; verbal probability information had no effect on risk perception. In Study 4, it appeared that respondents who received the low-probability warnings were more prone to take precautions when the warning included a high-severity statement than when it included a low-severity statement. Thus, simple verbal statements about high-severity seem to increase perceived riskiness and change behaviour compared to verbal probability information.

In short, the studies that examined verbal expressions of probability information showed that people have various interpretations of the same verbal expressions. Consequently, it might be difficult to develop verbal expressions for risk communication that all people interpret in the same way. However, at an individual level, people are consistent in their ratings of verbal expressions. Therefore, verbal expressions may be valuable in personal risk communication, perhaps in combination with numerical expressions, which we discuss below. The context (setting, frame, base rate and severity) in which the verbal expression is used should be taken into account when choosing a verbal expression to communicate a risk. Furthermore, verbal expressions about severity information seem to affect people's risk perception and behaviour more than those about probability information.

Numerical versus Verbal Information

As we discussed in the previous paragraphs, probability information can be expressed both numerically (e.g. frequencies or percentages) and verbally (a qualitative description). First, we discuss which type of information is preferred by most people. Second, we look at the type of information most people use to estimate risks. Third, we review studies that empirically compared the effects of verbal and numerical information on risk perception.

Recommendation 9: Present both numerical and verbal probability information in a risk message. People prefer numerical information for its accuracy but use a verbal statement to express the probability to others. Presenting both makes sure that people have the right information no matter for which purpose they are used.

First, we explore studies that examined whether people prefer to receive verbal or numerical information. In most studies, respondents were given both types of information and asked which type they preferred to receive (see Table 2.6, Berry et al., 2004; Dusenbury & Fennema, 1996; Erev & Cohen, 1990; Gurmankin et al., 2004a; Gurmankin, Baron, & Armstrong, 2004b; Hendrickx et al., 1989; Lindberg, Gärling, & Montgomery, 1991; Lion & Meertens, 2001; Marteau et al., 2000; Mazur et al., 1999; Shaw & Dear, 1990). Respondents most often favoured to receive risk or uncertainty information numerically when they had to interpret a hazard (Erev & Cohen, 1990; Lion & Meertens, 2001; Mazur et al., 1999; Shaw & Dear, 1990). Other studies showed that, compared to verbal information, numerical information was trusted more (Gurmankin et al., 2004a), gave

more satisfaction about the information (Berry et al., 2004), and was more understandable (Knapp et al., 2004; Marteau et al., 2000). Knapp et al. (2004) found that some of the verbal expressions suggested by the European Union to use on medicine leaflets ('common' and 'rare') caused considerable overestimations of the hazards' probabilities compared to numerical information (Table 2.6).

Contrary to the studies just discussed, the studies by Hendrickx et al. (1991; 1989) indicated that people preferred to receive verbal information to numerical information about risks, if they had the choice. These authors examined the effects of no risk information, relative frequency information, cognitive scenario information (verbal information) and a combination of these last two types on the perception of various risks (see Table 2.6). Frequency information varied on magnitude, credibility, reliability and validity, and scenario information on concreteness, number of scenarios and number of personal details. Results showed that the type of information received did not affect the respondents' choice of whether to undertake the risky activity or not. Only the magnitude of the frequency information affected the perceived probability: high frequency information resulted in a high probability estimation. The other frequency variations had no effect. The variations in scenario information changed the respondents' risk perception in the expected direction; e.g. more scenarios included in the risk message increased the perceived probability. More importantly, more respondents who had received both types of information preferred to use the scenario information than the frequency information to decide whether to take the risk. Respondents only used frequency information when they received little or no scenario information and when a large-scale risk was involved.

Second, we wanted to find out which type of information people actually use to evaluate risks. According to the Communication Mode Preference (CMP), the situation determines whether people use numerical or verbal information (Erev & Cohen, 1990). When people have to express the probability of a risk spontaneously to someone else, they will use verbal information because this mode is easier to understand by the receiver. However, when people are explicitly asked in which mode they prefer to receive probability information themselves, they will choose numerical information, because it represents accuracy. The CMP paradox was supported by an experiment in which experts and laypeople judged the attractiveness of sports gambles (Erev & Cohen, 1990) and by an experiment in which people had to choose between lotteries (Dusenbury & Fennema, 1996). In other words, these studies were not about health or environmental risks.

Teigen, Brun and Frydenlund (1999) conducted two studies about the use of quantitative expressions (verbal probability expressions) and qualitative expressions (e.g. consequences) to express a risk (see Table 2.6). In Study 1, one group of respondents had to provide arguments why a specific situation was risky, whereas a second group of respondents had to give arguments why a specific situation was *not* risky (i.e. expressing the probability of a risky event, in line with the CMP paradox). The arguments were then judged on the type of information included. Arguments were classified as quantitative expressions if they contained quantifiers such as 'often', 'many', 'some' or 'a number'. Both groups of respondents rarely appeared to use quantitative expressions when arguing why a situation was risky or not risky. The arguments often included qualitative expressions in both conditions, such as a specific negative outcome or side effect of the situation in the risky condition, and positive effects of the situation in the not-risky condition. In Study 4, respondents were given general vs. specific statements and numerical vs. verbal statements about a hazard. They had to explain and validate these statements by

Table 2.6 Characteristics of studies about numerical versus verbal information.

Authors	Study	Design	Respondents	N	Dependent variables	Independent variables	Risk
Erev & Cohen (1990)		experiment	experts and general public	4 + 36	probability assessment	numerical vs. verbal information	basketball games
Lion & Meertens (2001)		experiment	students	75	preference for and use of numerical (percentages) vs. scenario info	accountability of the choice, risk-taking tendency	medicine
Mazur et al. (1999)		survey	patients	226	surgery now option vs. waiting option	verbal vs. numerical information, age, education	prostate cancer
Shaw & Dear (1990)	2	survey	mothers	81	preference for numerical vs. verbal information	numerical or verbal information	health issues of baby
Gurmankin et al. (2004a)		experiment	general public	115	trust, comfort, evaluation physician	verbal expression, frequency or percentage	4 types of cancer
Berry et al. (2004)		experiment	general population	188	satisfaction, severity, likeliness, chance, perceived risk, behaviour intention	verbal vs. numerical information and action label	over-the-counter drugs
Marteau et al. (2000)		experiment	pregnant women	220	comprehension, anxiety	numerical vs. verbal information	screening for Down syndrome
Knapp et al. (2004)		experiment	patients of cardiac rehabilitation clinic	120	risk perception, probability estimation, severity of side effect, information satisfaction, decision to take medicine	2 (format: verbal vs. numerical expression) x 2 (side effect: constipation (frequent but mild) vs. pancreatitis (less frequent but severe))	medication to treat cardiac problems
Hendrickx et al. (1991; 1989)	1	experiment	students	128	risk-taking tendency, accident probability ranking, risk perception	frequency information, scenario information, or both; quality of this information	small-scale risks, e.g. a parachute-jumping course
Hendrickx (1991)	2	experiment	students	96	risk-taking tendency, accident probability ranking, risk perception	information type (scenario vs. frequency), personal control, information concreteness, information quality	large-scale risks, e.g. working in a nuclear power plant

Table 2.6 Continued.

Authors	Study	Design	Respondents	N	Dependent variables	Independent variables	Risk
	3	experiment	students	128	risk-taking tendency, perceived personal control, selected speed and allocated effort in gambling task, risk perception	actual risk level, personal control, information type (scenario vs. frequency)	gambling in computer task
Teigen et al. (1999)	4	experiment	students	64	actual driver speed, speed preferred by passenger	personal control, driving experience, information type	driving in blind curves
	1	experiment	students	101	use of verbal or numerical argument	arguments supporting or against the riskiness of hazardous activities	hazardous activities (e.g. unprotected sex) or hazardous substances (e.g. alcohol)
	4	experiment	students	64	use of verbal or numerical statements to explain and validate probability statements, and to choose between frequentistic and non-frequentistic explanations	general vs. specific statements and numerical vs. verbal statements	hazardous activities (e.g. unprotected sex) or hazardous substances (e.g. alcohol)
Gurmankin et al. (2004b)		experiment	general public	217	risk perception	verbal, verbal + percentage, verbal + frequency in scenario format	4 types of cancer
Teigen & Brun (1999)	1	experiment	students	154	treatment advise, probability estimate	positive verbal expression, negative verbal expression, numerical expression (percentage) or no info	migraine and exam questions

using quantitative or qualitative expressions. In addition, they had to choose whether numerical or verbal information was most useful to decide whether the statement was correct or incorrect. Again, only few respondents *used* quantitative expressions to explain or validate the statements about the uncertain event. Contrarily, the respondents *preferred* to receive numerical information to decide whether a statement was correct or incorrect. The results of both studies appear to be in agreement with the CMP paradox: people use verbal/qualitative information when they have to express the probability of an uncertain event and prefer to receive numerical information to judge an uncertainty event.

Third, it is interesting to know which type of information, verbal or numerical, affects risk perception. Gurmankin, Baron and Armstrong (2004b) found that verbal information caused more variability in risk perception than numerical information, both between and within the respondents (see Table 2.6). Teigen and Brun (1999) showed that verbal information directed treatment advice better than numerical information. Respondents who received positive verbal information about a treatment (e.g. “some possibility”) were more likely to advice the necessary treatment to others than respondents who received negative verbal information about a treatment (e.g. “quite uncertain”). Respondents who received numerical information were in between these two verbal groups; thus, indecisive. Further, two studies showed that verbal information is more likely to be overestimated or to lead to unnecessary treatment than numerical information (Berry et al., 2004; Mazur et al., 1999). Only the studies by Hendrickx et al. (1991; 1989) showed no difference between effects of verbal or numerical information on risk perception. This may be because Hendrickx et al. used risky leisure activities and external safety risks, whereas the other studies mainly tested medical risks (Berry et al., 2004; Gurmankin et al., 2004b; Mazur et al., 1999; Teigen & Brun, 1999). The effects of verbal and numerical information on risk perception should therefore be generalised to other types of risks with care.

Overall, the results of these studies seem to support the CMP paradox: people prefer to receive numerical information to evaluate a risk and use verbal information when they have to express a risk to others. Numerical information may be better understood and trusted than verbal information. Verbal information can also be helpful; for example, it may guide people in understanding the direction of a risk’s probability.

Graphs

Graphs can visualize probability information, such as the number of people affected by the risk (e.g. in stick figures), the cumulative risk over a certain time period (in mortality and survival curves), a comparison of the mortality rate of people affected versus the mortality rate of those unaffected by the risk (in histograms, bar charts, pie charts), and a comparison of the probabilities of different risks (in histograms, bar charts). First, we review studies about the effects of different types of graphs on comprehension, preference, risk perception and willingness to pay. Second, several studies are discussed that compared the effects of graphs to those of numerical information on understanding, accuracy and the willingness to pay for an improved product. Third, we examine studies about the layout and content of graphs.

Recommendation 10a. Graphs are useful means to present probability information as these increase understanding and accuracy of probability information compared to numerical information.

In the studies that compared graphs to numerical information, respondents received either a graph (stick figures or bar graphs) or numerical information about a risk and were then asked to evaluate the risk and its information on understanding, accuracy or the willingness to pay for an improved product (a risk aversion measure) (see Table 2.7, Fuller, Dudley, & Blacktop, 2002; Schirillo & Stone, 2005; Stone et al., 1997; Waters, Weinstein, Colditz, & Emmons, 2003). Graphs appeared to increase understanding (Fuller et al., 2002), accuracy (Waters et al., 2003), and the willingness to pay for an improved product (Schirillo & Stone, 2005; Stone et al., 1997) compared to numerical information independent of the risk's actual base rate (Schirillo & Stone, 2005). The facilitative effect of graphs may explain these findings, that is, graphs do not require an extra cognitive transformation to form a mental representation of the probability information, whereas this is needed for numerical information.

In addition, probability information expressed in graphs (pie charts) appeared to decrease perceived riskiness compared to the same information presented as percentages (Keller et al., 2006). The authors suggested that the probabilities in the pie charts appeared too small and, therefore, did not impress the respondents. Only large probabilities presented in graphs may be noticeable and increase perceived riskiness. Thus, most graphs seem to have beneficial effects on understanding and accuracy, except for pie charts, that represent small probabilities.

Recommendation 10b. The best type of graph depends on the task at hand: (1) pie charts: to visualize proportion information, (2) line and bar graphs: to understand a trend over time and cumulative risks, and to compare various risks, (3) stick figures and risk ladders: to compare people at risk, risks and treatments.

We found qualitative and quantitative studies that examined the effects of different graphs on risk perception, understanding, accuracy and preferences. We start with two qualitative studies (interviews) in which several graphical formats were evaluated. The first study indicated that women rated stick figures as easier to understand than bar graphs. However, stick figures were more likely to lead to biased interpretations of the probability (i.e. overestimation) compared to bar graphs by younger, less-educated women (see Table 2.2, Shapira et al., 2001). Bar graphs were preferred to present multiple risks, for example, to compare the probability of various risks. In another interview study, the respondents preferred bar graphs instead of line graphs, thermometer graphs, stick figures, and survival curves to present the probabilities of coronary heart disease, hip fracture and breast cancer, both with and without hormone replacement therapy (see Table 2.4, Fortin et al., 2001).

Stone et al. (1997) experimentally studied the effects of two types of stick figures (dummies and asterisks), bar graphs, and numerical information on the willingness to pay for a risk-free product (Study 2, Table 2.7). In Study 3, they compared the effect of dummies versus asterisks in stick figures on the willingness to pay. Although all graphs resulted in more willingness to pay than the numerical information in Study 2, this dependent variable did not differ between the two types of graphs, in either study.

In addition, the effects of mortality and survival curves were compared on risk perception and treatment preference (see Table 2.7, Armstrong et al., 2002). Mortality curves represent the probability of dying caused by the risk over time, whereas survival curves demonstrate the probability of surviving over time. Respondents either received survival curves, mortality curves or both about the risk of colon cancer. Respondents who received the survival curves or survival and mortality curves had a more accurate risk perception than the respondents of the mortality curves only. Furthermore, the survival

Table 2.7 Characteristics of studies about graphs.

Authors	Study	Design	Respondents	N	Dependent variables	Independent variables	Risk
Stone et al. (1997)	1	experiment	students	108	willingness to pay for improved product	graphs (stick figures) vs. numerical information	blowout injury by tires, gum disease from toothpaste
Fuller et al. (2002)	2	experiment	students	532	see Study 1	graphs (stick figures, asterisks, or bar graphs), numerical information	see Study 1
	3	experiment survey	medical inpatients	135	see Study 1	stick figures vs. faces of people	see Study 1
				42	comprehension	graph, percentage, frequency	none
Schirillo & Stone (2005)	1	experiment	general public	157	willingness to pay for risk reduction	numerical vs. graphical information, injury rates of improved product (1, 5, 10, 15, 20, 25, 29 per 5 mln)	tire blowouts
Waters et al. (2003)	2	experiment	general public	492	willingness to pay for risk reduction	numerical vs. graphical information, injury rates of improved product (1, 5, 10, 15, 20, 25, 29 per 50,000)	tire blowouts
		experiment	general public	2,601	understanding, risk perception	3 (cognitive effort: difficult, moderate, or easy) x 2 (text only vs. text + graph) x 2 (percent vs. frequency) x 2 (risk: large vs. small) x 2 (risk direction: increase vs. decrease) x 4 (preferred communication: words, numbers, pictures, no preference)	several types of cancer
Armstrong et al. (2002)		experiment	general public	451	understanding risk information, choice of surgery	survival curve, mortality curve, survival and colon cancer mortality curves	
Meyer et al. (1997)	1	experiment	students	60	accuracy and response speed	3 (display: table, bar graph, line graph) x 5 (tasks) x 2 (complexity: high vs. low) x 3 (experiment block)	none
	2	experiment	students	20	reading exact values, comparing values, identifying trends, reading max. values	3 (display: table, bar graph, line graph) x 5 (tasks) x 3 (level on x-axis: 3, 5, 7) x 2 (number of data series: 2 or 4)	none

Table 2.7 Continued.

Authors	Study	Design	Respondents	N	Dependent variables	Independent variables	Risk
Hollands & Spence (1992)	1	experiment	students	24	accuracy, reaction time	3 (graph: bar, line, pie chart) x 2 (task: change vs. proportion) x 2 (rates of change: increase vs. decrease)	none
	2	experiment	students	20* + accuracy, reaction time 16**		2 (scale: present vs. absent) x 5 (graph: line, none bar, pie, divided bar, tiered bar) x 2 (rate of change: increase vs. decrease)	
Zikmund-Fisher et al. (2005)		experiment	general public	864	disease seriousness, treatment effectiveness	2 (visual difference in lines: large vs. small) x 2 (time period: 5 vs. 15 years)	fictitious disease: Crawford disease
Armstrong et al. (2001)		experiment	general public	246	comprehension	survival curves with/without practice	fictitious disease

N.B. * change task, ** probability task

curves increased the preference for preventive surgery compared to the mortality and survival curves, which again resulted in a higher preference than the mortality curves.

The suitability of graphs may depend on the type of task. Line graphs are suggested to facilitate reading a trend over time and understanding cumulative risks; bar graphs and stick figures may be useful to compare risks or treatments (relative risk judgments); and pie charts may be suitable for evaluating risk proportions (Lipkus & Hollands, 1999). This task dependency has been tested in non-risk fields (cf. Hollands & Spence, 1992; Meyer, 1997) but, according to our knowledge, no risk communication study has yet examined this. Hollands and Spence investigated task dependency for pie charts, bar charts and line graphs to judge change and probability in non-risk situations (Table 2.7). Their two experiments showed that separated displays (pie chart, tiered bars) facilitated identifying the exact proportion of a probability, when the charts and graphs did not have scales. When scales were present, all types of graphs were suitable for a proportion task. Line and bar graphs were found to be appropriate to indicate an event's change over time because these graphs already integrate the necessary information for this task. Divided bars were less effective for identifying the correct information than line and bar graphs; pie charts and tiered bars appeared least effective in this task.

Recommendation 10c. Take the layout and content of the graph into account, as these affect the interpretation of the risk. Examples of these elements are the time frame, highlighting, legend and the visual difference between lines. Keep the graph's layout simple in risk messages for people who probably have no or little experience with graphs.

The content and layout of graphs can be varied in several ways. One of the interview studies reported before demonstrated that respondents preferred consecutive highlighting of dummies in stick figures (i.e. in rows) to random highlighting of stick figures, because it was easier to grasp the frequency information at once in the first format (Shapira et al., 2001). Also, graphs that represented multiple time horizons (i.e. the cumulative risk over 10 and 20 years or life time risks) were chosen above graphs with one time point (Fortin et al., 2001). More specifically, this study indicated that graphs with lifetime risk presentation were preferred to graphs with cumulative risks over 10 or 20 years. The respondents equally favoured receiving graphs with one disease over three time horizons and graphs with three diseases over one time horizon. Last, respondents preferred absolute risk information to relative risk information in graphs.

Zikmund-Fisher, Fagerlin and Ubel (2005) tested several variations in survival curves; that is, large vs. small visual-difference graphs (various slopes) combined with 5- vs. 15-year time periods (Table 2.7). Respondents rated a disease of which its probability was depicted in a graph with a large visual difference and 15-year time period to be more serious and its treatment more effective than when the same disease's probability was presented in a graph with a small visual difference and a 5-year time period. Because the annual risks were similar in both graphs, respondents seemed to have been misguided by the visual characteristics. The authors suggested to mention the time period explicitly in the title or legend and to be consistent in the units of time of different graphs in one risk communication, so that the effect size is in agreement with time.

Armstrong, Fitzgerald, Schwartz and Ubel (2001) found that people can learn to interpret complex survival curves about a disease (Table 2.7). Presenting people first with a simple survival curve facilitated their ability to identify the number of survivors at a single point in a complex survival curve, which showed the outcomes of two different treatments in one graph. However, the results of this study also revealed that people

have difficulty in calculating changes in survival between two points in both simple and complex survival curves.

In sum, probability information presented in graphs appears to lead to more risk aversion, better understanding and more accuracy than numerical probability information only. Also, people often prefer probability information that is presented in graphs to numerical presentation because the first reduces cognitive load and facilitates understanding. In addition, the task at hand may determine which graph is most suitable for probability information. Whether this task dependency should also be taken into account for probabilities about risks, needs to be studied more thoroughly. Last, we discussed several layout elements of graphs. Respondents preferred consecutive highlighting in stick figures to random highlighting, graphs with multiple time horizons to graphs with one time point, and absolute risk information to relative risk information in graphical presentation. Furthermore, a large visual difference (steep slope) and a long time period in a graph may increase perceived riskiness compared to a small visual difference and a short time period.

Risk Ladders

A risk ladder is a tool commonly used to present a risk in comparison to other risks (Connelly & Knuth, 1998; Sandman, Weinstein, & Miller, 1994). It includes several risks that range from low to high probability, with or without explicitly mentioning these probabilities. The probabilities determine their order of the different risks in the ladder. The risk to be evaluated is presented in between the other risks. Risk ladders can take different forms, such as the Paling Perspective Scale, the Community Risk Scale or the Lottery Scale (see Berry, 2004). Lipkus and Hollands (1999) already reviewed several studies about risk ladders (e.g. Connelly & Knuth, 1998; Sandman et al., 1994). We only repeat the main findings and add the Paling Perspective Scale.

Recommendation 11a. Risk ladders may be useful in risk communication as people seem to take the probability information presented in this format into account when they estimate a risk.

Recommendation 11b. The target risk's location should be considered in the design of the ladder as this affects perceived riskiness.

The target risk's probability and its location on the ladder appeared to determine people's risk perception (see Table 2.8, Sandman et al., 1994). Respondents rated risks that were presented with high probability levels (10 times higher probability) and those located high on the ladder as more risky than risks with low probability levels and those located low on the ladder. The type of hazard and the test magnitude (exposure levels of 15 fibres per litre vs. 450 fibres per cubic foot) used in the ladders did not influence perceived riskiness. According to another study, respondents evaluated a quantitative risk ladder (including numerical information) as more understandable than a qualitative risk ladder (including verbal labels) (see Table 2.8, Connelly & Knuth, 1998).

A specific example of a risk ladder is the Paling Perspective Scale (PPS, Singh & Paling, 1997; Stallings & Paling, 2001). It presents the probability of several risks on a horizontal logarithmic scale so that these risks can be compared. This scale shows relative probability levels of risks, e.g. the relative probability increase of exposure to radon to that of x-rays. The PPS was tested by Lee and Mehta (2003). The study consisted of a pre- and post-test

Table 2.8 Characteristics of studies about risk ladders.

Authors	Study	Design	Respondents	N	Dependent variables	Independent variables	Risk
Sandman et al. (1994)	1	experiment	general public	449	perceived likeliness, danger, threat, concern, fear, behaviour intention	exposure level of risk, risk level, location on risk ladder	radon in houses
	2	experiment	general public	534	perceived likeliness, danger, threat, concern, fear, behaviour intention, 5 risk characteristics	radon vs. asbestos, risk level, location on risk ladder	radon in houses
Connelly & Knuth (1998)		survey	general public	4,016	presentation preference, understanding, intention to behaviour change, information sufficiency	commanding vs. cajoling tone, reading level (5 th -grade vs. 11 th -grade), graphics vs. text, numerical vs. verbal risk ladder	fish consumption
Lee & Mehta (2003)		experiment	general public	200	knowledge, risk perception, qualitative characteristics (pre- and post-test)	quiz, numerical information vs. Paling Perspective Scale	blood transfusion

in which risk perception and knowledge were measured (Table 2.8). In between these two tests, respondents received either numerical information about the risk of blood transfusion or the PPS. The perceived riskiness decreased and knowledge increased between pre- and post-tests in both the numerical information and the PPS. The authors concluded that not the type of risk communication is important but the content: as long as its content is clear, numerical information and PPS result in similar levels of perceived riskiness and knowledge about the risk. The numerical information was quite similar to a risk ladder, that is, the target risk was presented between several risks that ranged vertically from small to high probability of occurring. Therefore, it can be concluded that the numerical information was actually presented as a simple risk ladder and the respondents probably compared this to the PPS.

In sum, risk ladders appear to be useful formats to compare risks with various probabilities. The location of the new risk on the ladder and the probability of the target risk can affect risk perception. Therefore, these two properties should be presented with care. The effects of risk ladders have not yet been compared to those of numerical or verbal information concerning understanding or risk perception.

Various risks can be compared in risk ladders. According to the literature about risk comparisons, this type of communication does often not have the desired effect on acceptance and risk perception because the risks that are compared differ in important characteristics (see Johnson, 2003a; Johnson, 2004; Roth et al., 1990; Slovic, Kraus, & Covello, 1990). Therefore, it is recommended to choose the other risks in the ladder with care, based on similar characteristics.

Discussion and Recommendations

This paper presents an overview of studies about probability information in risk communication. The studies reviewed covered a wide range of risks and sometimes uncertain events: from very specific diseases to consumer products and gambles. Also, the settings in which the studies were conducted varied, e.g. a hospital vs. laboratory setting. Moreover, various samples were used in these studies, such as students, patients of a specific disease, adolescents and homeowners.

We organized this review around several recommendations to provide some structure to the studies reviewed and their findings (see Box 2.1 and 2.2). The Boxes are organized according to the type of recommendation (general use or presentation format), themes and sub themes (e.g. the use of graphs and the presentation format of graphs), and the quality of the evidence. This way, practitioners may easily see the evidence, risks and samples on which the recommendations are founded.

Although we believe that, based on the empirical evidence available, these recommendations are the most obvious; they are no 'magic bullets'. This review namely shows that it is not easy to recommend which presentation format affects understanding, perception or acceptance of a risk; for example, are percentages or frequencies more effective in risk communication? Some uncertainties remain because the majority of studies reviewed here considered medical risks, although we searched for various types of risks in the literature databases. Consequently, a format that improved the understanding of the probability of a medical risk may not have the same effect when it is applied on another, for example, environmental risk. Moreover, we suggest that two other factors

Box 2.1 General recommendations about probability information in risk communication, including the quality of the evidence

Recommendation	Nr. of stars [#]
Relative Risk Reduction (RRR) vs. Absolute Risk Reduction (ARR)	
• Be careful about presenting RRR, as this may be mistaken for ARR (5a).	****
• RRR may be useful to present small risks that have serious consequences and are otherwise neglected as RRR promotes more risk aversion than ARR.(5b).	*
- Information about the number needed to treat (NNT) should be used with care because people evaluate it negatively and have difficulty understanding it (7).	****
Verbal information	
• Verbal expressions should only be presented in individual risk communication, because they can then be tailored to the individual's lexicon (8a).	***
Numerical vs. verbal information	
• Present both verbal and numerical information in a risk message. People prefer numerical information for its accuracy but use verbal statements to express the probability to others (9).	****
Graphs	
• Graphs are useful means to present probability information as these increase understanding and accuracy of probability information compared to numerical information (10a).	****
Risk ladders	
• Risk ladders may be useful in risk communication, as people seem to take the probability information presented in this format into account when they estimate a risk (11a).	***

NB (1). The numbers between brackets correspond to the order of the recommendations in the text.

NB (2). Recommendations about sub themes are presented one level below the main recommendation (indentation from left).

[#] Number of stars:

* one study with a clear effect, or several studies that identified a communication problem but did not find evidence for the solution;

** several studies in which the effects are not always clear (e.g. trends) about one type of risk (e.g. medical risks);

*** several studies in which the effects are not always clear (e.g. trends) about several types of risks;

**** several studies that show contradicting effects between (some of) them about several types of risks, or several studies with similar, clear effects about one type of risk;

***** several studies with similar, clear effects about several types of risks.

Box 2.2 Recommendations about presentation formats of probability information in risk communication, including the quality of the evidence

Recommendation	Nr. of stars [‡]
Frequencies	
• Present the same denominator in probability information throughout the risk message, so that people can compare probability information when they ignore the denominator (1).	****
• Use natural frequencies or a probability format with the same elements for risk estimates with false positives (e.g. test results) (2).	*****
Base rates	
• Comprehension of base rate information may be improved by notification of a random sampling method, the absence of stereotypical information and the inclusion of a reference class (3b). - Us tailored base rates, e.g. conditional base rates, in risk communication to people with small risk factors (3a).	*
Cumulative risk information	*
• Provide cumulative risk information directly to people in stead of letting them calculate this change in probability based on a single exposure (4a). - Disjunctive probabilities (chance that a harmful event happens at least once) of cumulative information are recommended over conjunctive probabilities (chance that a harmful event never happens) to make cumulative risks easier to understand (4b).	*
RRR vs. ARR	
• The probability of a risk is better understood when it is compared to the probability of another risk or to another group of people (6).	*
Verbal information	
• Take the context of the risk communication into account when selecting appropriate verbal expressions for a risk message (8b).	*
Graphs	
• The best type of graph depends on the task at hand: (1) pie charts: to visualize proportion information; (2) line and bar graphs: to understand a trend over time and cumulative risks, and to compare various risks; (3) stick figures and risk ladders: to compare people at risk, risks or treatments (10b). - Take the layout and content of the graph into account, as these affect the interpretation of the risk. E.g. time frame, highlighting, legend and visual difference between lines. Keep the graph's layout simple in risk messages for people who probably have no or little experience with graphs (10c).	**
Risk ladders	
• The target risk's location should be considered in the design of the ladder as this affects perceived riskiness (11b).	*
NIB (1). The numbers between brackets correspond to the order of recommendations in the text, (2). Recommendations about sub themes are presented one level below the main recommendation (indentation from left). [‡] Number of stars: see Box 2.1	

may determine which presentation format works best in risk communication. These are the content of the format and, more importantly, the situation or context in which the format is used.

Firstly, the exact content of the presentation format, or the way it is filled in, influences its effect. The discussion about natural frequencies illustrates this rather nicely. Although natural frequencies may lead to more accurate risk estimates, other studies showed that percentages can also have this effect as long as they are presented in the same way as natural frequencies (Giroto & Gonzalez, 2001). Similarly, we believe that other presentation formats that are not recommended here (such as NNT), could be rearranged in a risk message so that it is more understandable. We therefore do not suggest trying to find 'magic bullets' to communicate probabilities as the content of the presentation format, in addition to the type of format, seems to determine the way the probability information is understood or the way it influences risk perception.

Secondly, and more crucially, we suggest that the situation or context in which the probability is communicated, may explain its effect. Current views about the way people process risk information point out that people may interpret risks systematically or heuristically (see Heuristic-Systematic Information Processing Model, Chaiken et al., 1989; Trumbo, 1999). Heuristic information processing entails that people use schemata or simple inferential rules to come to an evaluation of a risk. Systematic information processing represents in-depth processing of the information, and is more deliberate and time consuming.

The type of processing that prevails depends on people's cognitive capacities, motivation and their available time. If people are sufficiently motivated, have enough time and cognitive capacities, they will probably process the information systematically. However, when they do not have these sources sufficiently available, people will process the information heuristically. It seems likely that the presentation format plays a larger role in the last situation than in the first. For example, an unmotivated person under time pressure may conclude that a mortality of 1,286 out of 10,000 represents a higher risk than a mortality of 24.14 out of 100, based on a heuristic (e.g. the anchoring and adjustment heuristic, Tversky & Kahneman, 1974). Whereas, someone who is not under time pressure but is highly motivated and capable to understand the probability information correctly, may spontaneously reorganize the different formats of probability information (e.g. "24.14 out of 100 means 2410 out of 10,000. Oh, that means 12.68% and 24.14% respectively."), and conclude that 24.14 out of 100 is the higher probability. This may imply that there will hardly be any impact of presentation format in situations where people have time, motivation and cognitive capacities to process information systematically.

The results of various studies reported here seemed to support this way of reasoning. Several studies showed for example that when the risk was made more personally relevant for people by presenting tailored probability information, this resulted in more accurate risk estimations (Emmons et al., 2004; Greening et al., 2005). Other studies reviewed here indicated that high-educated people were more likely to process probability information systematically than low-educated people as the former had learnt how to deal with probability and uncertainty information (Gyrd-Hansen et al., 2003; Shapira et al., 2001). Low-educated people appeared to have more problems in understanding numerical information than high-educated people (Sheridan et al., 2003). Further, some presentation formats appeared to activate systematic processing. For example, presenting probability information as natural frequencies appeared to stimulate Bayesian reasoning, which is an

elaborate and systematic form of statistical interpretation (Gigerenzer & Hoffrage, 1995).

Nevertheless, in many situations, people are not motivated or do not have the ability to process information systematically so that they rely on heuristic processing. Then, the presentation format of the probability information is crucial for the way it is interpreted. Information that is (unintentionally) highlighted in a risk message influences the way the risk and its information are interpreted, as explained by several heuristics. For example, many studies reviewed here indicated that respondents estimated a risk's probability based on the *first number* that was presented to them and neglected numbers that were presented later in the message or that should be computed (i.e. the anchoring and adjustment heuristic). Examples are studies about frequency information, RRR, (disjunctive) cumulative risk information, rates, and survival and mortality graphs. Also, when risk information was *primed* in memory, people appeared to perceive the risk as more likely than when risk information was less easily available. This was illustrated by the location effect in risk ladders. Similarly, information that was concrete and easy to *simulate* in memory was preferred to more abstract information, e.g. scenario information versus frequency information.

In sum, risk and probability information can be processed either systematically or heuristically. Risk communicators usually prefer people to process information systematically because this is more likely to lead to informed decision making. The presentation format may create the opportunity and may motivate people to use this type of processing. In addition, systematic processing may be influenced by the situation in which the message is presented (e.g. cognitive capacity, motivation, time and opportunity to deliberate). Nevertheless, the situation does not always provide the requisites for this kind of deliberation, so that people apply heuristic processing. Under these circumstances, they rely on the presentation of the probability information to interpret the risk. The recommendations that are presented in this review may be helpful for practitioners in situations where the message's receivers are expected to process the risk information heuristically. In situations where receivers are assumed to process the information systematically, these recommendations may not matter that much, because the receivers will manipulate the presentation format to their own wishes. However, even in such situations it may be advisable that practitioners follow up the recommendations as they assure that the risk information is processed more easily.

We suggest that future studies about the effects of probability information in risk communication on risk perception and understanding, should not solemnly concentrate on finding magic bullets, but also on the specific content of the format and on the way the risk information is expected to be processed. Moreover, it may be useful to take the situation (e.g. time, motivation and opportunity) in which the message is presented into account in the development of a risk message, as this may predict which type of processing people use and in what way probability information may influence them.

Chapter 3

How do the General Public Evaluate Risk Information?

The Impact of Associations with Other Risks

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Abstract

There is a considerable body of knowledge about the way people perceive risks using heuristics and qualitative characteristics, and about the way risk information should be communicated to the public. However, little is known about the way people use the perception of known risks (associated risks) to judge an unknown risk. In a first, qualitative study, six different risks were discussed in in-depth interviews and focus group interviews. The interviews showed that risk associations played a prominent role in forming risk perceptions. Associated risks were often mentioned spontaneously. Second, a survey was conducted to confirm the importance of risk associations quantitatively. This study investigated whether people related unknown risks to known risks. This was indeed confirmed. Furthermore, some insight was gained into *how* and *why* people form risk associations. Results showed that the semantic category of the unknown risks was more important in forming associations than the perceived level of risk or specific risk characteristics. These findings were in line with the semantic network theory. Based on these two studies, we recommend using the mental models approach in developing new risk communications.

Introduction

People are informed about unknown risks through risk communications, which form a bridge between the results of risk assessments by experts and risk perceptions among the general public. However, the general public seem to interpret risk information differently from the experts (Fischhoff et al., 1981; Tversky & Kahneman, 1974). So far, several studies have looked at the way the public perceive risks (Kasperson et al., 1988; Tversky & Kahneman, 1974), what information they use to judge a risk (Slovic, 1987, 1999), what kind of information they want about a risk (Lion et al., 2002), and how risk messages can influence risk perception (e.g. Connelly & Knuth, 1998; Golding et al., 1992; MacGregor, Slovic, & Morgan, 1994). Nevertheless, it is not clear how this information is used to judge an unknown risk, for instance, the way the public process the results of risk analyses, and what other knowledge they mobilize. The two studies reported on in this paper were designed to examine the process of evaluating risk information and focused on the effects of associated risks.

Previous research has shown that people process risk information by using cognitive mechanisms such as inductive reasoning (Sternberg, 1996) and heuristics (Tversky & Kahneman, 1974). In addition, several studies have explored which characteristics of a risk and its context influence risk perception (Sandman, Miller, Johnson, & Weinstein, 1993; Slovic, 1987) and some guidelines are available about the way risks can be appropriately communicated (Covello et al., 1986; Fischhoff & Downs, 1997). A few theories and frameworks of risk perception, such as the mental models approach, assume that people's prior knowledge affects their risk perception (e.g. MacGregor, Slovic, & Malmfors, 1999; Niewöhner, Cox, Gerrard, & Pigeon, 2004). However, it has not yet been specified how people use prior knowledge, and especially associated risks, when they evaluate an unknown risk.

The first study reported here was a qualitative study. One of its goals was to find out how known risks are associated with unknown risks and how the former are used to interpret the latter. In the second study, a survey, the role of prior knowledge in risk perception was explored by investigating similarities in judgment about unknown risks and associated risks. We conclude by presenting recommendations for the communication of risks to the general public.

Theoretical Background

Surprisingly, the effect of prior knowledge on the understanding of risk communications has not received much attention in this field of research. Nevertheless, several theories and concepts, implicitly, assume that prior knowledge is important for risk perception and comprehension. The first approach is the mental models approach, which uses respondents' prior knowledge to list existing ideas and possible misconceptions about a specific risk (Bostrom, Fischhoff, & Morgan, 1992; Morgan et al., 2002). The respondents' mental model is then compared with an expert model, and the results are used to design a risk communication that fills the gaps in knowledge and changes the respondents' incorrect beliefs. However, the mental models approach uses knowledge schemes to identify the *differences* between experts and the general public concerning a specific risk. This approach acknowledges that prior knowledge (and thus risk associations) is an important factor that influences risk perception. It is unknown *how* people use prior knowledge and whether associated risks play a part in risk evaluations. Therefore, we wanted to

investigate this in these two studies.

The second approach that assumes an influence of prior knowledge is the construction-integration theory (Kintsch, 1998). This approach holds that text information (in general, not only information on risks) is understood in two phases; construction and integration. In the construction phase, a rough scheme is created from the text, the receiver's goals, and prior knowledge. In the integration phase, this scheme is adjusted to the current context by the process of spreading activation until it forms a well-structured representation of the information. Prior knowledge is important because a text is easier to understand when readers can fit new information to what they already know. This is also facilitated when the tenor of the text is in accordance with this knowledge and the readers' personal goals (Fletcher, 1981). Thus, associated risks that correspond to these characteristics may improve the understanding of risk communication.

Lastly, the representativeness heuristic is discussed here because when people apply it, their judgments are based on prior knowledge (about the reference group). The probability of an event is estimated by whether this event is representative of similar events stored in memory (Kahneman & Tversky, 1972). The effect of this heuristic on judgments has already been demonstrated. For example, in a study in which the description of an intelligent but not very creative man led most respondents to categorize him as a computer science or engineering student because this description seemed to be representative of these two categories (Kahneman & Tversky, 1972). The respondents ignored the low base rates of computer science students and engineering students in the general population (Kahneman & Tversky, 1973). To our knowledge, no study has investigated the effect of this heuristic on the way people perceive risks in a more spontaneous or realistic setting.

In the first study, we were particularly interested in finding out how respondents used prior knowledge about known risks to evaluate unknown risks in real life situations. We used unknown risks so that people could not yet have specific attitudes or beliefs about them.

Study 3a: Qualitative Study

Goals

The overall aim of this study was to examine the way people handle risk information when they judge an unknown risk. We wanted to explore what information is used to evaluate a risk and how risk characteristics can affect this. We also had two specific goals. The first was to assess whether people associate an unknown risk with known risks to interpret the unknown risk. The second aim was to examine the way and why they use associations with known risks to interpret unknown risks.

Method

Design

Focus group interviews and in-depth interviews were chosen as complementary research methods. Focus group interviews are group discussions that intend to examine feelings and opinions about a given problem, experience or specific situation (Basch, 1987). We also used in-depth interviews with individuals to investigate a particular subject in greater

depth than was possible in the focus group interviews.

Respondents

The participants of all in-depth interviews and of two focus group interviews had answered a call for respondents in a free local paper. The other focus group respondents were recruited from a drama group and two choirs, and from among students at two schools for higher vocational training (taking courses on social work and information management). The interviews took place at Maastricht University and at different locations in the town of Maastricht (e.g. a community centre or the respondent's home) between October 2002 and January 2003. The study was presented as an interview about the comprehensibility of newspaper articles, to prevent response biases. Each respondent received a €7 reward for a one-hour interview.

In total, eleven in-depth interviews and seven focus group interviews were carried out. Participants to the in-depth interviews included ten women and one man. Their mean age was around 42 years, ranging from 23 to 67 years. The number of participants in the focus group interviews ranged between three and 11 respondents per group. In total, nine men and 19 women participated in the focus groups; their mean age was around 40 years, ranging from 17 to 71 years.

Materials

The following materials were used in both types of interview: six different purpose-made newspaper articles, a tape recorder, and a question route. The six newspaper articles concerned different risks. They were written in an objective style and were made more realistic by using a newspaper font and by mentioning the name of the journalist or press agency. We chose these risks because we believed that they were relatively unknown to the general public and were suitable for newspaper articles. For example, one article considered the risk of acrylamide in food, which can be carcinogenic when large amounts are consumed (Livsmedelsverket, 2002; Scientific Committee on Food, 2002). Another article discussed the risk of living in a town near a chemical weapons depot, where the army is going to incinerate these weapons (Bragg & Wilson, 2002; Gettleman, 2003). The other newspaper articles were about nuisance caused by artificial light (Health Council of the Netherlands, 2000b), deoxynivalenol (DON) in wheat products (Health Council of the Netherlands, 2001a; Pieters, Freijer, Baars, & Slob, 2001), phthalates in cosmetics (Houlihan, Brody, & Schwan, 2002; Raloff, 2000) and medicine residues released into the environment (Health Council of the Netherlands, 2001b).

The participants of all interviews read and discussed at least four newspaper articles during the interview; in two in-depth interviews, there was enough time to discuss five newspaper articles. The order of the articles was varied so that each article was discussed ten to 13 times.

Procedure

The interviewer started each session of the focus group and in-depth interviews by welcoming the respondents and explaining how the interview would work. The interviewer emphasized that it was important for the respondents to give their own opinion. This was particularly emphasized in the focus group interviews. After the respondents had read the first article, the interviewer started the tape recorder and asked questions about the article, for example about the respondents' first impression of the article, the perceived probability of the risk, the number of people involved, and associations with other risks.

The respondents in the in-depth interviews were allowed to give more attention to the process of risk perception, whereas in the focus group interviews, more time was spent on discussion about the risk itself. When all questions had been answered, respondents proceeded to the next newspaper article, until at least four newspaper articles had been discussed. Each respondent was then thanked and paid.

Analyses

The taped interviews were transcribed verbatim and divided according to the topics of the newspaper articles. This resulted in 74 interview sections, 13 sections about phthalates, 10 about DON, 12 about acrylamide, 14 about the incineration of chemical weapons, 13 about of medicine residues released into the environment, and 12 about light nuisance.

The interview sections were coded using the QSR NVivo 2.0 qualitative data program (QSR International, 2002). The codes were based on the main issues discussed in the interview, such as credibility, familiarity, consequences, risk evaluation, and risk associations (see Table 3.1). A second coder also coded all interviews. The agreement between the two coders was 81%. In cases of disagreement, the codes of the first coder were accepted.

We then first examined the issues that had been mentioned during the interviews. This background information relates to the issues respondents discussed when they were confronted with an unknown risk. Secondly, we analysed risk associations, in terms of whether, how, and for what reasons they were used.

Results

Background issues

When confronted with one of the press releases about an unknown risk, the respondents often tried to make a *risk evaluation* (see Table 3.1 for the mean number of interview sections devoted to each issue by the respondents). The respondents frequently talked about the probability of the risk occurring and the severity of its consequences. For example, respondents evaluated the probability of the environment being polluted by medicine residues as high but the consequences of this risk for humans and animals were judged to be only slightly harmful. On the other hand, the probability that an accident would happen during the incineration of chemical weapons was estimated to be low, whereas its consequences were judged to be very serious.

The participants also frequently discussed the *method of risk evaluation* in both types of interviews (Table 3.1). This aspect related to *how* they evaluated the unknown risk, for example by relating it to the number of people affected by the risk. Many of the interview sections that were coded as *method of risk evaluation* were connected to the risk characteristics described by Slovic (1987). These risk characteristics, however, are beyond the scope of this article. Only the risk characteristic of *familiarity* is discussed here, since it relates to risk associations. Respondents frequently talked about the *familiarity* of the risk. For example, the respondents often said that they were unfamiliar with the risks of light nuisance and medicine residues in the environment, but they could imagine that these risks existed.

Table 3.1 Mean number of interview sections per issue in descending order.

Issue	Mean number of interview sections
Risk evaluation	3.85
Method of risk evaluation	2.69
Risk association	2.65
Familiarity	1.96
Future behavior	1.84
Consequences for humans and animals	1.77
Controllability	1.49
Information need	1.43
Credibility	1.38
Balance of advantages and disadvantages	1.07
Frequency of event	.82
Consequences for the environment	.15

Risk associations

As can be seen in Table 3.1, respondents frequently *associated* the unknown risk with known risks. These risk associations were mentioned when the interviewer explicitly asked for them (mean number of sections per interview: .72), but more often spontaneously (mean number of sections per interview: 1.93).

Associated risks were used as a stepping-stone to relate the unknown risk to what respondents already knew. We constructed a mental model about the risk of phthalates in cosmetics to obtain an impression of the kind of associated risks respondents used in the interviews (Bostrom et al., 1992; Morgan et al., 2002). As can be seen in Figure 3.1, the risk associations took various forms, ranging from associations with similar risks to events that had no clear connection to the present risk.

Next, we were interested in *how* and *why* risk associations were made. As regards the way these associations were formed, the interviews showed that risk associations were based on personal experience with known risks, information provided by the media, and general knowledge that had been obtained from other risks in the past.

Respondents usually related the information about the unknown risk presented in the article to a cognitive scheme for a known risk, based on similarity of characteristics. The unknown risk seemed to inherit the characteristics of the associated risk, so that the scheme of the associated risk often seemed to determine the perception of the unknown risk. For example, after reading the acrylamide article, one respondent assumed that foods such as French fries and chips were risky because she already knew that they contain fat, which is unhealthy. She therefore concluded that acrylamide was also a risk to health. By contrast, acrylamide reminded another respondent of fruit that is unhealthy because it is sprayed with insecticides, which made her conclude that it was impossible to avoid food with acrylamide and that she would also accept this risk.

Sometimes respondents appeared to use schemes of known risks that were only vaguely related or were not related at all to the unknown risk. In these cases, the respondents only focused on one characteristic of the unknown risk and ignored others. In the above example about acrylamide, the first respondent only focused on fatty foods that may

contain acrylamide and which she already knew to be unhealthy, thereby ignoring the fact that acrylamide can also be present in healthy foods such as bread.

Figure 3.1 Mental model of risk of phthalates.

In short, the respondents used various risk associations in these examples, leading to different views about accepting or avoiding the unknown risk. In addition, unknown risks could inherit the characteristics of the associated risks. In some cases, the associations were based on one common characteristic so that other features of the unknown risk were ignored.

We discovered four different reasons *why* respondents used risk associations. First, they were used to characterize the possible *severity and consequences* of the unknown risk. For example, one respondent compared the effects of phthalates on unborn children with the effect of the drug Softenon (Thalidomide), by commenting: “What shouldn’t happen is that this comes onto the market and later it appears that it is totally wrong, and something like the Softenon babies occurs. We just give them those pills and later, ‘oh, damn’...” This example also illustrates an assimilation effect; the properties of the associated risk were adopted by the unknown risk.

Second, risk associations were made to illustrate that people had already *tolerated* many similar risks although these were known to cause harm. One respondent compared DON to the artificial nutrients mentioned on the labels of food products: “I think that all the other ingredients in food products are not very healthy for people either [just like DON], and those are mentioned on the product. Only, people do not know what they are, so they don’t get alarmed by them...”

Third, respondents used associations to clarify that some risky activities also had *benefits*. For instance, “I think that there’s a bigger problem of not getting enough light... perhaps not enough production of melatonin. And I think of people with depressions and

so on. Then I think of light therapy; then I think, light is more positive than negative.” This type of risk association can also be described as a contrast effect, in that the consequences of the unknown risk were contrasted with those of an associated risk.

The fourth reason for using risk associations was to illustrate that risks could also be *remedied*. One respondent associated phthalates with CFCs: “Just like the refrigerator thing, with the CFC, the gas that was in them. And that they no longer have this gas, but something totally different. They will be able to find some solution for this [i.e. phthalates].”

In short, the results suggested that associated risks and their cognitive schemes were important in assessing unknown risks. Associated risks influenced the perception of an unknown risk via similar characteristics of the two risks’ schemes and by narrowing the focus to a limited amount of information about the unknown risk.

Discussion

Respondents in the in-depth interviews and focus group interviews often talked about issues that were related to risk associations. These risk associations seemed to be based on the respondents’ personal experiences, media coverage and general knowledge. They were used for several reasons: to illustrate the severity and consequences of the unknown risk, to indicate that similar risks had been tolerated in the past, to highlight the benefits related to these risky activities, and to illustrate the possibility that risks can be remedied. Alternatively, the use of associated risks may be described as an assimilation effect or contrast effect.

The cognitive scheme of the associated risk may determine the perception of the unknown risk. This is in line with the construction-integration theory, in that respondents referred to their existing schemes to understand the unknown risks and linked the content of these schemes to the new information. The cognitive scheme and salient qualities of the associated risk seemed to affect the perception of the unknown risk.

The example of the risk of phthalates showed that a mental model offers a good representation of the respondents’ knowledge propositions about that risk. This may therefore be in agreement with the construction-integration theory. At the same time, the mental models approach can help risk communicators to understand the public’s risk perception and adjust risk communications accordingly. This may facilitate the construction and integration phases in the public’s comprehension of the risk message.

Study 3b: Survey

This survey had two principal goals. The first was to explore in a quantitative study the main finding of the qualitative study in greater depth, namely that the respondents used associated risks to judge an unknown risk. Hence, we empirically investigated whether associated risks are related to unknown risks.

As we mentioned above, the mental models approach assumes that prior knowledge is important in evaluating a risk, for example, through associations with known risks. Because this approach does not explain *how* these associations are formed, our second goal was to find out how people relate unknown risks to known risks. More particularly, we wanted to know what information (risk perception and risk characteristics) people use to choose an associated risk.

We asked respondents to judge four types of risk in terms of several risk perception aspects and qualitative characteristics. The four types were an unknown risk, a risk that they themselves associated with the unknown risk (*self-associated risk*), a risk that others associated with the unknown risk (*risk associated by others*), and a risk not related to the unknown risk (*unrelated risk*). We then calculated the correlations between the risk perception aspects of these four types of risk. If the perception of self-associated risks affected the perception of unknown risks, the perceptions were assumed to correlate (r_{12}). Figure 3.2 presents an overview of the correlations and comparisons of the correlations in this study.

However, a high correlation between the perceptions of unknown risks and those of self-associated risks could also be caused by a third variable, for example in that people who are risk averse may judge all hazards as risky. We therefore compared, for each unknown risk, the correlation between the risk perceptions of the unknown risk and those of the self-associated risk (r_{12}) with the correlation between the risk perceptions of the unknown risk and those of an unrelated risk (r_{14} , comparison I in Figure 3.2). If the correlation between the former pair was higher than between the latter pair, this would mean that a third variable like risk aversion cannot be the cause of the high correlation between the risk perceptions of an unknown risk and those of a self-associated risk.

Figure 3.2 Overview of the comparisons of this study

Next, we wanted to know whether the choice of an associated risk is to some extent personal. If that is the case, it would be difficult to use associated risks in risk

communication, because everyone at risk would need to receive a risk communication that included his or her own personal risk associations. On the other hand, if respondents also accept a risk associated by others, it would be easier to use risk associations in risk communication. Therefore, we also compared, for each unknown risk, the correlation between the risk perceptions of the unknown risk and those of the risk associated by others (r_{13}) with the correlation between the risk perceptions of the unknown risk and those of the self-associated risk (r_{12} , comparison II in Figure 3.2). If the correlation between the former pair does not differ substantially from the correlation between the latter pair, it might be concluded that perceptions of risks associated by others do not differ greatly from self-associated risks. This would allow risks associated by others to be used in risk communication.

Method

Respondents

The respondents were members of an Internet research panel. Seven hundred adult members who formed a representative sample of the Dutch population received an e-mail announcing the study, with a link to an Internet site that presented the first questionnaire. They received four questionnaires at one-week intervals. Respondents were paid in points; they received 100 points for every questionnaire they filled in and if they completed all four questionnaires they received a 50-point bonus. The maximum number of points (450) could be exchanged for a gift voucher equivalent to €5. The survey was conducted between May and June 2004.

Material

In the first questionnaire, respondents judged three risks that were, at the time, relatively unknown: food irradiation, avian influenza, and the transport of chlorine by train in the Netherlands, resulting in three questionnaire parts. In each part, respondents had to read a short description of the risk, consisting of approximately three sentences. They then filled in the questionnaire, which consisted of risk perception aspects and qualitative characteristics. The risk perception aspects were *perceived health damage*, *severity of the consequences*, *probability estimation*, *risk estimation*, and a *ranking of risks* in which the unknown risk should be placed (ranging from the risk of *Creutzfeldt-Jacob disease* to the risk of *coronary heart disease*). The internal reliabilities of these aspects were moderate to high in all four questionnaires and for all three risks: Cronbach's $\alpha > .71$. Therefore, we used the average sum score of the risk perception aspects in the analyses as a risk perception scale.

The qualitative characteristics were *familiarity with the risk*, *vulnerability*, *acceptance*, *fear*, *voluntariness*, *controllability*, *controllability by other people*, *benefits*, *known by science*, and the *time interval* at which its consequences would be noticed. Most items were measured on 7-point Likert scales, with higher scores indicating higher levels of the variables measured. Two items, the probability estimate and the ranking of risks, consisted of multiple-choice questions with 7 and 6 options, respectively, to choose from. Each questionnaire consisted of 45 items, 15 items in each part.

At the end of each part of the first questionnaire, respondents were also asked to indicate a risk that they associated with the unknown risk. This resulted in three self-associated risks (e.g. one participant associated x-rays with food irradiation). One week later, the

respondents received the second questionnaire, in which they judged the three self-associated risks they had mentioned in the first questionnaire, using the same items. Thus, the second questionnaire could be unique to each respondent. The third questionnaire consisted of three risks that other respondents had mentioned in the first questionnaire and that the respondents had not mentioned themselves (risks associated by others). For each unknown risk, we selected two or three risks that were frequently associated by the respondents. Each respondent was presented with one of these selected risks. For food irradiation, the respondents evaluated either genetically modified food or pesticides on fruit and vegetables. For avian influenza, they evaluated Severe Acute Respiratory Syndrome (SARS) or Bovine Spongiform Encephalitis (BSE). For the transportation of chlorine by train, they evaluated either the transportation of inflammables, an accident at a nuclear power station, or an airplane crash. We made sure that the *risk associated by others* that was presented to a respondent was not similar to the self-associated risk. Hence, the respondents (or at least some of them) received different questionnaires. In the fourth and final questionnaire, respondents judged risks that were unrelated to the unknown risks and had not been mentioned by any of the respondents, namely phthalates in cosmetics, an anaphylactic shock caused by an allergy, or flooding of the Netherlands in the next century.

Results

Respondents

The first questionnaire (about the unknown risks) was completely filled in by 349 respondents. In the end, 256 respondents had completed at least two parts of all four questionnaires. Thus, 73.35% of the respondents of the first questionnaire could be included in the analyses after the final questionnaire. The demographics of the final sample were as follows: 55.9% of the respondents were female; the mean age was 41.95 years ($SD = 13.43$); 27.3% of the respondents had a low level of education (primary school or lower professional training), 43.4% a medium level (secondary education and lower secondary professional training), and 29.3% a high level (higher professional training or university).³ The education level of our sample was representative of that of the population in the Netherlands (Centraal Bureau voor de Statistiek [Statistics Netherlands], 2005). The respondents were evenly distributed across the Netherlands.

Risk associations

The first goal of this study was to find out whether the risk perceptions of the unknown risk and those of the self-associated risk were related. This was tested by calculating the correlations between the unknown risks and the self-associated risks, that is, between the scores on the risk perception scales of questionnaires 1 and 2 (r_{12}), for each part. As can be seen in Table 3.2, the risk perception scales of the three unknown risks correlated significantly with the corresponding risk perception scales of the three self-associated risks.⁴

Thus, this result supported our hypothesis that the risk perception of an unknown risk would be related to the risk perception of a self-associated risk. It may imply that people use the perception of the self-associated risk to judge the unknown risk.

Table 3.2 Correlations between risk perception scale of the unknown risk and the self-associated risk, for each part of the questionnaires.

		Self-associated risk		
		Part 1	Part 2	Part 3
Unknown risk	Part 1: Food irradiation	.48**		
	Part 2: Avian influenza		.47**	
	Part 3: Chlorine transport			.40**

Note. * $p < .05$, ** $p < .01$.

Self-associated versus unrelated risks

Since the above high correlations could also be the result of a third variable, for example risk aversion, we compared the correlations between the risk perception scales of the unknown risks and those of the self-associated risks (r_{12}) with the correlations between the risk perception scales of the unknown risks and those of the unrelated risks (r_{14} , comparison I in Figure 3.2). For this purpose, we used Steiger's test for equality of two dependent correlations, $Z1bar^*$, since the correlations originated from a single sample (Steiger, 1980).

If people associate an unknown risk with a risk that they consider to be related in terms of risk perception, rather than with an unrelated risk, the correlations r_{12} should be significantly larger than the correlations r_{14} . The risks of avian influenza and of transportation of chlorine by train (parts 2 and 3) had an r_{12} that was significantly larger than r_{14} , $Z1bar^*s > 2.33$, $ps < .01$. As regards food irradiation (part 1), no significant difference was observed between r_{12} and r_{14} , $Z1bar^* = -.47$, $p = .32$. Based on these results, we may conclude that the risk perception of an unknown risk is more strongly related to the risk perception of a self-associated risk than to the risk perception of an unrelated risk. This was in accordance with our hypothesis.

Self-associated risks versus risks associated by others

Next, we wanted to find out whether the self-associated risk was personal or whether it could also be replaced by a risk associated by others. To this end, we compared the correlations between the risk perception scales of the unknown risk and those of the self-associated risk (r_{12}) with the correlations between the risk perception scales of the unknown risk and those of the risk associated by others (r_{13} , comparison II in Figure 3.2). Only in the third part (chlorine transport) was r_{12} marginally larger than r_{13} , $Z1bar^* = 1.53$, $p = .06$. In the other two parts, r_{12} did not differ from r_{13} , $Z1bar^*s > -.79$, $ps > .21$.

In sum, the correlations between the unknown and self-associated risks appeared to be similar to the correlations between the unknown risk and the risk associated by others. People's evaluations of unknown risks, self-associated risks, and risks associated by others were related and sometimes even strongly related, whereas the evaluations of unknown risks and of unrelated risks were not related. Thus, we conclude that the association between two risks may not be purely personal. People seem to share, to some extent, a risk association network that a certain risk evokes. This might be based on semantics or representativeness, which leads to the second goal of this study: how are risks associated?

How are risks associated?

The second goal of this study was to find out how people relate unknown risks with known risks: why do they associate these specific risks and not the unrelated ones? We tested three possible modes of association. First, the self-associated risks might be chosen because they had a semantic connection with the unknown risks: people used the wording of the unknown risk to find a related risk. A second possibility was that the unknown risks and the self-associated risks evoked similar risk perceptions. The third option we studied was that people chose the self-associated risks because these had similar qualitative characteristics as the unknown risks.

These three different association modes were investigated in different ways. First, the semantic connection between unknown and self-associated risks was examined by studying the content of the self-associated risks. We did indeed find that the self-associated risks and the unknown risks often had a semantic connection. As a result, the respondents regularly related the unknown risk to a known risk of the same semantic category. The risk of food irradiation reminded most respondents of one of the two words that characterize this technology, namely food risks, such as genetically modified food and food poisoning; and radiation risks, such as radioactivity and cell phones. The second risk, that of avian influenza, reminded respondents of other infectious diseases of humans or animals, such as Severe Acute Respiratory Syndrome (SARS) and Bovine Spongiform Encephalitis (BSE). The third unknown risk, the transportation of chlorine by train, reminded most of the respondents of other dangerous transports, for example those of nuclear waste and petrol. In addition, the respondents mentioned other catastrophic accidents, such as an airplane crash or the explosion of the nuclear power station in Chernobyl. Thus, the semantics of the unknown risks appeared to be important for the choice of self-associated risks.

Second, we examined whether the self-associated risks were chosen because the risk perceptions of the unknown risks were similar to those of the self-associated risks. To this end, the absolute difference in scores between the risk perception scales of the unknown risks and those of the self-associated risks (ΔRP_{12}) were compared with the absolute difference in scores between the risk perception scales of the unknown risks and those of the unrelated risks (ΔRP_{14}). If the respondents associated unknown risks with risks that had similar risk perceptions, ΔRP_{12} should be smaller than ΔRP_{14} . We conducted paired t-tests between ΔRP_{12} and ΔRP_{14} for each part of the questionnaire.

Only in part 1 was ΔRP_{12} ($\Delta M_{12} = -.77$, $SD = 1.31$) significantly different from ΔRP_{14} ($\Delta M_{12} = .36$, $SD = 1.12$), $t(220) = -10.89$, $p = .0001$. However, the difference was contrary to our expectations, in that ΔRP_{12} was larger than ΔRP_{14} . In the other two parts, ΔRP_{12} did not differ from ΔRP_{14} , $t(221) = -.37$ and $t(214) = 1.30$.

In sum, the analysis of the second association mode yielded mixed results. The mean differences between the risk perceptions of the unknown risks and those of the self-associated risks were in most cases not significantly different from the mean differences between the risk perceptions of the unknown risks and those of the unrelated risks. Thus, people do not appear to form associations with risks based on the level of perceived risk.

Third, we wanted to find out whether the respondents used certain qualitative characteristics to choose the self-associated risks, such as the fact that both the unknown risk and the self-associated risk might not be controllable by the victims. The qualitative characteristics that were assessed in this part of the study were *familiarity*, *vulnerability*,

acceptability, fear, voluntariness, controllability, controllability by others, benefits, known by science, and time interval. A qualitative characteristic was considered to be an important determinant of the risk association if the absolute difference between the unknown risk and the self-associated risk for a particular item (ΔQC_{12}) was significantly smaller than the absolute difference between the unknown risk and the unrelated risk (ΔQC_{14}). In such cases, the unknown risk and the self-associated risk would be evaluated as more similar in terms of this characteristic than the unknown risk and the unrelated risk. The paired t-tests for ΔQC_{12} and ΔQC_{14} for all items showed significant differences for 18 of the 30 items, $ts < -2.28$ and $ts > 2.27$, $ps < .02$. The qualitative characteristics *controllability, controllability by others, known by science* (part 1), *benefits, time interval* (part 2), and *familiarity, voluntariness, and controllability* (part 3) yielded a ΔQC_{12} that was significantly smaller than ΔQC_{14} . The characteristics *familiarity, vulnerability, acceptability, benefits, time interval* (part 1), *familiarity, vulnerability, benefits* (part 2), *vulnerability, and time interval* (part 3) yielded a ΔQC_{12} that was significantly larger than ΔQC_{14} . There were no other significant effects of the type of risk association on the scores for the qualitative characteristics, $ts > -1.85$ and $ts < 1.70$, $ps > .07$.

In short, the qualitative characteristics had mixed results, just like the risk perception scales. Therefore, we cannot conclude that the associations between the unknown risks and the self-associated risks were based on similarity in terms of these qualitative characteristics. Some qualitative characteristics yielded smaller absolute differences between the unknown risks and the self-associated risks than between the unknown risks and the unrelated risks in all three parts, whereas other characteristics yielded larger absolute differences between the unknown and self-associated risks than between the unknown and unrelated risks. Thus, it is unlikely that respondents related risks based on similarity of qualitative characteristics.

Discussion

This survey had two goals. The first was to explore, quantitatively, whether people relate unknown risks to other risks. The use of prior knowledge (and associated risks) was assumed to be important in risk perception. However, *how* risks are related had not yet been studied. Therefore, our second goal was to study the way people relate an unknown risk with a known risk.

The findings of this study showed that respondents did indeed link unknown risks to known risks, and that the perceptions of the unknown risk and the self-associated risks were related. The association between two risks was not the result of a personality variable such as risk aversion, nor was it due to a similar level of risk perception, or to similar qualitative characteristics of the two risks. Instead, it appeared that the self-associated risks were semantically connected to the unknown risks. Furthermore, our findings indicated that other risks, associated by other people, could also be acknowledged as associated risks. This may imply that associated risks can influence the perception of unknown risks due to a semantic connection between these risks. However, this remains to be tested empirically.

The choice of a risk association can be explained by a semantic network model (Collins & Quillian, 1969; Markman, 1998). In this type of model, concepts that are related to each other are connected by means of nodes and links. The strength of the link between two nodes is based on the frequency of simultaneous activation of the nodes. Concepts are strongly linked when they are often activated together. If one concept is

activated, the activation spreads through the network of nodes and links, so that other related concepts are activated (Collins & Loftus, 1975). The spreading of activation is determined by the activation of the initial concept and the strength of the links between this concept and connected concepts. A link degenerates when two concepts are no longer activated together. The semantic network model represents an economical storage method because concepts can 'inherit' the features of connected concepts.

The semantic network model can be applied to the association between unknown risks and known risks as follows. Learning about an unknown risk (e.g. "food irradiation") activates the general concept of the unknown risk based on the semantic category it belongs to (e.g. "food risks"). The activation then spreads further to nodes of known risks and instances (e.g. "contaminated food") that are also connected to the general concept. Personal experience determines which familiar risks and instances are included in the network, which of them are already strongly activated and which are related to the general concept. Therefore, associated risks could at first sight be expected to be personal, but other familiar risks (e.g. "pesticides on fruit") may also be acknowledged as associated risks because they are present in the network only not as strongly as the self-associated risks. For example, extensive media attention to a recent incident may activate some nodes strongly, so that the recent incident is temporarily linked to many other nodes. This might not have occurred without the media coverage.

Other theories and concepts may also be able to explain how people associate risks. For example, people may associate unknown risks with known risks because of certain risk attributes, like Renn's (1998) "pending danger, slow killers, cost-benefit ratio, and advocational thrill" and Sjöberg's (2000c) "tampering with nature". In addition, risks may be associated with each other because they are both stigmatized risks (Gregory, Flynn, & Slovic, 1995; Kasperson, Jhaveri, & Kasperson, 2001). It would be interesting to explore the influence of these attributes in further research.

This study used on-line questionnaires completed by an Internet research panel, which has several advantages. We found that by using an Internet research panel, we were able to reach a reasonably large sample of respondents with relatively little effort. Response rates for on-line questionnaires are known to be high, since the questionnaires are easy to fill in and return (Krantz, Ballard, & Scher, 1997). However, Internet research has been criticized for its limited opportunities to monitor the respondents; respondents may not fill in the survey honestly or seriously (Gosling, Vazire, Srivastava, & John, 2004). It has also been argued that the respondents' sample was self-selected. Nevertheless, it turned out to be easier to find respondents with various demographic characteristics through web surveys than by paper-and-pencil surveys, because people with a wide range of backgrounds now have Internet access (Gosling et al., 2004). Moreover, several studies have shown that the validity of Internet surveys is similar to that of lab surveys (Gosling et al., 2004; Krantz et al., 1997; Krantz & Dalal, 2000).

Recommendations and Conclusions

How can we improve risk communication by using the findings of these two studies? According to the construction-integration theory, a text is easy to comprehend if the readers' schemes are in accordance with the text and vice versa. Therefore it is important to identify the public's knowledge schemes that are related to the risk, so that the content of the risk communication can be tailored to this knowledge. The mental model approach

is useful to attune the public's knowledge to new risk information (Bostrom et al., 1992; Morgan et al., 2002). This could be achieved by first separately interviewing experts and a sample of the public on the specific risk. The two resulting mental models could then be mapped to form a frame to which the content of the risk communication should be tailored. Associated risks that are present in the public's mental models can be used in risk communication to guide people toward a particular perception of the unknown risk. For example, according to the findings of our survey, the known SARS risk can be used in a risk communication about avian influenza (as it was mentioned by 16% of the respondents in the first questionnaire). The known risk activates the semantic category of infectious diseases, so that avian influenza is linked to the characteristics of this category and other accompanying risks, e.g. that it spreads easily and that it needs to be prevented immediately. We recommend pretesting the presumed associated risks to make sure that the associated and unknown risks have semantic similarities, since studies about risk comparisons showed that not all comparisons are accepted by the public (e.g. Roth et al., 1990). However, it may be even more important to include certain associated risks in risk communication for the purpose of explaining in what respect(s) these are different from the risk presented, so that these associated risks do not affect the presented risk in undesirable ways.

The interviews revealed that known risks were associated with unknown risks for four different reasons. First, they were used to characterize the possible severity and consequences of the unknown risk. Second, they were used to show that similar risks had been tolerated before. Third, the associations served to indicate that risky activities could also have benefits. Fourth, they illustrated that previous risks had also been remedied. Thus, risk associations can be used to achieve several effects in risk communication. Depending on the goal, the risk communication can use associated risks to promote different effects. For example, if risk managers want to emphasize the severity of the unknown risk, they should associate it with risky activities that are known for their severe consequences. The mental model approach is useful to identify which risk associations result in which effects.

Associated risks may be applied in risk communication in two different ways, in both of which the mental models approach can be important. The first possible form of risk communication focuses on individuals or small groups of people at risk. These individuals and groups can be identified by field workers (e.g. physicians, policymakers, and risk managers) as 'risk populations'. The members of the group at risk fill in a detailed questionnaire about their knowledge, attitudes, beliefs and behavior concerning the risk, which are then used to construct a personal mental model (e.g. De Vries & Brug, 1999). Next, all individuals or small groups receive a risk communication that is tailored to their specific mental model. According to construction-integration theory, this would optimize comprehension of the message. A study about tailored (computer-based) risk communication to prevent colorectal cancer showed that respondents who had received tailored messages had a more accurate risk perception and were more likely to correct their misperceptions about their personal risk than the respondents who had received messages without personalized information (Emmons et al., 2004).

However, this method is expensive and labor-intensive. In addition, the results of our second study showed that people might not need a personal risk association; risk associations made by others can also be related to unknown risks. Thus, tailored interventions should only be used when the target subgroup is expected to be difficult to

reach by mass risk communication or differs considerably from the general population.

The second possible method of risk communication uses the mental models approach on a sample of the population and, based on its results, develops a communication with associated risks for the entire population. This type of risk communication takes the form of mass communication and might be less effective in informing the public than an individually tailored communication, since it is uncertain whether every member of the population understands it and takes it seriously. Nevertheless, this method is much cheaper and less labor-intensive. We recommend the mass communication approach when the risk is easy to understand and when no problems are expected in reaching the public.

To conclude, these studies showed that associated risks can assume a prominent, spontaneous role when people respond to an unknown risk or interpret risk communication: people often associate unknown risks with known risks. The qualitative study also revealed four different reasons why risk associations are made. Moreover, the semantic category of the unknown risk was found to determine people's choice of associated risks, which can be explained by a semantic network theory. In short, our findings support the implicit assumption of the construction-integration theory, the mental models approach, and the representativeness heuristic that prior knowledge (and thus associated risks) is important in the way the general public form risk perceptions.

Chapter 4

An Associative Approach to Risk Perception: Measuring the Effects of Risk Communications Directly and Indirectly

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Abstract

Risk perception is often measured by a direct method, e.g. a questionnaire. This mainly reveals the deliberate evaluation of risks (a so-called secondary evaluative process), whereas risk perception can also be based on a first, spontaneous reaction (a primary evaluative process). An indirect test such as the Extrinsic Affective Simon Task (EAST, De Houwer, 2003) may be needed to reveal this first, spontaneous reaction. In this study, a questionnaire and an EAST measured the effects of varying risk communications (high risk, low risk or control article), about high-voltage power lines. The results of the EAST showed that the respondents associated power lines stronger with unhealthy than with healthy. However, the questionnaire results did not seem to indicate that the respondents considered power lines as risky. The EAST did not reveal an effect of article variation on the associations of power lines with (un)healthy. Conversely, the questionnaire results showed that article variation influenced the secondary evaluative process. Further, our findings demonstrated that the direct and indirect measures were unrelated. An indirect test may complement a direct test to get an overall picture of how people evaluate risks.

Introduction

We are regularly confronted with new risks because of technological and social developments. Especially when public concern about the new risk is expected, governments, scientists and companies are interested in how ‘the man in the street’ perceives these risks. Also, they want to know how risk communication may affect people’s risk perception. Therefore, adequate measures of risk perception are needed. The risk perception measures that have so far been used are interviews, questionnaires and behaviour changes (e.g. Connelly & Knuth, 1998; Niewöhner et al., 2004; Shapira et al., 2001). This article explores a different method to measure risk perception and the effects of varying risk communications on risk perception, namely an indirect test.

Risk perception questionnaires use items about probability, severity and risk characteristics based on the psychometric paradigm (e.g. MacGregor et al., 1994; Slovic, 1987). These types of tests mainly reveal a deliberate process of how a risk and its information are evaluated. However, we believe that risk perception is formed by another process next to this deliberate one. We call these two processes the ‘primary evaluative process’ and the ‘secondary evaluative process’ of risk perception. Risk perception that is based on the former process reflects the first, spontaneous response to a risk. This fits in Zajonc’s (1980) proposition that affective reactions precede cognitive reactions and can be elicited with minimal stimulus input. The secondary evaluative process comes after the first reaction and occurs with relatively more deliberate effort than the primary evaluative process. This does not exclude the influence of affect and heuristics on this process. The primary evaluative process takes place easily, whereas the secondary evaluative process may only occur under certain conditions, like sufficient motivation, time and cognitive capacity (cf. Chaiken et al., 1989; Olson & Fazio, 2003). Then the secondary evaluative process may overrule the primary evaluative process, although it can be influenced by the latter process at the same time.

Perhaps the primary evaluative process offers evolutionary advantages (Damasio, 1994; Epstein, 1994; Loewenstein et al., 2001; Zajonc, 1980). The decision as to whether something or somebody is dangerous or not is basic, intuitive and very important for survival. An elaborate, conscious decision takes time and might severely limit survival chances. For example, when an individual encountered a lion in ancient times, an immediate behavioural response (e.g. running away) was required (see Cannon, 1915); a deliberate process would take too long. Therefore, the decision whether something is dangerous or harmless is conceived to be anchored in a primary evaluative process, which developed earlier in evolution than the secondary evaluative process. As a result, even a ‘modern’ risk, such as the risk of a nuclear power, may still activate a primary evaluative response before a more deliberate evaluation can occur. The primary evaluative process may lead to a different risk perception than the secondary evaluative process. For example, people’s first gut reaction to a snake might be “It is dangerous, I want to avoid it”, but when they give it a second thought they may realise that it is a ringed snake and these are harmless. The secondary evaluative process may or may not overrule the first reaction in these cases. If it does not overrule, the primary evaluative process results in an avoidance reaction when people have an automatic, negative association with the hazard, although the secondary evaluative process would not lead to this response. When people have an automatic, positive association with the hazard, the primary evaluative process may lead to an approach reaction, e.g. fat food is nice, even though their secondary evaluative

process would lead to the conclusion that it is risky. Our line of thoughts about these two processes follows that of other dual process theories about risk perception on several points (cf. Loewenstein et al., 2001; Slovic et al., 2004; Trumbo, 1999). In the present study, we try to measure the effects of risk communication on both processes.

For that purpose, two different types of tests are needed. A questionnaire is suitable to measure the secondary evaluative process because it is a direct measure. In this type of measure, the answers can be constructed extensively on the spot instead of being an immediate reaction to the risk (Greenwald et al., 1998). However, this type of test is not appropriate for the primary evaluative process, which requires a test that reveals the first, spontaneous reaction and that can be minimally distorted by deliberate processing. In this respect, the field of risk perception can learn from implicit attitude research (e.g. De Houwer, 2003; Greenwald et al., 1998). Implicit attitudes can be activated automatically, outside of conscious attention and more quickly than explicit attitudes (Ajzen, 2001; Fazio, 2001). Because of their automatic activation, it is difficult to report which stimuli are responsible for evoking implicit attitudes in a direct test (Greenwald et al., 1998). An indirect measure is more suitable for implicit attitudes. In this measure, the association strength between an attitude object and an evaluation is assessed (NB, in some tests, more attitude objects and evaluations are measured simultaneously). The respondents are instructed to react as fast as possible so that explicit, cognitive processes cannot disturb the reaction. Moreover, respondents are not aware that their attitude is being measured, although they may be aware that they possess this attitude (Fazio & Olson, 2003). For these reasons, the indirect test seems to be an appropriate measure of the primary evaluative process of risk perception. This study used an indirect test next to a direct test to find out whether both tests lead to similar outcomes concerning how people perceive risks.

We chose the Extrinsic Affective Simon Task (EAST, De Houwer, 2003) as the indirect test and adopted it to measure risk perception. The EAST is a reaction time task on the computer and measures the association strength between an attitude object (e.g. “flower”) and two opposite evaluations (e.g. “good” versus “bad”). This test has the advantage that it can measure reactions to a single attitude object, whereas two attitude objects often need to be compared in other implicit measures. In addition, because the EAST uses both the extrinsic characteristics of the object and the intrinsic valences (i.e. meaning) of the evaluation words, respondents cannot recode the meaning of the object in the meaning of the evaluation words, which could interfere with the results. The EAST’s exact design and procedure are explained in the Materials section. To our knowledge, the EAST had not yet been used to measure risk perception.

In short, people may perceive a risk using the primary and secondary evaluative processes. Both an indirect and a direct measure were therefore applied to analyse these processes of risk perception in our experiment. We tried to create different levels of risk perception to test the sensitivity of the direct and indirect measures by varying risk communications. The subject of the risk communications was the risk of high-voltage power lines, because we thought that our respondents were unfamiliar with this risk.

Aims of this Study

Three aims were pursued in this study. First, we wanted to measure the respondents’ risk perception of power lines using the EAST and a questionnaire. Second, it was tested

whether the EAST and the questionnaire were sensitive to the risk communication variations. The risk of power lines was presented in three article variations (a high risk, low risk and control article) to cause different levels of risk perception. We expected that, according to the questionnaire, the respondents who had read the high-risk article would judge power lines as riskier than the respondents who had read the low-risk article, who would again evaluate this hazard as riskier than the respondents of the control article would. In addition, we expected that the EAST results would reveal a stronger association of power lines with unhealthy than with healthy in the high-risk condition. This association would be less strong in the low-risk and control condition. Third, the results of these two measures were related.

Method

Respondents

Ninety first-year students of Maastricht University agreed to participate in this study. They received €5 for participation. One respondent was removed from the analyses because she did not perform the tasks in the correct order. The mean age of the respondents was 19.71 years ($SD = 3.37$); 65 respondents were female and 24 respondents were male. The respondents were randomly assigned to one of the three conditions and one of two EAST versions.

Materials

Risk communication. The risk that we used in this study was that of high-voltage power lines. Several epidemiological studies found an association between living nearby power lines and the prevalence of childhood leukaemia (e.g. Angelillo & Villari, 1999; Draper, Vincent, Kroll, & Swanson, 2005). However, other studies did not reveal such an association (e.g. Linet et al., 1997). In addition, the biological mechanism that could explain the relation between power lines and childhood leukaemia is unclear (Draper et al., 2005; Health Council of the Netherlands, 2000a).

We developed three articles about power lines: a high-risk, a low-risk and a control article. The high-risk article stated that a clear connection was found between living nearby power lines and the occurrence of childhood leukaemia. The emphasis was placed on the certainty of this finding. The risk was framed negatively, e.g. “(in the Netherlands) 150 children get leukaemia every year. As a result, approximately 30 children die each year”. The low-risk article mentioned that the risk of living near power lines is exaggerated in the media and that it has not yet been demonstrated that power lines cause childhood leukaemia. The risk was framed positively, e.g. “(in the Netherlands) approximately 80% of the children that get leukaemia recover from this disease”. The control article discussed the number, length and types of power lines in the Netherlands. A pre-test among respondents of comparable age and educational level showed that these articles satisfied our expectations concerning understanding and risk perception.

EAST. The original EAST consists of three types of blocks: two practice blocks and one test block (De Houwer, 2003). In the first practice block, respondents learn to classify evaluation words according to their intrinsic valences (i.e. meaning); if they see a good/positive word, they should press the left button and if they see a bad/negative

word, they should press the right button. Thus, the left key becomes associated with 'good' and the right key becomes associated with 'bad'. In the second practice block, the respondents are trained to categorize the extrinsic characteristics of the object words (based on their colours: blue-left and green-right) by pressing one of two response keys. The intrinsic valence of the coloured words needs to be ignored. Then, four test blocks are done in which the evaluation and object words are mixed. Reaction time and the response accuracy are recorded. Responding to the object words is difficult because their intrinsic valence is related to the intrinsic valence of the evaluation words. As a result, if respondents associate the object words with a positive evaluation, they respond faster and make fewer mistakes on the object words that require the same response (green: right key) as the positive evaluation words (right key) than on the object words that require the same response (blue: left key) as the negative evaluation words (left key). The reverse effect occurs for object words that have a negative intrinsic valence.

Our EAST was programmed in E-Prime, a software programme developed for psychological experiments specifically (Schneider, Eschman, & Zuccolotto, 2002). It was adopted in the following three ways to measure risk perception. First, we changed the evaluation words from positive-negative to healthy-unhealthy, because we believed that these were better characterizations of risk perception. Second, we used pictures instead of words since it was difficult to describe power lines in words. Third, the object pictures were converted in a grey scale and covered under a lilac or purple colour film, similar to Callan and Ellard (2003). We chose these colours because we thought that green (original EAST) would be associated with good environmental quality and thus would lead to biased results. There were 10 different power line pictures, of which 10 lilac and 10 purple versions were made. In addition, we chose five pictures of a healthy environment (e.g. a nature reserve) and five pictures of an unhealthy environment (e.g. a factory with black-coloured emissions) to represent the intrinsic evaluations. These evaluation pictures were in their original colours. All pictures were approximately 11 cm wide and 9 cm high. Two versions of the EAST were developed in which we switched the colours lilac and purple to check for hand preference.

The instructions for the EAST were presented on the computer screen. Respondents were told that this was a reaction time task and that they should try to react as fast as possible without making mistakes. After the instructions, three illustrations were shown of an original, a lilac and a purple picture. In the evaluation pictures practice block, participants were instructed to press the left key (Q-key) if they saw a healthy picture and the right key (P-key) if they saw an unhealthy picture. In the object pictures practice block, respondents were instructed to press the left key (Q) if they saw a lilac picture and the right key (P) if they saw a purple picture (this was reversed in the second EAST version). The picture presentation intervals, inter-trial intervals and feedback intervals were similar to the EAST by De Houwer (2003).

We expected that respondents who perceived power lines as unhealthy would react faster and make fewer mistakes on the coloured power lines pictures with the same response as the unhealthy pictures than on the coloured power lines pictures with the same response as the healthy pictures. Conversely, respondents who perceived power lines as healthy would respond faster and make fewer errors on the coloured pictures that were associated with healthy pictures than on the coloured pictures associated with unhealthy pictures.

Questionnaire. The questionnaire contained nine items about risk perception: personal health damage, health damage for children, seriousness of the consequences, number of people affected by the risk ('probability estimation', ranging from "fewer than 1 in a million people" to "more than 500 in a million people"), order of risks in which the risk of power lines should be placed based on its perceived probability ('order of risks', ranging from the risk of Creutzfeldt-Jakob disease to the risk of coronary heart disease), order of quotations by other people of which the respondents should choose one that corresponded to their personal opinion about power lines ('order of quotations', ranging from "not concerned at all" to "a very serious problem"), concern, personal vulnerability and acceptability of the risk. The internal reliability of the risk perception items was high, Cronbach's $\alpha = .91$, $K = 9$. Therefore, we computed the average sum score of these items and used this as a risk perception scale in the analyses.

Procedure

Respondents were invited to the laboratory of the Faculty of Health Sciences at Maastricht University, maximally six respondents at a time. The respondents were instructed about the experiment, after which they took their places in separate cubicles. Respondents completed an informed consent form for participating in this experiment. Then they read one of the three articles about power lines. They started the EAST by pressing the space bar, which took approximately 12 minutes to complete. Subsequently, the respondents received and completed the questionnaire. After this, they were paid, debriefed about the actual risk of power lines, 'sworn to secrecy' and thanked for participating.

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Results

Indirect measure

Following De Houwer (2003) and Greenwald and colleagues (1998), the reaction times and accuracy of the first response to the coloured pictures in the test blocks were used for the analyses. The reaction times belonging to inaccurate responses were removed from the analyses that used the reaction times as dependent variable. Reaction times below 300ms and above 3,000ms were recoded in 300ms and 3,000ms, respectively. The distribution of the reaction times were skewed to the right and the Kolmogorov-Smirnov test of normality showed that the reaction times were not normally distributed, $D(89) = .14$, $p = .0001$. Therefore, we log-transformed the reaction times, which improved the normal distribution a little, $D(89) = .11$, $p = .01$.

Risk perception as measured by the EAST was analysed by computing difference scores between the pictures associated with unhealthy and pictures associated with healthy of the mean log-transformed reaction times and of the percentage of errors. A significant difference score is also called the EAST effect (De Houwer, 2003). A negative EAST effect would indicate that the respondents reacted faster to the association power lines – unhealthy than to the association power lines – healthy. A positive difference score would indicate the opposite.

Two one-sample t-tests of the mean log-transformed difference score and of the percentage of errors difference score were done. Significant EAST effects were found for both the mean log-transformed reaction times ($\Delta M = -14.35$, $SD = 59.10$; $\Delta M_{\log} = -.01$, $SD_{\log} = .04$)⁶ and the percentage of errors ($\Delta M = -4.27$, $SD = 6.46$), $t_s < -2.64$, $p_s <$

.01.⁷ Respondents reacted faster and made fewer errors on the pictures associated with unhealthy than on the pictures associated with healthy. Thus, the EAST indicated that the respondents associated power lines more strongly with unhealthy than healthy.

To test whether article variation had an effect on reaction time and number of errors, the mean log-transformed reaction times and the percentage of errors were calculated separately for unhealthy association and healthy association. Next, two 3 (article variation: high-risk, low-risk, control) $\times$ 2 (association: healthy vs. unhealthy) ANOVAs with repeated measures were conducted for the mean log-transformed reaction times and the percentage of errors separately.

The ANOVA of the mean log-transformed reaction times showed a significant main effect of association, $F(1, 86) = 6.81, p = .01$. This is similar to the negative EAST effect, which we just described. Article variation had no significant main effect, $F(2, 86) = 1.28, p = .29$. The interaction that was of most importance to test the effect of article variation on the results of the EAST, between association and article variation, was not significant, $F(2, 86) = .19, p = .83$. Thus, the article that the respondents had read did not influence their association strength between power lines and unhealthy or healthy, as measured by the reaction times.

The same ANOVA with repeated measures for the percentage of errors as dependent variable showed a significant main effect for association, $F(1, 86) = 39.19, p = .0001$. This main effect was the same as the negative EAST effect that we just described. Article variation had no significant main effect, $F(2, 86) = .34, p = .71$. The interaction between article variation and association was not significant, $F(2, 86) = 1.26, p = .29$. Thus, the article that the respondents had read did not affect the association strength between power lines and unhealthy or healthy, as measured by percentage of errors.

In short, because the responses to the power lines pictures associated with unhealthy were faster and had fewer mistakes than the responses to the power lines pictures associated with healthy, we may conclude that the respondents associated power lines with unhealthy according to the EAST results. One of the aims of this study was to test whether the EAST results are sensitive to the effect of article variation. This was not found; our risk article variations did not lead to different associations with power lines as measured by the EAST.

Direct measure

First, the results of the direct measure of risk perception were analysed by means of a one-sample t-test of the mean score on the risk perception scale. This mean score ($M = 3.37, SD = 1.19$) was significantly lower than the midpoint of the 7-point Likert scale (4), $t(88) = -5.01, p = .0001$. Thus, one would probably not conclude that the respondents perceived power lines as risky based on this finding, although the midpoint of the scale is of course not a gold standard of perceived riskiness.

Next, an ANOVA with the risk perception scale as dependent variable and article variation as independent variable was conducted. This univariate test showed a significant effect of article variation on the risk perception scale, $F(2, 86) = 11.39, p = .0001$. Post-hoc tests with Bonferroni correction revealed that reading the high-risk article led to a higher score on the risk perception scale ($M = 4.12, SD = .97$) than the low-risk ($M = 2.90, SD = 1.08$) or control article ($M = 3.06, SD = 1.19$). There was no significant difference on the risk perception scale between the low-risk and the control condition.

In sum, the respondents did not seem to evaluate power lines as risky overall, according

to the questionnaire findings. The risk article variations resulted in various levels of perceived riskiness according to the direct measure. The respondents who received the high-risk article had a higher score on the risk perception scale than the respondents who received the low-risk or control article.

Comparing the indirect measure with the direct measure

Another goal of this study was to relate the results of the indirect measure, the EAST, to the results of the direct measure, the questionnaire. Therefore, we used the difference scores between the power lines pictures associated with unhealthy and the power lines pictures associated with healthy of the log-transformed reaction times and percentage of errors of the EAST (Greenwald et al., 1998). Next, we computed the correlations between these difference scores and the risk perception scale of the questionnaire. There were no significant correlations between the direct and indirect measure, $-.04 < r < .03$, $ps > .72$. This seems to demonstrate that the EAST and the questionnaire results were not related with each other; the two tests may measure different outcomes of the two processes of risk perception.

Discussion

This study had three aims. The first was to measure risk perception using the EAST and a questionnaire. Overall, the respondents appeared to associate power lines more strongly with unhealthy than with healthy, according to the EAST. Thus, the EAST may be an appropriate measure of the primary evaluative process because it uncovers the first spontaneous reaction to an object. The questionnaire results did not lead to the conclusion that our respondents were concerned about power lines, since the risk perception score was below the midpoint of the questionnaire scale, although a gold standard is not available.

The second aim of our study was to examine whether the EAST and the questionnaire were sensitive to risk communications. The questionnaire results showed that the respondents who had read the high-risk article perceived power lines as more risky than the respondents who had read the low-risk article or the control article. Hence, the risk messages seemed to influence the secondary evaluative process.

On the other hand, the EAST did not reveal an effect of article variation; the respondents' association between power lines and unhealthy was not influenced by the information they had read. Thus, the various risk articles did not seem to influence the primary evaluative process. It may be that the manipulation of the articles was not extreme enough to influence the primary evaluative process although it seemed to affect the secondary evaluative process. It is assumed that information can influence the cognitive (secondary evaluative) as well as the affective (primary evaluative) processes of risk perception (cf. Loewenstein et al., 2001). However, the information's effect may be different on these two processes. The secondary evaluative process may be determined by 'rational' information such as the probability and outcomes of the hazard as well as affect, whereas the primary evaluative process may only be influenced by affective and situational signals (e.g. vividness of the information). Such cues should produce new associative links and strengthen or weaken existing links in the primary evaluative process. Our risk articles do not seem to have succeeded in this. Nevertheless, the article variation was sufficient to

affect the secondary evaluative process. In future research, it should be examined whether risk communication that attempts to influence associative links can have an effect on the primary evaluative process.

We should make one further remark about the risk communications of this study. In the three different risk articles, the contents were varied in accordance with variations as they can be found in reality, such as in the media. For example, we accentuated some facts in the high-risk article but not in the other two articles, without misinforming the readers. We chose different article variations for the external validity of the study. However, they complicated our conclusions about which aspects of the articles influenced the respondents' risk perception of power lines. Moreover, it may be that the EAST could not tap the effects of all these aspects so that it is unclear what caused the EAST effect.

Our third aim was to examine whether the two tests were related. Two findings seem to indicate that the EAST and the questionnaire measured two different processes of risk perception. First, the EAST revealed that power lines were strongly associated with unhealthy, whereas the questionnaire did not reveal such a negative perception. Second, we found no correlations between the direct and indirect measures. In this case, the outcome of the primary process may not have been fully incorporated in that of the secondary evaluative process.

It is not surprising that we did not find a relation between the direct and indirect measurements. Previous studies found weak correlations between these two types of measurements (Callan & Ellard, 2003; Greenwald et al., 1998). As expected and as other researchers already have suggested, this may indicate that different constructs underlie the primary and secondary evaluative processes of risk perception (cf. Loewenstein et al., 2001; Wilson, Lindsey, & Schooler, 2000). These processes may therefore cause different outcomes; the former process may predict spontaneous behaviour and the latter deliberate behaviour. The required response (spontaneous or deliberate) determines which process is activated, which may result in different reactions to the same risk. Further research should confirm whether these two processes relate to behaviour in the way we just predicted.

We tentatively conclude that the EAST is valuable to measure risk perception. It may be complementary to the 'classical' measures because it reveals the instantaneous response to a risk. This reaction may be important for risk managers and communicators in the field as people may sometimes, for example, report explicitly that they do not worry about a risk, whereas their first reaction to the risk may reveal the opposite, as our results showed. Moreover, first reactions may be important to predict behaviour in spontaneous situations (Loewenstein et al., 2001).

Risk perception is not only determined by the risk's characteristics but also by personal, social and cultural factors. It may be inappropriate to generalize the outcomes of the primary and secondary evaluative processes of a certain risk to other groups of people because they may react differently to the same risks. However, we expect that *the way* hazards are evaluated, by a primary and a secondary evaluative process, is fundamental to humans.

One may wonder whether our EAST measured risk perception. Although respondents were provided with risk perception related evaluations of the object (i.e. healthy-unhealthy), we cannot exclude that our respondents transformed these specific evaluations into more general ones (positive-negative), as in the original EAST. This may imply that we did not measure risk perception but a general affective evaluation of the hazard. In addition, the evaluations we used in the EAST (unhealthy-healthy) may not reflect the concept of risk

perception very well. Perhaps ‘dangerous’ versus ‘harmless’ would be better evaluative words. This is also interesting for further study.

We adjusted the EAST in this study by using pictures instead of words. Pictures have not often been used in the EAST. Pictures have been shown to result in significant EAST effects and correlations with a reliable explicit measure in studies about the evaluation of an innocent victim (Callan & Ellard, 2003) and about spider phobia (Huijding & de Jong, 2005). Also, the use of coloured and originally coloured pictures appeared to work very well here. Pictures are especially useful in an EAST about an issue that is difficult to explain in words.

Conclusion

The study reported here was the first to use the EAST to measure the primary evaluative process of risk perception. The EAST’s results showed that the respondents overall associated power lines with unhealthy, whereas the questionnaire results would not lead to the conclusion that respondents considered power lines as a risk to their health. An indirect test may be useful to measure the primary evaluative process because it reveals the first reaction to a risk. Moreover, one might expect that this measure is a better predictor of people’s behaviour in a spontaneous situation than a direct measure (Loewenstein et al., 2001). We suggest using the EAST complementary to a questionnaire to measure risk perception. Risk managers may want to know the results of both risk perception processes so that they can anticipate them in risk communication. It would therefore be interesting to find out how risk communication can affect both the primary and secondary evaluative processes so that both processes result in adequate risk perception. The indirect test of risk perception is still in its infancy. It should be further explored how the EAST can be validated and optimised to reveal the primary evaluative process.

Chapter 5

Audiovisual Risk Communication Unravelling: Effects on Gut Feeling and Common Sense

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Abstract

Audiovisual material is increasingly applied in risk communication (e.g. information films on the Internet) to affect the public's risk perception. This study investigated how the sound/footage and text of videos can influence two processes of risk perception: a primary (associative) and a secondary (deliberate) evaluative process. Our main hypothesis was that the sound/footage of a video would particularly influence the primary evaluative process and its text would affect the secondary evaluative process. This was investigated using a 2 (text: yes/no) by 2 (sound/footage: yes/no) design. We applied an indirect test to measure the videos' effects on the primary evaluative process (the Extrinsic Affective Simon Task, De Houwer, 2003) and a direct test (questionnaire) to assess the effects on the secondary evaluative process. These two tests were applied immediately after the respondents had seen one of the videos and two weeks later. Text only appeared to affect the self-reported risk perception (questionnaire) at the first measurement. Sound/footage influenced risk perception as measured by the EAST merely at the second measurement. The results are discussed in light of the two risk perception processes.

Introduction

The development of new communication technologies, such as the Internet and digital television, stimulates the use of audiovisual means in risk communication (e.g. information films from NGOs on television and on Internet sites). Only little research has focused on how moving pictures (i.e. footage) and sound can affect the way people evaluate risks (cf. Meijnders, Midden, & Wilke, 2001). Pfau and colleagues (2000) suggested that audiovisual material probably influences someone's general evaluation or impression of an object. Thus, audiovisual material may have more effect on general feelings about a risk than text material only. In this article, it is explored how audiovisual material can affect risk perception.

Like other researchers, we distinguish a global, associative and affective evaluation of a risk from a deliberate evaluation (see Chaiken et al., 1989; Loewenstein et al., 2001; Slovic et al., 2004). The former evaluation is the result of an associative, experiential process, leading to a 'gut feeling', which we call the primary evaluative process (cf. Zajonc, 1980). It forms an instantaneous reaction to a risk. The deliberate evaluation is the result of an analytic, elaborative process, which we name the secondary evaluative process (Chaiken et al., 1989; Strack & Deutsch, 2004). This process takes place at a later stage, for example, after being explicitly asked for an opinion. The primary evaluative process is evoked by minimal stimulus input. The secondary evaluative process is only activated when there is opportunity (e.g. time) and motivation to do so (e.g. a strong negative association that stimulates further deliberate processing) (see Chaiken et al., 1989; Fazio & Olson, 2003). This process may then overrule the primary evaluative process. It seems worthwhile to develop risk communication methods that pay attention to both processes. For reasons explained later, we examined the effects of various forms of audiovisual risk communication on the two processes of risk perception in the present study.

Two different tests are needed to measure the two risk perception processes, namely a direct and an indirect test. So far, risk communication research has mainly used questionnaires to measure risk perception (e.g. Hendrickx et al., 1989; MacGregor et al., 1994). In our view, these studies mostly concentrated on the secondary evaluative process as respondents could think relatively elaborately about their responses when they filled in a questionnaire. Such a direct test is less suitable to reveal the primary evaluative process in isolation because the conscious character of a direct test contradicts the spontaneity required for the latter process. Instead, the primary evaluative process requires a global and immediate evaluation. We used an indirect measure to assess the primary evaluative process since this test does not allow conscious control and reveals the instantaneous association with an object (cf. Siegrist et al., 2006).

We chose the Extrinsic Affective Simon Task (EAST) as indirect test in this study (De Houwer, 2003) and adapted it to measure risk perception. The EAST is a computer task that measures the association strength between a stimulus (e.g. "flower") and two contradicting evaluations (i.e. positive vs. negative). An earlier study already suggested that the EAST is valuable for assessing risk perception (Visschers, Meertens, Passchier, & de Vries, in press-a). The procedure of the EAST is described in the Materials section.

Audiovisual material or video (including text, footage and sound) is often classified as a vivid information source because of its multimedia characteristics (Chaiken & Eagly, 1983). Video information can provide its audience with a concrete visualization due to the combination of images and corresponding text, whereas readers of only text have to

visualize the information themselves. People may therefore think that events presented in video format are more likely to happen in reality than events reported only in text information (cf. Sherman, Cialdini, Schwartzman, & Reynolds, 1985). Moreover, because video information often includes both text and images, it can be stored in multiple codes in memory (symbolic and analogous, respectively, see Clark & Paivio, 1991). So that it may be easier to process and recall this type of information, than information presented in one code, such as text (Mousavi, Low, & Sweller, 1995). Furthermore, video information may affect the primary evaluative process because of its vividness (cf. Loewenstein et al., 2001) and because it relies on images and impressions, which are all primary evaluative elements (cf. Pfau et al., 2000).

In short, audiovisual material may have more effect on the primary evaluative process than text information. Text information may mainly be expected to affect the secondary evaluative process. Visschers et al. (in press-a) indeed showed that text information influenced risk perception (of high voltage power lines) as measured by a questionnaire but not as measured by the EAST. In the present study, we unravelled the effects of text and sound/footage in video material on the two risk perception processes.

This resulted in the following three hypotheses. First, the different elements of audiovisual material would influence the two risk perception processes differently. This hypothesis consisted of two parts: the sound/footage of videos would mainly affect the primary evaluative process (Hypothesis 1a) and text videos would particularly influence the secondary evaluative process (Hypothesis 1b). Second, we expected the effects of sound/footage videos on risk perception to persist over time while the text videos' effects might decrease (Hypothesis 2). Third, we hypothesized that the possibly risky activity we chose as subject of this study, nanotechnology, would generally be associated more strongly with danger than with harmlessness (Hypothesis 3). Confirmation of this last hypothesis would show that an indirect measure like the EAST may shed some light on the way people perceive a risk, although non-confirmation of this hypothesis would not mean that the EAST does not measure the primary evaluation of a risk. In addition, we investigated in an explorative sense whether the two measurements, that is, EAST and questionnaire were related.

Method

Respondents

Ninety respondents participated in the first measurement of the study. All respondents were students at Maastricht University who were recruited in their first year to join a respondent pool that could be called up for studies in our laboratory. At the second measurement, four respondents did not show up. The remaining sample of 86 respondents was used in all analyses.⁸ Their mean age was 21.02 years ($SD = 2.66$), 75 were women and 11 were men. Respondents received €5 for each measurement, €10 in total. They were randomly assigned to one of four video conditions and one of two EAST versions.

Materials

Informed consent. Before starting the experiment, the respondents read and signed an informed consent form in which it was stated that they could stop the experiment at any time. The respondents also agreed that their anonymous data were used for analyses.

Further, they promised that they would not inform other students about the content of the experiment.

Risk. The video addressed the risks associated with nanotechnology. Nanotechnology is a relatively new technology, in which materials are manipulated at atomic, molecular and macromolecular level to develop and produce new structures, systems and applications (The Royal Society & The Royal Academy of Engineering, 2004). The technology is used in various fields, among which medicine, pharmacology, defence, and information and communication technology (Van Est, Malsch, & Rip, 2004). It may lead to beneficial applications, such as more specific administration of chemotherapy, increasingly smaller computers and sensor networks that can detect radioactivity and explosives. Opponents of this technology fear that nanoparticles may pollute the environment, that terrorists might misuse it, that it can lead to super-intelligent systems no longer understood by humans and that nanoparticles in the atmosphere become the “asbestos of the future” (Arnall, 2003; ETC Group, 2003; Mnyusiwalla, Daar, & Singer, 2003). In short, the balance between positive and negative consequences of nanotechnology is still unclear and debated.

Video risk communications. We used four different videos, which varied on the presence of footage and music, and of text (subtitles). This resulted in four videos: a text and sound/footage video, a text video without sound/footage, a sound/footage video without text, and a control video (no text and no sound/footage). A collage of nine nanotechnology pictures that would appear in the EAST was shown during the first 7 seconds of all videos so that these would be recognized in the EAST. The videos lasted between 2.5 and 4.1 minutes; except for the control video, which lasted 14 seconds. The text and sound/footage video presented the possible negative consequences of nanotechnology, such as nanoparticles in the human body that cross the blood-brain barrier and damage the brain, and terrorist attacks. The footage fitted the subtitles of the video (text) and it included threatening music. The sound/footage video without text consisted of the same music and footage as the previous video, but without subtitles. The text video without sound/footage included the text, formatted as videotext, and no music or footage. The control video consisted of the collage that appeared for 7 seconds after which the title “Nanotechnology” was presented for 7 seconds and the video ended. This video did not provide any information about nanotechnology; it simply included sufficient material to get sensible EAST data.

EAST. The EAST was programmed in E-Prime (Schneider et al., 2002). This test measures the attitude strength between an object and two contradicting evaluations (positive-negative). We adapted the original EAST (De Houwer, 2003) to measure risk perception by changing the evaluations in dangerous-harmless. Also, we used pictures instead of words to express the risk and evaluations, as these could ‘describe’ the risk better than words.

The procedure of the EAST was as follows. The instructions were presented on the computer screen. Respondents were told that this was a reaction time task and that they should try to respond as fast as possible without making mistakes. The EAST consisted of three types of blocks. The first type of block was a practice block in which participants learnt to response to the intrinsic valence (i.e. meaning) of the evaluation pictures (dangerous-harmless). They had to press the left key (Q-key) when a harmless picture (information sign) was presented and the right key (P-key) for a dangerous picture (warning sign). We

chose five warnings, e.g. a poison and an electric shock warning, and five information signs, e.g. a toilet and a parking sign. All were black-and-white pictures. The inter-trial interval, presentation time of the pictures and feedback interval were similar to the original EAST (2003). The second type of block was a coloured pictures practice block, in which the respondents learnt to classify nanotechnology pictures according to their extrinsic characteristics (i.e. colours: blue-left and green-right). The intrinsic valence of the pictures should be ignored. We chose 10 different nanochips, nanotubes and nanostructures, which were converted in a grey scale and covered under a blue or green colour film, similar to Callan and Ellard (2003). This resulted in 20 coloured nanotechnology pictures. Two versions of the EAST were developed to switch the colour-key combination and control for hand preference. Then, the third type of block followed: four test blocks. In each block, five dangerous, five harmless, 10 blue and 10 green pictures were randomly presented. Reaction times and response accuracy to the coloured pictures in the test blocks were recorded.

We expected that respondents who perceived nanotechnology as risky would react faster and make fewer mistakes on the coloured nanotechnology pictures that had the same response as the dangerous pictures (warning signs) than on coloured pictures that had the same response as the harmless pictures (information signs). Conversely, respondents who perceived nanotechnology as safe would react faster and make fewer mistakes on the coloured pictures that were associated with harmless than on coloured pictures that were associated with danger. The same EAST was used in the second measurement.

Questionnaire. The questionnaire at Measurement 1 included items to assess demographic characteristics (gender, age and current main course) and two items to measure the video's effects, namely clarity and vividness. The questionnaires at Measurement 1 and 2 had the same risk perception and affect items. Ten items measured risk perception, namely perceived health damage, perceived environmental damage, health consequences, environmental consequences, probability estimation, order of seven risks in which the risk of nanotechnology should be placed (*order of risks*, ranging from "the risk of drowning in a flood" to "the risk of lung cancer caused by smoking"), order of six quotations in which the risk of nanotechnology should be placed (*order of quotations*, ranging from "...not at all concerned.." to "...a very serious risk.."), concern about the risk, vulnerability and acceptability of the risk. At both measurements, the risk perception items perceived health damage, perceived environmental damage, health consequences, environmental consequences, probability estimation, order of quotations, concern and vulnerability had high internal reliabilities, Cronbach's α 's > .88, $K = 8$. We calculated the mean sum scores for these items in both measurements to form a risk perception scale. The items order of risks and acceptance had low item-test correlations and were excluded from the risk perception scale at both measurements so that they were analysed separately.

Three items measured affect: a feeling thermometer about nanotechnology (ranging from negative (0) to positive (100)), positive feelings about nanotechnology and negative feelings about nanotechnology. Except when mentioned differently, the items were measured on 7-point Likert scales; higher numbers indicated higher levels of the items measured.

Procedure

Respondents were invited to the laboratory of the Faculty of Health Sciences, Maastricht University, with a maximum of six respondents at a time. The experiment was presented as “Information processing of visual material”. After entering the lab, the respondents were instructed about the experiment and the order in which they should do the different tasks. Respondents took place in separate cubicles in which they filled in the informed consent form. Next, they put on the headphone that was next to the computer screen. After watching the video, the computer automatically switched to the EAST and then the respondents completed the questionnaire. This was the end of Measurement 1. Respondents got paid and made an appointment for the second measurement. Each respondent received a unique number to link their data of Measurement 1 to those of Measurement 2.

Measurement 2 took place approximately two weeks later. The same procedure was used as before, except that the participants did not watch a video. After completion of this measurement, the respondents left the cubicle, were ‘sworn to secrecy’, thanked and paid for participation. Finally, they received written information about the experiment and nanotechnology.

Results

Manipulation Check

The items clarity and vividness (Measurement 1) functioned as a manipulation check of the videos’ effects. We conducted a Multivariate Analysis of Variance (MANOVA) with these two items as dependent variables and text (text videos vs. no-text videos) and sound/footage (sound/footage videos vs. no-sound/footage videos) as independent variables. There were significant multivariate main effects of text and sound/footage on these two items, $F_s > 8.07$, $ps < .001$.⁹ The univariate tests showed an effect of text on the item clarity, $F(1, 82) = 79.27$, $p = .0001$. The text videos (text video without sound/footage, and text and sound/footage video) were perceived to be clearer ($M = 5.17$, $SD = 1.46$) than the no-text videos (sound/footage video without text and control video, $M = 2.33$, $SD = 1.52$). The univariate tests also revealed an effect of sound/footage on vividness, $F(1, 82) = 14.36$, $p = .0001$. The sound/footage videos were judged to be more vivid ($M = 3.48$, $SD = 1.70$) than the videos without sound/footage ($M = 2.33$, $SD = 1.15$). Thus, risk communications with moving pictures and sound were perceived as more vivid, while risk communications with text were perceived to be more clearly.

Hypothesis 3

In our presentation of the results, we start with Hypothesis 3 as this was the most basic hypothesis. First, we report on the EAST results and then the questionnaire results that are relevant for this hypothesis.

EAST. Mean reaction times and accuracy of the first response to the coloured pictures in the test blocks were used for analyses. Reaction times that were lower than 300ms or higher than 3,000ms were recoded as 300ms and 3,000ms, respectively. Only the reaction times of correct first responses were used (De Houwer, 2003; Greenwald et al., 1998). The reaction times were skewed to the right and not normally distributed at both

measurements, $D_s > .15$, $p_s < .0001$. Therefore, we conducted log-transformations on the reaction times, which somewhat improved the distributions at both measurements, $D_s < .13$, $p_s > .001$.

The difference scores of the log-transformed reaction times and percentage of errors between the pictures associated with danger and the pictures associated with harmlessness were used to test whether nanotechnology would be more strongly associated with danger than with harmlessness in the EAST (Hypothesis 3). This would be the case if the respondents reacted faster to and/or made fewer errors on the association nanotechnology–danger than on the association nanotechnology–harmlessness.

The one-sample t-tests using the log-transformed reaction times and the percentage of errors showed that the difference scores of the log-transformed reaction times ($\Delta M = -12.08$, $SD = 48.45$; $\Delta M_{\log} = -.01$, $SD_{\log} = .04$)⁶ and of the percentage of errors ($\Delta M = -2.38$, $SD = 6.43$) were significantly negative at Measurement 1, $t_s < -2.64$, $p_s < .01$.¹⁰ These findings suggest that the respondents associated nanotechnology more strongly with danger than with harmlessness.

We did the same analyses for the results of Measurement 2. The difference score of the log-transformed reactions times was significantly negative ($\Delta M = -14.44$, $SD = 47.11$; $\Delta M_{\log} = -.01$, $SD_{\log} = .04$)⁶ $t(85) = -3.10$, $p = .003$.¹⁰ The respondents reacted faster to the pictures that were associated with danger than those associated with harmlessness. The difference score of the percentage of errors was not significantly different from zero ($\Delta M = .96$, $SD = 7.79$), $t(85) = 1.14$, $p = .26$. Thus, there is also some evidence that the respondents associated nanotechnology with more strongly with danger than with harmlessness at the second measurement. The findings of the first and second measurement together lead to the conclusion that respondents associated nanotechnology more strongly with danger than with harmlessness.

Questionnaire. The risk perception scale showed that the respondents scored nanotechnology around the midpoint (4) of the 7-point Likert scale at Measurement 1 ($M = 3.62$, $SD = 1.01$). The respondents compared the risk of nanotechnology most often with the risk “dying of cancer due to regular eating of scorched meat” (25.6%) in the order of risks item, which was the second lowest risk in the list. They scored the acceptability of nanotechnology around the average of the scale ($M = 4.17$, $SD = 1.40$). The mean score on the feeling thermometer was around the neutral label of the scale from 0 to 100 ($M = 48.95$, $SD = 16.51$). The respondents were not extremely negative or positive about nanotechnology ($3.41 < M_s < 4.31$, $1.26 < SD_s < 1.32$). Thus, the questionnaire results suggested that respondents had neutral feelings about nanotechnology and did not perceive it as risky.

In conclusion, the EAST data indicated that respondents associated nanotechnology more strongly with danger than with harmlessness. However, the questionnaire data suggested that respondents had a neutral perception of nanotechnology. Thus, the EAST data supported Hypothesis 3, whereas the questionnaire data did not. This may imply that a questionnaire and the EAST reveal different aspects of risk perception and that the EAST may be a complementary measure to a questionnaire.

Hypothesis 1a

Next, we tested Hypothesis 1a, namely that sound/footage videos would particularly affect the primary evaluative process as measured by the EAST. We therefore analysed a 2 (text: text videos vs. no-text videos) $\times$ 2 (sound/footage: sound/footage videos vs.

no-sound/footage videos) $\times$ 2 (association: harmlessness vs. danger) Analysis of Variance (ANOVA) with repeated measures for the log-transformed reaction times. This analysis was repeated for the percentage of errors.

The results of both analyses showed that the interactions that would show an effect of text and/or sound/footage on association were not significant for both outcomes of the EAST, $F_s < 2.30$, $p_s > .13$. This suggests that the stronger association between nanotechnology and danger than between nanotechnology and harmlessness was not influenced by the type of video the respondents had viewed. Thus, Hypothesis 1a was not supported at Measurement 1.

We performed the same ANOVAs with repeated measurements on the EAST data of Measurement 2. The interaction between sound/footage and association was significant, $F(1, 82) = 4.96$, $p = .03$. Paired samples t-tests (Bonferroni correction: $\alpha = .025$) showed that the sound/footage videos may have led to faster responses to the pictures associated with danger ($M = 511.68$, $SD = 97.58$; $M_{\log} = 2.70$, $SD_{\log} = .07$) than to the pictures associated with harmlessness ($M = 526.11$, $SD = 98.22$; $M_{\log} = 2.72$, $SD_{\log} = .07$),⁶ $t(41) = -3.96$, $p < .0001$. The no-sound/footage videos did not show this difference, $t(43) = .68$, $p = .50$.¹¹ The main effect of text and the other main and interaction effects were not significant, $F_s < 1.88$, $p_s > .19$. The ANOVA with repeated measures for percentage of errors showed no significant interaction effects, $F_s < 3.19$, $p_s > .08$.

Thus, after a delay period, only the sound/footage videos may have caused the respondents to associate nanotechnology more strongly with danger than with harmlessness as measured by the reaction times. These results are in accordance with Hypothesis 1a; the primary evaluative process was particularly affected by sound/footage videos, but only after a delay period.

Hypothesis 1b

Hypothesis 1b related to the effects of text and sound/footage of videos on the secondary evaluative process, as measured by the questionnaire. At the first measurement, the MANOVA with the risk perception scale and the items order of risks, acceptance, feeling thermometer, positive feelings and negative feelings as dependent variables, and text and sound/footage as independent variables showed a significant multivariate main effect for text, $F(6, 77) = 3.21$, $p = .01$, but not for sound/footage, nor for the interaction between text and sound/footage, $F_s < 1.22$, $p_s > .31$.⁹ The multivariate main effect for text could be explained by univariate effects on the items positive feelings, negative feelings and acceptance, $F_s > 5.38$, $p_s < .02$. The respondents who had watched a text video evaluated nanotechnology less positively ($M = 3.07$, $SD = 1.09$), more negatively ($M = 4.76$, $SD = 1.01$), and reported less acceptance ($M = 3.81$, $SD = 1.45$) than the respondents of the no-text videos ($M = 3.73$, $SD = 1.45$; $M = 3.89$, $SD = 1.33$; and $M = 4.53$, $SD = 1.27$, respectively).

In short, one risk perception item (acceptance) and two affect items (positive and negative feelings) seemed to be influenced by the text of the videos at Measurement 1, which resulted in a more negative perception of nanotechnology. These findings supported Hypothesis 1b, that is, text videos appeared to influence the secondary evaluative process as measured by the questionnaire. However, risk perception as such (i.e. the risk perception scale) was not affected by text.

Next, we analysed the results of the second measurement. We conducted a MANOVA with the risk perception scale, the remaining risk perception items and the affect items as

dependent variables, and text and sound/footage as independent variables. There were no significant multivariate effects for text, sound/footage or text and sound/footage on these items, $F_s < 1.38$, $p_s > .26$.⁹ Thus, at Measurement 2, the text and sound/footage variations did not influence any of the risk perception or affect items as measured by the questionnaire.

In sum, as expected, the text of the videos appeared to influence some of the questionnaire items immediately after watching the video. After a delay period, the effect of text video variation on the questionnaire items seemed to have declined.

Hypothesis 2

EAST. Hypothesis 2 stated that the effects of text would deteriorate over time, while the effects of sound/footage would last. An explicit test of Hypothesis 2 required a repeated measurement analysis of the EAST data. We analysed a 2 (measurement) $\times$ 2 (sound/footage) $\times$ 2 (association) ANOVA with repeated measures for the log-transformed reaction times, as footage appeared to affect the reaction times at Measurement 2. The interaction between association and sound/footage showed a trend, $F(1, 82) = 3.11$, $p = .08$. However, the interaction between measurement, association and sound/footage was not significant, $F(1, 82) = 1.71$, $p = .20$. In short, the effect of sound/footage on the association strength between nanotechnology and danger was only present in Measurement 2. It was not an overall effect and did not seem to change over time.

Questionnaire. The finding that text had an effect on acceptance and affect as measured by the questionnaire at Measurement 1 but not at Measurement 2 seemed to support Hypothesis 2. We conducted three 2 (measurement) $\times$ 2 (text) ANOVAs with repeated measures on the items positive feelings, negative feelings, and acceptance, as these items were affected by text at the first measurement. Measurement appeared to have an effect on the positive feelings and negative feelings, $F_s > 6.11$, $p_s < .02$. Nanotechnology evoked more positive feelings ($M = 4.05$, $SD = 1.26$) and less negative feelings ($M = 3.85$, $SD = 1.26$) at Measurement 2 than at Measurement 1 ($M = 3.41$, $SD = 1.32$; $M = 4.31$, $SD = 1.26$, respectively). For negative feelings, the main effect of measurement was qualified by an interaction between measurement and text, $F(1, 37) = 4.29$, $p = .05$. The respondents who had viewed a text video appeared to evaluate nanotechnology less negatively at Measurement 2 ($M = 3.77$, $SD = 1.27$) than at Measurement 1 ($M = 4.59$, $SD = 1.14$), $t(21) = 3.37$, $p = .003$ (Bonferroni correction: $\alpha = .025$). This was not found for the respondents who had viewed a video without text, $t(18) = .36$, $p = .73$. The scores on the item acceptance were not influenced by measurement or the interaction between measurement and text, $F_s < 1.39$, $p_s > .24$.

Thus, it appeared that the evaluation became somewhat less negative over time and that the text videos increased this effect on one item. We conclude that the questionnaire data did not provide clear support for Hypothesis 2.

Relation between EAST and questionnaire

In an explorative sense, we wanted to find out whether the results of the EAST and of the questionnaire were related. Hence, we correlated the difference score of the mean log-transformed reaction times and the difference score of the percentage of errors of the EAST to the risk perception scale, the remaining risk perception items, and the affect items of the questionnaire, for the two measurements separately. At Measurement 1, we found only one significant correlation: the difference score of the percentage of errors of

the EAST correlated significantly with the questionnaire item order of risks, $r = -.30$, $p = .01$. This may imply that a stronger association of nanotechnology with dangerous than with harmlessness correlated with a higher score on the order of risks (i.e. a more serious risk). There were no other significant correlations between the EAST and the questionnaire items, $-.01 < r_s < .15$ $p_s > .17$. At Measurement 2, the questionnaire items did not appear to correlate with the difference scores of the EAST, $-.10 < r_s < .16$, $p_s > .14$. In short, the two measures of risk perception hardly correlated at both measurements. This may imply that these indirect and direct measures tap two separate processes of risk perception.

Discussion

Overall, we may conclude that the respondents spontaneously associated nanotechnology more strongly with danger than with harmlessness, as was shown by the EAST results (Hypothesis 3). The questionnaire results suggested relatively neutral feelings about nanotechnology. We therefore believe that the EAST can be a valuable complement to a direct test in risk perception research. This suggestion may be supported by the finding that the EAST and the questionnaire data hardly correlated. This may imply that the EAST reveals another aspect of risk perception, such as the primary evaluative process, than a questionnaire.

Our first and main hypothesis was that text would particularly have an effect on the secondary evaluative process and sound/footage mainly on the primary evaluative process. Text in videos appeared to affect the acceptance of nanotechnology and the positive and negative feelings as tested by the questionnaire at Measurement 1. Thus, the text of the videos seemed to have influenced the secondary evaluative process only directly after the intervention. The prediction that sound and footage would influence the primary evaluative process was only supported at the second measurement. At this measurement, the participants who had watched a sound/footage video associated nanotechnology more strongly with danger than with harmlessness; whereas those who had watched a video without sound/footage did not. This may imply that the sound/footage of videos can only affect risk perception through the primary evaluative process after a delay period. We further discuss the effect of time below.

Our second hypothesis concerned the long-term effects of video risk communication. We proposed that the effect of sound/footage video would have a more lasting impact than a text only video. Nanotechnology was evaluated more negatively in the questionnaire at Measurement 1 than at Measurement 2. At the same time, the effect of sound/footage videos on the primary evaluative process was only present after a delay. However, an analysis that included both measurements did not show clear effects over time. Thus, there is no conclusive proof of Hypothesis 2 that the effects of sound/footage have a more persistent impact than the effects of text.

We interpret our findings as a support for the idea that text is suitable to affect the secondary evaluative process, while the combination of footage and music is fit to affect the primary evaluative process. One may also infer from the present findings that the text and sound/footage variation only influenced the measurement that required the same type of processing (Clark & Paivio, 1991). The text videos may have influenced the questionnaire results because both require verbal processing, whereas the sound/footage videos may have affected the EAST results, because both involve visual processing. Nevertheless, the

sound/footage videos only seemed to influence the EAST results after two weeks, so a match in type of processing cannot fully account for this effect.

We had expected that the sound/footage videos would influence the primary evaluative process directly after watching the video and not only after a delay period. This may imply that it takes longer to establish the effect of sound/footage information on the primary evaluative process than the effect of text information on the secondary evaluative process. The sound/footage videos seemed to require a sort of incubation time.

A so-called sleeper effect may be able to explain this delayed effect of sound/footage videos (Kumkale & Albarracín, 2004). The sleeper effect is described as an initial suppression of a message's persuasive effect due to a discounting cue (e.g. a distrusted source) because the recipients feel that the message influences them incorrectly. At a later stage, the discounting cue is forgotten or decayed so that the message can persuade its recipients. Several studies have shown that the sleeper effect primarily occurs when the discounting cue is presented at the end of the persuasive message. Then, the effect of the discounting cue declines more rapidly than the effect of the message's content, and compared to when the cue is presented at the beginning of the message (Kumkale & Albarracín, 2004; Pratkanis, Greenwald, Leippe, & Baumgardner, 1988). This is called differential decay: the effects of the content and of the discounting cue decline at different rates.

Our findings suggest that the effect of the sound/footage videos on the EAST results may have been suppressed at the first measurement, perhaps because respondents experienced the end of the footage material, about nanotechnology and terrorism (i.e. the airplanes flying into the World Trade Centre at 9/11), as manipulative. This perceived manipulation may have operated as a discounting cue. As the discounting cue was presented at the end of the video, it declined more rapidly than the content of the sound/footage videos due to the sleeper effect and differential decay. Consequently, the persuasive effect of the sound/footage videos only appeared at Measurement 2.

We should make a short comment on the indirect measure of our study. The evaluative valences in the EAST were harmless and dangerous. However, in the original EAST these were labelled positive and negative, which have affective connotations, whereas harmless-dangerous may be denotations. It might be that the respondents translated the denotations of the risk perception valences into affective connotations. Thus, we are not sure whether the EAST measured risk perception or general affect.

In sum, the findings of this study suggest that a video's text particularly affects cognitive aspects related to risk perception, while its sound/footage particularly affects the gut feeling about a risk. Furthermore, this study exemplified once more that an indirect measure of risk perception, such as the EAST, may be a valuable complement to other risk perception measures, for example questionnaires. The results of this study also suggested that people not only rely on cognitive processes when interpreting a risk but also on their gut feeling. It would be interesting to explore further how risk communication can influence these two processes immediately and long-lasting, because both play a role in forming a risk perception and appear to react differently to risk messages.

Chapter 6

The Effect of Active Risk Communication on the Relation between Associative and Cognitive Processes

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Abstract

Two processes may explain the way people perceive risks: an associative process, which we call the primary evaluative process, and a cognitive process, also labelled the secondary evaluative process. These two processes may lead to different risk perception outcomes. We hypothesized that active risk communication would relate the two risk perception processes. In the present experiment, respondents were assigned to one of three risk communication conditions: active (scenario writing), passive (scenario reading) or no risk communication about being a pedestrian in traffic situations. A direct measure (questionnaire) was used to assess the secondary evaluative process. We applied an indirect measure to assess the primary evaluative process, namely De Houwer's Extrinsic Affective Simon Task. The direct measure revealed that the respondents perceived the hazard as risky. According to the indirect measure, they associated the hazard more strongly with danger than with harmlessness. As predicted, active risk communication seemed to relate the two processes. However, the type of risk communication appeared to affect neither of the two processes on condition level. The implications of these findings are discussed.

Introduction

Despite efforts by risk managers and communicators to inform people adequately about risks and to prevent outrage, this still appears to be difficult (e.g. Johnson, 2003b; Smith & Desvousges, 1990). People sometimes worry about trivial risks or ignore actual risks. One reason why people's opinions about risks may be hard to change by communication or education is that people often stick to their first impression (Lion & Meertens, 2005). Information communicated at a later stage might barely be able to affect this instantaneous impression.

First impressions of risks have not yet received much research attention (Visschers, Meertens, Passchier, & de Vries, *in press-b*). Usually, researchers use questionnaires to measure risk perception so that relatively deliberate risk evaluations are assessed. This study tries to gain more insight into the first impression of risks and into how this type of associations and more deliberate evaluations can be integrated.

In our view, two separate processes determine risk perception: an associative process based on 'gut feeling' and immediate responses, which we entitle the primary evaluative process. In addition, there is a relatively cognitive process, also called the secondary evaluative process (cf. Chaiken et al., 1989; Loewenstein et al., 2001). The first process is activated with minimal stimulus input and creates an associative and (almost) intuitive reaction (cf. Zajonc, 1980). The second process describes a later stage of risk perception and is deliberate. This latter process only occurs when there is sufficient opportunity and motivation to evaluate the risk elaborately (Chaiken et al., 1989). The two processes may lead to dissimilar judgments of the same risk. For example, some people may say, when explicitly asked, that they consider it extremely unlikely that their family members will get ill from a soil contamination (secondary evaluative process). However, at the same time, they may feel extremely uneasy about living with their children on contaminated soil (primary evaluative process).

Our interest in this discrepancy was aroused by the results of a previous study in which the effect of textual risk communication was examined (high-risk article, low-risk article, and no risk information article) on the two processes of risk perception (Visschers et al., *in press-a*). Respondents appeared to associate the risk (high-voltage power lines) more strongly with unhealthy than with healthy according to the primary evaluative process, whereas the secondary evaluative process did not show such a negative perception. Furthermore, the measures of the two processes did not correlate.

A risk communicator may want to bring these two processes into line by means of one type of message to make sure that people have the same perception of a risk, not matter which process people rely on in a certain situation. In the present study, we therefore wanted to examine how risk communication may influence the relation between the primary and secondary evaluative processes. Perhaps a different type of risk communication strengthens the relation between these two processes so that people have an integrated and consistent perception of a risk no matter which process prevails.

We hypothesized that active risk communication would promote the consistency between the primary and secondary evaluative processes. This type of risk communication would stimulate respondents to process the information profoundly and extensively (cf. Natter & Berry, 2005). Deeper processing may cause stronger associations between the risk and its evaluation than information from passive risk communication. Moreover, it may be better coded in memory, as is described in the Levels of Processing Framework:

the deeper information is processed, the easier and more likely it is that this information is re-activated (Craik & Lockhart, 1972). Hence, active risk communication was expected to trigger more associations between the risk and its evaluation in both the primary and secondary evaluative processes.

In the few studies about active risk communication that we could find, participants marked the risk magnitude in a graph, reflected elaborately on the magnitude of the risk (Natter & Berry, 2005) or intentionally imagined the risk's consequences (feelings and reactions) (Sherman et al., 1985). We suggest that writing a script about a risky event (a scenario) is also active risk communication. A scenario describes a script of a risky event, from beginning to its fatal ending (Hendrickx et al., 1989). It should be vivid, concrete and emotionally conspicuous, so that the event is easy to imagine. This may influence the perception of the risky event as described by the simulation heuristic (Kahneman & Tversky, 1982; Tversky & Kahneman, 1973). When using the simulation heuristic, people evaluate the probability or riskiness of an event by mentally simulating this event. The ease of this simulation determines the perceived probability or riskiness. Vivid and concrete scenario information can facilitate the ease of simulation so that the event's perceived probability or riskiness are increased (see Hendrickx et al., 1989).

In the present study, we applied an active form of scenario information: respondents were asked to write a scenario about how a risky event could turn out badly. This may create consistency between the primary and secondary evaluative processes for two reasons. Firstly, thinking about and writing a scenario may stimulate deliberate processing and, thus, associations in the secondary evaluative process. Secondly, imagining and simulating a vivid and concrete scenario may also trigger associations in the primary evaluative process. The activation of associations in both processes by the same source, although at slightly different moments in time, may increase the consistency between these processes.

Different methods are needed to measure the outcomes of the primary and secondary evaluative processes. A questionnaire, a direct method, is appropriate to assess the secondary evaluative process because respondents can consider their answers extensively and elaborately (Greenwald et al., 1998). For the primary evaluative process, a test is required that measures the first, spontaneous reaction to a risk and is scarcely distorted by conscious processing. We chose the Extrinsic Affective Simon Task (EAST) as indirect test (De Houwer, 2003). This computer task measures the association strength between one object and two opposite evaluations. Because respondents are instructed to react as fast as possible, it is implausible for explicit, conscious processes to intrude.

In short, risk perception can be the result of two processes, a primary and a secondary evaluative process. We expected that active risk communication (writing a scenario about a risky event) would stimulate associations between the risk and its evaluation in both processes, due to processing at a deeper level and ease of simulation. We therefore hypothesized that active risk communication would lead to stronger relations between the measures of the primary and secondary evaluative processes. In addition, we put forward that, based on the simulation heuristic, scenario information (reading or writing) would increase the perceived riskiness among respondents, whereas receiving no scenario information would not increase this (see also Hendrickx et al., 1989).

Method

In this study, respondents either wrote a risk scenario (active risk communication), received scenario information about a risk (passive risk communication), or wrote a scenario about an irrelevant event (no risk communication). Next, they conducted the EAST and filled in a questionnaire.

Respondents

Sixty-three respondents participated in exchange for €12.50 or 1.75 participant points that counted towards course credits. They were all students at Maastricht University, 53 women and ten men. Their mean age was 20.9 years ($SD = 2.75$). The respondents were randomly assigned to one of the three risk communication conditions and (independently) to two EAST versions.

Materials

Informed consent form. Respondents read and signed an informed consent form, whereby they agreed that they could end the experiment at any time and that their anonymous data were used for analyses. Further, the respondents promised that they would not inform other students about the content of the experiment.

Risk communication and filler task. The risk communication in this study concerned the risk of being a pedestrian in traffic situations, i.e. the hazard of being harmed in an accident due to traffic participation as a pedestrian. This risk is commonly known by people, and we expected this risk to be associated with danger. It was chosen for its concreteness. A pre-test showed that respondents were able to write a scenario about this risk.

The respondents of all three conditions received the same general information about pedestrians in traffic. It described the advantages (being mobile) and disadvantages (number of pedestrian casualties per year in the Netherlands) of being a pedestrian. Participants in the active risk communication condition were instructed to write a scenario about how a pedestrian can get involved in a road accident. We provided guidelines about what a scenario usually looks like and an example of a risk scenario (based on Hendrickx et al., 1989). The respondents were further motivated to write a good scenario by the introduction of a contest. A jury would select the two best scenarios for which the authors received a bonus of €10. There was no time limit to write the scenario.

In the passive risk communication condition, participants received a scenario about how a pedestrian (named Peter) was hit by a scooter when he hurried over a pedestrian crossing. Peter was taken to hospital and needed several months of rehabilitation before he could walk again. This scenario appeared the best understandable, vivid and personally relevant in a pre-test of four scenarios. Then, the respondents received a filler task to make sure that they spent about the same amount of time on the assignment as the respondents of the other two conditions and elaborated the risk communication in a (different) cognitive way. This task included counting the number of two-syllable words and nouns that began with a consonant in the passive scenario. The respondents were further motivated by a raffle in which two respondents who had both assignments correct could win €10.

In the control condition (no risk communication), participants had to write a scenario about organising the staging of a Shakespeare play. The respondents also received guidelines about what a scenario looks like and the same scenario example as in the

active risk communication. The participants who wrote the two best scenarios could win €10.

EAST. The EAST was programmed in E-Prime (Schneider et al., 2002). In the original EAST, respondents learn to classify evaluation stimuli (usually words) on their meaning (e.g. positive versus negative) and target stimuli (also usually words) on their appearance (e.g. blue versus green font). The target stimuli require the same response keys as the evaluation stimuli so that target stimuli and evaluations get linked. The association strength between the target stimuli and the evaluations is assessed by measuring the reaction times and number of errors on the combinations of target stimuli and evaluations (see De Houwer, 2003, for a detailed description of the original EAST).

Our EAST was somewhat different from the original EAST. We used pictures instead of words because it was easier to represent various traffic situations visually than semantically. In addition, we changed the meaning of the evaluations from “positive-negative” to “harmless-dangerous” (in Dutch: “ongevaarlijk” and “gevaarlijk”). The evaluation pictures consisted of five harmless and five dangerous activities, e.g. someone reading a book versus someone bungee jumping. These pictures were presented in their original colours. Ten different, ambiguous pedestrian-traffic situation pictures were selected to describe the risk (target), e.g. a pedestrian crossing in a blind bend. These pictures were converted into grey scale and covered with a blue or green filter (Callan & Ellard, 2003). The respondents were instructed to respond to the colour and not to the meaning of the pictures. All pictures were approximately 15cm wide and 10cm high.

The procedure of the EAST was as follows. The instructions for the test were presented on the computer screen. Respondents were told that this was a reaction time task and that they should try to react as fast as possible without making mistakes. Respondents successively completed an evaluation pictures practice block, a coloured pictures practice block and four test blocks in which the evaluation and coloured pictures were mixed. In the evaluation pictures practice block, participants were instructed to press the left key (Q-key) if they saw a harmless picture and the right key (P-key) if they saw a dangerous picture. In the coloured pictures practice block (pedestrian-traffic situations), they were told to press the left key (Q-key) if they saw a green picture and the right key (P-key) if they saw a blue picture. In each of the four test trials, five dangerous pictures, five harmless pictures, and ten green and ten blue pedestrian-traffic situation pictures were randomly presented. Respondents received the same instructions about the key-picture combinations as in the practice blocks. Reaction times and response accuracy to the target words were recorded. The stimulus onset time, presentation interval of the pictures, interval between pictures and feedback interval were similar to the original EAST (De Houwer, 2003). Two versions of the EAST were developed in which the colours blue and green were switched to check for hand-colour preference.

We expected that if our respondents associated being a pedestrian with danger, they would react faster and make fewer mistakes on pedestrian-traffic situation pictures with the same response (due to its colour) as the dangerous evaluation pictures than on the target pictures that had the same response (due to its colour) as the harmless evaluation pictures. If they associated being a pedestrian with harmlessness, the effect would be vice versa.

Questionnaire. The questionnaire considered demographic background (two items)

and risk perception (nine items). Demographic background items were gender and age. Risk perception items were probability estimate, perceived severity, vulnerability, number of people affected by the risk (*number of people*, ranging from “1 in a million people” to “more than 5,000 in a million people”), an order of risks in which the risk of getting a traffic accident as a pedestrian should be placed (*order of risks*, ranging from “dying from Creutzfeldt-Jacob disease” to “dying from the flu”), order of quotations of other people in which the risk of having an accident as a pedestrian should be placed (*order of quotations*, ranging from “not concerned at all” to “very serious risk”), acceptability of the risk (recoded), concern about the risk, and probability of health damage. Unless mentioned differently, the items were measured on 7-point Likert scales; higher numbers indicating higher levels of the items measured. The internal reliability of the risk perception items was high, Cronbach’s $\alpha = .77$, $K = 9$. Therefore, we felt justified to compute the average sum score of these items and used this as a risk perception scale in the analyses.

Procedure

Respondents were invited to the laboratory of the Faculty of Health Sciences, with a maximum of five respondents at a time. Each respondent was seated in a separate cubicle. The cover story was that this study examined the cognitive and affective effects of information messages and that it consisted of several independent parts. First, the respondents filled in the informed consent form. The respondents were randomly assigned to one of the tasks (i.e. conditions). Then, the EAST was conducted and they filled in the questionnaire. After completion, they were probed for suspicion concerning the true nature of the experiment, debriefed and ‘sworn to secrecy’.

Results

EAST

The data were similarly prepared for analyses as in the studies by De Houwer (2003). The reaction times were not normally distributed, $D(63) = .17$, $p = .0001$. We therefore conducted a log-transformation on the reaction times, which corrected the distribution, $D(63) = .10$, $p = .20$. Then, we calculated the mean log-transformed reaction times and the percentage of errors separately for the pedestrian-traffic pictures related to harmless and those related to dangerous.

Next, we tested the effect of risk communication on the log-transformed reaction times and percentage of errors. We conducted a 3 (risk communication: active, passive or control) $\times$ 2 (association: harmless vs. dangerous) Analysis of Variance (ANOVA) with repeated measures for the mean log-transformed reaction times and for percentage of errors, separately. Overall, a one-tailed significance level of $\alpha = .05$ was used for predicted effects.

The analysis of the log-transformed reaction times showed no main effects for risk communication and association, $F_s < .79$, $p_s > .23$. The interaction between association and risk communication was not significant, $F(2, 60) = .14$, $p = .43$. Thus, type of risk communication did not affect the association with the pedestrian-traffic situations according to the reaction times of the EAST.

The analysis of the percentage of errors revealed that association had a significant main effect, $F(1, 60) = 3.69$, $p = .03$. The respondents seemed to make fewer errors when

the pedestrian-traffic situations were associated with danger ($M = 6.90$, $SD = 6.32$) than when they were associated with harmlessness ($M = 8.45$, $SD = 8.11$).¹² There was no significant main effect for risk communication, $F(2, 60) = 1.14$, $p = .16$. Moreover, the interaction between risk communication and association was not significant, $F(2, 60) = .79$, $p = .23$. The type of risk communication did again not influence the association with the pedestrian-traffic situations, according to the percentage of errors.

In short, as expected the respondents seemed to associate the pedestrian-traffic situations more strongly with danger than with harmlessness according to the errors they made in the EAST. This may indicate that their first association with pedestrian-traffic situations was that these are dangerous. The type of risk communication did not influence the respondents' association with the pedestrian-traffic situations.

Questionnaire

The average score on the risk perception scale was 4.63 ($SD = .83$). The average score was significantly higher than the midpoint (4) of the scale, $t(62) = 5.93$, $p = .0001$. This may imply that the respondents perceived being a pedestrian in traffic situations as relatively risky, independent of the type of risk communication they had received. However, the midpoint of the scale is of course not a gold standard of neutral risk perception.

An ANOVA with the risk perception scale as dependent variable and risk communication condition as independent variable did not show a significant effect, $F(2, 60) = .37$, $p = .69$. Thus, risk communication did not seem to affect the self-reported risk perception.

Relation between the results of the direct and indirect measure

The results of the direct and indirect measures were correlated to test whether active risk communication would create a relation between the outcomes of the direct and indirect measures. We computed the difference score of the log-transformed reaction times of the pedestrian-traffic situation pictures associated with danger minus those of pictures connected with harmlessness, for each condition (see Greenwald et al., 1998). In a similar way, difference scores were calculated for the percentage of errors per condition. These two EAST difference scores were then correlated with the risk perception scale for each condition.

In the active risk communication condition, the difference score of the log-transformed reaction times correlated significantly with the rating on the risk perception scale, $r = -.45$, $p = .02$. This negative correlation indicated that when the association between the pedestrian-traffic situations and danger in the EAST became stronger than between pedestrian-traffic situations and harmlessness, a higher score was reported on the risk perception scale of the questionnaire. The correlation between the difference score of the percentage of errors and the risk perception scale was not significant, $r = .22$, $p = .17$. In the other two conditions, no significant correlations were found, $-.18 < r < .03$, $ps > .21$.

We compared the correlation of the active risk communication condition with the correlation between the two measures of the other two conditions, $r = -.07$, $p = .34$, using a Fisher's Z transformation. This resulted in a significant difference, $Z = -1.46$, $p = .03$.

In sum, these findings may indicate that the primary and the secondary evaluative processes of risk perception were connected under certain circumstances, namely, when the respondents were actively processing the scenario information. This was not the case when passive risk communication or no risk communication was presented.

Discussion

First, this experiment investigated whether active risk communication increases the relation between the measures of the primary and secondary evaluative processes of risk perception. Second, we examined whether scenario information (reading or writing) leads to higher perceived riskiness than no scenario information.

To start with the first aim, we found that the direct and indirect measures were only related in the active risk communication condition, as we hypothesized. This finding may suggest that writing a risk scenario activates more associations with the risk in both the primary evaluative process, due to imagination and simulation, and the secondary evaluative process, due to deeper processing. Thus, active risk communication seemed to evoke more existing associations in both processes, than passive or no risk communication, so that the two processes had more opportunities to be connected in this condition than in the other conditions.

Hofmann, Gschwendner, Nosek and Schmitt (2005) described several moderators that affect the relation between implicit and explicit representations, which resemble our primary and secondary evaluative processes, respectively. Interesting for the present discussion is the group of moderators that affect the *translation* between implicit and explicit representations, i.e. the tuning and mutual influence between the two processes. Examples of such moderators are representational strength (how strongly an attitude is held) and the individual's awareness of the implicit and explicit representations. The participants of our active risk communication condition may have been indirectly prompted to translate instantaneous associations to cognitive processes and vice versa by scenario writing. This strengthened the relation between the two processes.

The second hypothesis of this study was that scenario information would increase perceived riskiness compared to no scenario information. Type of risk communication did not seem to influence the outcomes of the two risk perception processes. However, at an individual level, active risk communication may have caused some effects compared to the other two conditions. After all, only the former communication type resulted in a correlation between the two processes. Thus, individual participants appeared to have changed their responses on the EAST or questionnaire due to active risk communication, but this did not influence the effects on the two measures at condition level.

Previous studies showed effects of active risk communication on understanding and (affective) risk perception at condition level (e.g. Natter & Berry, 2005; Sherman et al., 1985). An explanation for the lack of an effect on condition level in our study may be that we used a different type of active risk communication (scenario writing) than the other studies. Scenario writing had not yet been applied. An alternative explanation may be that active risk communication led to deeper processing than passive or no risk communication, as we predicted, but this only *activated* the existing perception of the risk and did not change it.

Regarding the indirect measure that we used in our studies, it is uncertain whether the EAST measured risk perception or some general affective evaluation, as in the original EAST. It may be that our respondents generalized the risk perception labels to general affect labels. Nevertheless, the correlations that we found between the EAST results and risk perception scale in the active risk communication condition may have indicated that the concept measured by the EAST is connected to self-reported risk perception and not affect, under some conditions.

Based on the present findings and those of a previous experiment (Visschers et al., in press-a), we believe that an indirect test, such as the EAST, can make a valuable contribution to measuring risk perception. It reveals people's first, spontaneous reaction to a hazard, which may be a good predictor of their reaction in real life when they are suddenly confronted with a hazard (Loewenstein et al., 2001). In addition, it may be useful for risk communication practitioners to know the outcomes of both the primary and secondary evaluative processes in reaction to a risk, as this information can indicate whether risk communication is needed and what its focus should be.

To summarize, our findings showed that active processing of risk information may relate the primary and secondary evaluative processes of risk perception. Perhaps active risk communication prompted more existing associations with the risk than the other types of risk communication. Consequently, each individual could bring the two processes into line based on these existing associations. We suggest that both processes should be taken into account in risk perception and communication research.

Footnotes

1. The personal pronoun 'we' is used in this Overview to indicate that this dissertation, and also this Overview, were the result of cooperation between my supervisors and me.
2. A frequency can be defined as "the number of times an event or character occurs in a given sample" (Oxford English Dictionary, 2006). In case of health and environmental risks, the sample mostly consists of a certain group of people, e.g. all women in the age of 40 to 50 years living in The Netherlands.
3. The demographic characteristics of the dropouts (who did not complete at least two parts of all questionnaires, $N = 93$) did not differ markedly from those of the final sample ($N = 256$). The majority of the dropouts were men (53.8%); their mean age was similar to that of the final sample ($M = 41.10$, $SD = 12.74$). Only 22.6% of the dropouts had a low educational level, while 49.5% had a medium level (which was more than the percentage in the final sample), and 28% had a high educational level.
4. These findings were consistent with the findings on the item level; all risk perception items of the unknown risks correlated significantly with the corresponding risk perception items of the self-associated risks, $r_s > .21$, $ps < .01$.
5. The findings of the risk perception scale were mostly consistent with those on the item level. In all three parts, r_{12} was significantly larger than r_{14} for five of the 15 items, namely risk estimation, health damage, probability estimation, ranking of risks (part 2), and health damage (part 3), $Z1bar*s > 2.061$, $ps < .05$. The correlation r_{12} was significantly lower than r_{14} on the item ranking of risks (part 1), $Z1bar* = -2.828$, $p = .01$. The items severity of the consequences, probability estimation (part 1), severity of the consequences (part 2), ranking of risks (part 3) showed that r_{12} was marginally larger than r_{14} , $Z1bar*s > 1.518$, $ps = .06$. The other items had no significant differences between r_{12} and r_{14} , $Z1bar*s < 1.272$, $ps > .10$.
6. For the ease of understanding, we first report on the mean *untransformed* reaction times and corresponding standard deviations and then the *log-transformed* reaction times and corresponding standard deviations.
7. The log-transformed reaction times were still not normally distributed. Also, the percentage of errors did not have a normal distribution, $D(89) = .15$, $p = .0001$, and transformation did not improve this. Therefore, we analysed these data using the non-parametric Wilcoxon Signed Ranks Tests. These analyses showed similar results: the respondents reacted faster to and made fewer errors on the pictures related with unhealthy than those related with healthy, $zs < -2.58$, $ps < .01$.
8. The results of the analyses of the first measurement including all respondents ($N = 90$) hardly differed from the results of the analyses of the first measurement excluding the dropouts from the second measurement ($N = 86$).
9. The Kolmogorov-Smirnov test of normality showed that several questionnaire items deviated too much from normality. In Measurement 1, these were the two video characteristics, $Ds > .16$, $ps < .0001$, order of risks, feeling thermometer, positive feelings, negative feelings and acceptance, $Ds > .12$, $ps < .003$. In Measurement 2, the item dread was not normally distributed, $D(85) = .18$, $p = .0001$. Nevertheless, the data were examined using a MANOVA test because there is no method that can analyse non-parametric data with several dependent variables and more than one independent variable. Moreover, transformation of the data did not lead to more

normal distributions.

- ^{10.} Because the log-transformed reaction times were still not normally distributed, we also analysed these data using the non-parametric Wilcoxon Signed Ranks Test. This test showed similar results: the respondents reacted faster to the pictures related with danger than those related with harmlessness at both measurements, $z_s < -2.46$, $p_s < .01$.
- ^{11.} The results of the Wilcoxon Signed Ranks Tests revealed similar results: the respondents who had seen a sound/footage video, responded faster to the pictures associated with danger than those associated with harmlessness at Measurement 2, $z = -3.45$, $p = .001$. While the respondents who had seen a video without sound/footage responded just as fast to the pictures associated with danger as to the pictures associated with harmlessness at this measurement, $z = -.05$, $p = .96$
- ^{12.} The percentage of errors did not have a normal distribution but a non-parametric test showed a trend in the same direction.

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Summary & Samenvatting

Summary

Most studies about risk perception have so far examined the role of cognitive processes in this evaluation, that is, the relative conscious elaborations that result in risk perception. This focus on cognitive processes reflects the research method that has been used, namely questionnaires in which respondents were given the opportunity to elaborate on a certain risk.

In addition to cognitive processes, risk perception may be influenced by so called associative processes, that is, the first association people have with a risk, a kind of gut feeling. These fundamental, associative processes lead to a first, spontaneous response to a risk: can I approach this risk or should I rather avoid it? Further, people use specific associations to evaluate risks, for example, associations with other risks. This thesis examines whether and how people apply both associative and cognitive processes to perceive risks.

Chapter 1 provides an overview of the dissertation. It starts with an outline of the field of risk perception, including theories and concepts that concentrate on mental processes within individuals. We subsequently discuss risk characteristics and the psychometric paradigm of risk perception, several heuristics, and various dual process models. In this thesis, risk perception is also described by a dual process model. The two processes are called the primary evaluative process and the secondary evaluative process. The former is based on gut feeling, direct associations and prior experiences, which results in the first, spontaneous response to a risk. The latter process is more consciously and takes place subsequently to the primary evaluative process. It is only activated when people have sufficient opportunity and motivation to do so. In short, the primary evaluative process is similar to fundamental associative processes, whereas the secondary evaluative process is produced by cognitive and specific associative processes.

We applied an indirect test to measure the primary evaluative process. This type of test can assess the first, spontaneous reaction so that conscious processes can not interfere. In this project, the Extrinsic Affective Simon Task (EAST, De Houwer, 2003) was adapted to measure risk perception. The EAST has originally been created to reveal attitudes.

In addition to risk perception, this dissertation concerns risk communication. It is intended to study how risk communication can affect the primary and secondary evaluative processes of risk perception. Risk communication has a narrow definition here, so that it only includes the message that is transmitted from sender to public and it does not entail the broad process in which risk communication usually takes place.

In short, the following two goals are examined in this thesis. The first is to study the roles of cognitive and associative processes in the way people perceive risks and risk communications. The second goal is to examine whether and how risk communication can have an effect on the primary and secondary evaluative processes of risk perception.

Chapter 2 covers a literature review about the way probability information can be presented in risk communication and in what way this affects, for example, understanding, acceptance and behaviour in relation to the risk. We evaluated studies about various probability formats, such as frequencies (e.g., 27 per 100,000 people), percentages (e.g. 2.7% of the people), cumulative risk information (e.g. after 10 years of exposure the probability has increased to 2.7%) and graphs (e.g. bar graphs and pie charts). This resulted in several recommendations about how to present probability information in risk communication. As an example, various studies showed that people often ignore

the base rate (denominator) of frequency information. It was therefore recommended to use frequencies with the same denominator throughout risk messages so that people can easily compare probability information within the same message when they ignore the denominator (Box 2.1 and 2.2 present all recommendations). It appeared not always possible to make recommendations based on the reviewed studies. We explained this primarily by referring to heuristic and systematic processing of risk information. Systematic processing means that people handle information elaborately and consciously, whereas people apply rules of thumb when they use heuristic processing. Systematic processing is only applied when people have sufficient time and motivation; otherwise the information is processed heuristically. The presentation format will especially influence the interpretation of a probability or risk when people use this latter type of processing. The presentation format can save people time and cognitive capacity when they process risk information. Because people themselves search and organise information about a risk when they use systematic processing, the presentation format is less important in this situation. Our recommendations are mainly useful when it is expected that people process risk information heuristically.

In sum, risk communication research should not only concentrate on which presentation formats of probability information are effective. It should also focus on how the situation in which the risk message is presented (e.g. available time, characteristics of the receivers and type of risk) can stimulate heuristic or systematic processing, as the situation seems to determine how people interpret risk information and risks.

In *Chapter 3* it was examined whether and how people create associations with known risks to evaluate a new, unknown risk. First, a qualitative study was conducted. Participants discussed several newspaper articles about unknown risks in in-depth and focus group interviews. The interviewees frequently appeared to associate unknown risks with known risks. We identified four different reasons why respondents made risk associations: (1) to demonstrate the seriousness and consequences of the unknown risk, (2) to show that people had accepted similar risks in the past, (3) to express that the unknown risk also had benefits, and (4) to argue that the unknown risk will also be remedied.

Next, we report a survey study that was conducted to demonstrate in a quantitative way that people associate unknown risks with known risks and to examine *how* these risk associations were made. This study revealed that risk perceptions of unknown risks and those of risks associated by the respondents themselves (*self-associated risks*) were strongly related. Risk associations were not purely personal and, in addition, were not the result of a third variable such as someone's personality. They appeared to be produced by a semantic connection between the unknown risk and the associated, known risk. In addition, salient characteristics shared between the unknown and known risks seemed to determine the choice of risk association.

The findings of these two studies offer interesting implications for risk communication in practice. It appeared unnecessary to use personal risk associations in risk communication. The mental model approach can be applied to indicate which risks the target group, or a proportion of it, associates with the unknown risk so that the risk message can anticipate on these associations.

Chapter 4 describes an experimental study about the effects of various risk messages on the primary and secondary evaluative processes. Respondents read an article in which high-voltage power lines were either described as a high risk (high-risk article), a small risk (low-risk article), or not as a risk (control article). Then they conducted the indirect

test, the EAST, and filled in a questionnaire about risk perception.

The participants appeared to associate power lines more strongly with an unhealthy environment than with a healthy environment according to the EAST (the primary evaluative process). The article which the respondents had read did not influence this association. Overall, they did not have a negative risk evaluation of power lines according to the questionnaire results (secondary evaluative process). This measurement also revealed that respondents who had read the high-risk article appeared to perceive power lines as more risky than the respondents who had received the low-risk or control article.

The EAST showed to be valuable to measure risk perception as it provides additional information about how people perceive risks, in addition to, for example, a questionnaire. According to our interpretation, the type of article did not affect the primary evaluative process because the risk message should have included more affective elements to influence this process than there were present in the articles of this experiment.

The *fifth chapter* reports an experiment in which audiovisual risk communication was investigated: a video. Video is considered as a vivid information source. We therefore hypothesized that this would affect the primary evaluative process. Moreover, the visual and verbal information of a video should ensure that people store this information better in memory and recall it better than for example textual information alone. The main research question was how the two video elements (text and sound/footage) would influence the two risk perception processes. We also wanted to find out how a video can affect risk perception on the long-term. The respondents watched one of four videos about nanotechnology: a text and sound/footage video, a text video without sound/footage, a sound/footage video without text and a control video (no text and no sound/footage). The first three videos showed potential risks and uncertainties concerning nanotechnology. The participants then completed the EAST and filled in a questionnaire about risk perception. These two measures were repeated two weeks later with the same respondents.

According to the EAST results, respondents associated nanotechnology more strongly with danger than with harmlessness. The questionnaire results did not reveal such a negative evaluation of this risk. The first questionnaire measurement indicated that the videos that included text caused a more negative evaluation of nanotechnology than the videos without text. Text thus appeared to influence the secondary evaluative process on the short term. The sound/footage of the videos seemed to trigger a stronger association between nanotechnology and danger than between nanotechnology and harmless at the second measurement, as measured by the EAST. Thus, sound/footage appeared to have an effect on the primary evaluative process on the long-term.

This study again showed that the EAST is a valuable method to reveal people's risk perception, in addition to a direct measure. Video appeared to be an appropriate communication channel because it can influence both the primary and the secondary evaluative processes, though at different points in time.

In *Chapter 6* an experiment about active risk communication is described. Active risk communication means that the receivers should actively adapt the message. This study utilized so called 'scenario information', which describes step by step how a risk can result in a disastrous event. Respondents either received a scenario about how a pedestrian was involved in a traffic accident (passive risk communication), had to write such a scenario themselves (active risk communication), or had to write a scenario about a different subject (control communication). We assumed that active risk communication would cause a stronger relation between the primary and the secondary evaluative process

than passive risk communication or the control communication.

The EAST and a questionnaire were applied to measure the two risk perception processes. The results indicated that active risk communication produced a stronger relation between the primary and the secondary evaluative processes within individuals than passive risk communication or the control communication.

Discussion en Conclusion

The results of the various studies presented in this dissertation confirmed that both associative and cognitive processes play a role in the way people perceive risks. People seem to use associations with known risks to interpret unknown risks. In addition, people appear to have a first, spontaneous association (primary evaluative process) with risks. This first, spontaneous association can differ from the subsequent, cognitive response (secondary evaluative process). We therefore conclude that people have both associative and cognitive processes at their disposal when they perceive risks. Other factors, such as social context, risk characteristics and someone's personality, influence the outcomes of these two processes.

Further, the experimental studies showed that risk communication does not always affect the primary and secondary evaluative processes of risk perception. It appeared particularly complex for risk communication to affect the first process. Interventions that offer risk information repeatedly, for example mere exposure, or that associate a risk frequently with an evaluation, such as conditioning, may be more effective in this respect. Our results only provide some indications about which type of media may influence which process or processes. Text information mainly appears to affect the secondary evaluative process. Sound/footage seems most appropriate to influence the primary evaluative process. There are also some indications that active risk communication can bring the two risk perception processes into line. More research is needed to convert these findings into recommendations for risk communication.

This was the first project in which the EAST was adapted to measure risk perception. We conclude that this indirect measure is appropriate to assess the first, spontaneous response to risks, that is, the primary evaluative process. This test provides additional information about the way people perceive risks, in addition to the results of a direct test, which reveals the secondary evaluative process.

In short, people use both associative and cognitive processes in risk perception. It is recommended to focus on both processes in studies about risk perception as well as in the development and evaluation of risk communications. This may create a comprehensive view of the way people perceive risks. Furthermore, a focus on both processes may optimize risk communication.

Samenvatting

De meeste studies over risicoperceptie dusver hebben de invloed van cognitieve processen op dit oordeel onderzocht, oftewel de relatief bewuste overwegingen die tot een risico-oordeel leiden. De focus op cognitieve processen weerspiegelt de gebruikte onderzoeksmethode, namelijk vragenlijsten waarin mensen uitgebreid de gelegenheid krijgen om over een bepaald risico na te denken.

Risicoperceptie kan naast door cognitieve processen ook bepaald worden door zogenaamde associatieve processe: de eerste associatie die men met het risico heeft, een soort onderbuikgevoel of 'gut feeling'. Deze fundamentele, associatieve processen vormen een eerste, spontane reactie op een risico: kan ik het benaderen of moet ik het liever vermijden? Daarnaast gebruiken mensen specifieke associaties om risico's te evalueren, bijvoorbeeld associaties met andere risico's. In dit proefschrift is onderzocht of en hoe mensen associatieve en cognitieve processen gebruiken om risico's te evalueren.

In *Hoofdstuk 1* wordt een overzicht gegeven van het hele proefschrift. Het begint met een beschrijving van een deel van het risicoperceptieveld: theorieën en concepten die zich concentreren op mentale processen binnen het individu. Achtereenvolgens worden risicokenmerken en het psychometrisch paradigma van risicoperceptie, enkele heuristieken, en verschillende duale procesmodellen besproken. Ook in dit proefschrift wordt risicoperceptie beschreven door een duaal verwerkingsmodel, namelijk door het primair evaluatieve proces en het secundair evaluatieve proces. Het eerste proces wordt gevormd door gut feeling, directe associaties en eerdere ervaringen. Dit resulteert in de eerste, spontane reactie op een risico. Het tweede proces speelt zich meer in het bewustzijn af en vindt iets later plaats dan het primair evaluatieve proces. Het wordt alleen geactiveerd als daar voldoende mogelijkheden en motivatie voor zijn. Kortom, het primair evaluatieve proces komt overeen met basale associatieve processen, terwijl het secundair evaluatieve proces uit cognitieve en specifiek associatieve processen bestaat.

Om het primair evaluatieve proces te onderzoeken is een indirecte test gebruikt. Deze test kan de eerste, spontane reactie meten en wordt niet beïnvloed door bewuste processen. Voor dit project is de Extrinsic Affective Simon Task (De Houwer, 2003), een indirecte test die attitudes kan blootleggen, aangepast om risicopercepties te meten.

Naast risicoperceptie gaat dit proefschrift ook over risicocommunicatie. Er is bestudeerd hoe risicocommunicatie de primair en secundair evaluatieve processen van risicoperceptie kan beïnvloeden. We hebben het hier over risicocommunicatie in de enge zin van het woord; namelijk alleen de boodschap die van de informatiezender naar het publiek gestuurd wordt en niet het brede proces waarin risicocommunicatie normaliter plaats vindt.

In het kort zijn de volgende twee doelen in dit proefschrift onderzocht. Ten eerste is bestudeerd welke rollen cognitieve en associatieve processen spelen in hoe mensen risico's en risicocommunicaties interpreteren. Ten tweede is onderzocht of en hoe risicocommunicaties de primair en secundair evaluatieve processen kunnen beïnvloeden.

Hoofdstuk 2 is een literatuurreview over hoe kansinformatie in risicoboodschappen gepresenteerd kan worden en welke effecten dit heeft op, bijvoorbeeld, begrip, acceptatie en gedrag ten opzichte van het risico. Hier zijn studies over een aantal presentatiewijzen van kansinformatie geëvalueerd, zoals frequenties (bijvoorbeeld, 27 per 100.000 mensen), percentages (bijvoorbeeld 2,7% van de mensen), cumulatieve risico-informatie

(bijvoorbeeld na 10 jaar blootstelling is de kans toegenomen tot 2,7%) en grafieken (bijvoorbeeld staafdiagram en taartdiagram). Dit leidde tot een aantal aanbevelingen over het gebruik van kansinformatie in risicocommunicatie. Uit meerdere studies is bijvoorbeeld gebleken dat mensen bij frequenties vaak de base rate (de noemer) negeren. Daarom adviseerden wij om frequenties met dezelfde noemer in risicoboodschappen te gebruiken zodat mensen deze kansinformatie eenvoudig kunnen vergelijken binnen dezelfde boodschap wanneer zij de noemer negeren (in Box 2.1 en 2.2 staan alle aanbevelingen). Het bleek niet altijd mogelijk te zijn om aanbevelingen te geven op basis van de gevonden studies. Wij verklaarden dit voornamelijk doordat mensen risico-informatie zowel heuristisch als systematisch kunnen verwerken. Bij systematische verwerking wordt uitgebreid en bewust met informatie omgegaan, terwijl bij heuristisch verwerken snelle beslisregels gebruikt worden. Systematische verwerking wordt alleen toegepast als men voldoende tijd en motivatie heeft, anders wordt heuristische verwerking gebruikt. Vooral bij deze laatste verwerkingsvorm zal de presentatiewijze de interpretatie van een kans of risico beïnvloeden. De presentatiewijze kan mensen namelijk tijd en cognitieve capaciteit sparen. Bij systematische verwerking zoeken en organiseren mensen zelf informatie. Dus is de presentatiewijze van de kansinformatie minder belangrijk. Onze aanbevelingen zijn vooral bruikbaar wanneer verwacht wordt dat mensen de risicoboodschap heuristisch zullen verwerken. Kortom, in risicocommunicatie-onderzoek moet niet alleen uitgezocht worden welke presentatiewijzen van kansinformatie effectief zijn, maar ook hoe de situatie waarin risicoboodschappen gepresenteerd worden (bijvoorbeeld beschikbare tijd, eigenschappen van de ontvangers en het type risico) heuristische of juist systematische verwerking bevordert. De situatie lijkt namelijk te bepalen hoe mensen de kansinformatie en het risico interpreteren.

In *Hoofdstuk 3* is onderzocht of en hoe mensen associaties met bekende risico's gebruiken om een nieuw, onbekend risico te interpreteren. Eerst wordt een kwalitatieve studie gepresenteerd. In focusgroep- en diepte-interviews discussieerden respondenten over enkele krantenartikels die onbekende risico's beschreven. De geïnterviewden bleken onbekende risico's vaak met bekende risico's te associëren. Dit leken zij om vier verschillende redenen te doen: (1) om de ernst en gevolgen van het onbekende risico aan te tonen, (2) om te demonstreren dat mensen in het verleden gelijke risico's geaccepteerd hadden, (3) om aan te tonen dat het onbekende risico ook voordelen had en (4) om te betogen dat ook voor het onbekende risico een oplossing gevonden zou worden.

Vervolgens is een vragenlijststudie besproken die op een kwantitatieve manier onderzocht of mensen onbekende risico's associëren met bekende risico's en *hoe* mensen deze associaties leggen. Uit deze studie kwam naar voren dat er sterke verbanden bestaan tussen de risicopercepties van onbekende risico's en die van risico's die mensen zelf associëren (*zelfgeassocieerd risico's*). De associaties tussen twee risico's bleken niet zeer persoonlijk bepaald te zijn en waren ook niet het resultaat van een derde variabele, zoals iemands persoonlijkheid. Risicoassociaties leken bepaald te worden door een semantische connectie tussen het onbekende risico en het geassocieerde, bekende risico. Bovendien leken opvallende kenmerken die beide risico's bezaten de keuze van een risicoassociatie te bepalen. De bevindingen van deze twee studies bieden mogelijkheden voor het risicocommunicatieveld. Het lijkt niet nodig te zijn om strikt persoonlijke risicoassociaties in risicocommunicatie te gebruiken. Door middel van mentale modellen kan men nagaan welke associaties (een deel van) de doelgroep met het onbekende risico heeft en daar kan deze boodschap vervolgens op inspelen.

Hoofdstuk 4 beschrijft een experimentele studie over de effecten van verschillende risicoboodschappen op de primair en secundair evaluatieve processen. Respondenten kregen een artikel te lezen waarin hoogspanningslijnen of als een groot risico gepresenteerd werd (hoogrisico artikel), of als een klein risico (laagrisico artikel), of waarin niets gezegd werd over de risico's van hoogspanningslijnen (controleartikel). Vervolgens deden ze de indirecte test, de EAST, en vulden ze een vragenlijst in over risicoperceptie.

De respondenten bleken hoogspanningslijnen sterker met ongezonde leefomgeving te associëren dan met gezonde leefomgeving volgens de EAST (primair evaluatieve proces). Deze associatie werd niet beïnvloed door het artikel dat zij gelezen hadden. In het algemeen hadden de respondenten geen negatief risico-oordeel over hoogspanningslijnen volgens de vragenlijstresultaten (secundair evaluatieve proces). De respondenten die het hoogrisico artikel gelezen hadden, bleken volgens de vragenlijstresultaten meer waargenomen risico te ervaren dan de respondenten die het laagrisico of controleartikel ontvangen hadden. De EAST bleek waardevol om risicoperceptie te meten aangezien het aanvullende informatie gaf over hoe mensen risico's waarnemen, naast bijvoorbeeld een vragenlijst. We suggereerden dat de artikelversies geen effect hadden op het primair evaluatieve proces, omdat voor dit proces meer affectieve elementen in de risicoboodschap nodig zijn dan in onze artikelen gegeven werden.

Het *vijfde hoofdstuk* beschrijft een experiment waarin audiovisuele risicocommunicatie onderzocht werd: een videofilm. Video wordt beschouwd als een levendige informatiebron. Daarom veronderstelden we dat deze het primair evaluatieve proces zou beïnvloeden. Bovendien kan de visuele en verbale informatie uit een video ervoor zorgen dat mensen de informatie goed opslaan en zich deze beter herinneren dan bijvoorbeeld alleen tekstinformatie. De belangrijkste onderzoeksvraag was hoe de twee video-elementen (tekst en geluid/beeldmateriaal) effect hadden op de twee risicoperceptieprocessen. Daarnaast wilden we weten hoe een video risicoperceptie op langere termijn kan beïnvloeden. De respondenten kregen een van vier video's over nanotechnologie te zien: een video met tekst en geluid/beeldmateriaal, een video met alleen tekst, een video met alleen geluid/beeldmateriaal of geen video (controlevideo). De eerste drie video's vertoonden mogelijke risico's en onzekerheden rondom nanotechnologie. Vervolgens deden de respondenten de EAST en vulden ze een vragenlijst in over risicoperceptie, direct na het zien van de video en twee weken later.

Volgens de EAST associeerden de respondenten nanotechnologie sterker met gevaarlijk dan met ongevaarlijk. De vragenlijstresultaten lieten niet zo een negatief oordeel over dit risico zien. In de eerste vragenlijstmeting bleken de video's met tekst een negatiever oordeel over nanotechnologie te veroorzaken dan de video's zonder tekst. De tekst leek dus het secundair evaluatieve proces op de korte termijn te kunnen beïnvloeden. Het geluid/beeldmateriaal van de video's bleek juist bij de tweede meting voor een sterkere associatie van nanotechnologie met gevaarlijk dan met ongevaarlijk te zorgen, zoals de EAST liet zien. Het geluid/beeldmateriaal leek dus het primair evaluatieve proces op de langere termijn te beïnvloeden.

Deze studie liet wederom zien dat de EAST een bruikbare methode kan zijn om de risicoperceptie van mensen bloot te leggen, naast een directe maat. Video bleek een geschikt communicatiekanaal te zijn omdat het invloed kan hebben op zowel het primair als het secundair evaluatieve proces, al kan dat op verschillende momenten zijn.

In *Hoofdstuk 6* is een experiment over actieve risicocommunicatie besproken. Actieve risicocommunicatie wil zeggen dat de ontvangers van de boodschap deze actief moeten

bewerken. In deze studie werd gebruik gemaakt van zogenaamde ‘scenario informatie’, hierin wordt stap voor stap beschreven hoe een risico kan uitmonden in een rampzalige gebeurtenis. Respondenten werden ofwel een scenario aangeboden over hoe een voetganger een verkeersongeval kreeg (passieve risicocommunicatie), ofwel moesten zelf een dergelijk scenario schrijven (actieve risicocommunicatie), ofwel moesten een scenario schrijven over een ander onderwerp (controle communicatie). We veronderstelden dat de actieve risicocommunicatie een sterker verband tussen het primair en het secundair evaluatieve proces zou veroorzaken dan passieve risicocommunicatie of de controle communicatie.

De EAST en een vragenlijst werden gebruikt om de twee risicoperceptieprocessen te meten. De resultaten lieten zien dat de actieve risicocommunicatie een sterker verband veroorzaakte tussen het primair en het secundair evaluatieve proces dan passieve risicocommunicatie of de controle communicatie.

Discussie en Conclusie

De resultaten van de verschillende studies in dit proefschrift bevestigden dat zowel associatieve als cognitieve processen een rol spelen in hoe mensen risico's waarnemen. Mensen kunnen associaties met bekende risico's te gebruiken om een onbekend risico te interpreteren. Daarnaast lijken mensen een eerste, spontane associatie (primair evaluatief proces) met een risico te hebben. Deze eerste, spontane associatie kan anders kan zijn dan hun latere, cognitieve reactie (secundair evaluatief proces). Wij concluderen dan ook dat mensen zowel associatieve als cognitieve processen tot hun beschikking hebben wanneer zij risico's waarnemen. Andere factoren, zoals sociale omgeving, risicokenmerken en iemands persoonlijkheid, beïnvloeden de uitkomsten van deze twee processen.

Daarnaast bleek uit de experimentele studies dat risicocommunicatie niet altijd het primair en het secundair evaluatieve proces beïnvloedt. Vooral het eerste proces was moeilijk te sturen door risicocommunicatie. Wellicht dat interventies die risico-informatie herhaald aanbieden, zoals mere exposure, of die een risico meerdere malen met een evaluatie verbinden, bijvoorbeeld conditioneren, meer effect zullen hebben. Onze resultaten geven alleen enkele indicaties over welke typen media welke processen kunnen beïnvloeden. Zo lijkt tekstinformatie vooral effect te hebben op het secundair evaluatieve proces. Om het primair evaluatieve proces te beïnvloeden lijkt geluid/beeldmateriaal het meest geschikt. Verder zijn er aanwijzingen dat actieve risicocommunicatie de twee risicoperceptieprocessen kan verbinden. Meer onderzoek is nodig om deze bevindingen om te kunnen vormen tot aanbevelingen voor risicocommunicatie.

Het is voor het eerst dat de EAST toegepast werd om risicoperceptie te meten. We concluderen dat deze indirecte maat geschikt is om de eerste, spontane reacties op risico's te meten, namelijk het primair evaluatieve proces. Deze maat geeft aanvullende informatie over hoe mensen risico's waarnemen, naast de resultaten van een directe maat, die het secundair evaluatieve proces kan weergeven.

Kortom, mensen gebruiken zowel associatieve als cognitieve processen in risicoperceptie. Het is raadzaam om beide processen mee te nemen in zowel studies naar risicoperceptie als de ontwikkeling en evaluatie van risicocommunicaties. Dit kan een volledig beeld creëren over hoe mensen risico's waarnemen. Bovendien kan door op beide processen te focussen risicocommunicatie optimaal gemaakt worden.

Tot slot...

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Curriculum Vitae

Vivianne Visschers was born 5 October 1978 in Geleen. She grew up happily in Schimmert, Limburg. Her secondary school period took place at the Stella Maris College in Meerssen, where she received her gymnasium diploma in 1997.

The following autumn, she took up psychology at Maastricht University and chose cognitive ergonomics as her major subject in her third year. During the spring semester of 2001, she followed additional electives in psychology with ergonomics at Loughborough University in Loughborough, UK.

Back in Maastricht, she graduated in cognitive psychology in April 2002. After this she immediately moved from Uns 40 to Deb 1 to start a Ph.D. project, called "Risk communication about risk analyses" at the Department of Health Education and Promotion of the Faculty of Health Sciences, Maastricht University. This resulted in the thesis you just finished reading.

From July 2006 to June 2007 Vivianne worked as a researcher at the National Institute for Public Health and the Environment (RIVM), Centre for Environmental Health Research (MGO), in Bilthoven. As of 1 July 2007 she will start as a postdoc at the Institute for Environmental Decisions of the Eidgenössische Technische Hochschule Zürich (ETH Zürich). Her research will focus on risk communication.