Policy Insights from the
Behavioral and Brain Sciences
1–7

DOI: 10.1177/2372732217720223
journals.sagepub.com/home/bbs

Health Risk Perception and Risk Communication

Ralf Schmälzle[1], Britta Renner[2], and Harald T. Schupp[2]

Abstract

Risk perceptions are a prerequisite for protective action. Both scientists and practitioners need to understand the multifaceted nature of health risk perception and risk communication. This article reviews insights from psychophysiological research, with a focus on neuroscientific approaches that examine the biological basis of risk perception in the brain and capture the brain response to health and risk messages. Specifically, we discuss the key role of intuitive processes for personal risk perception and the difference between absolute and comparative risk. We then describe the relationship between risk perception and health behavior change and present recent work that measures responses to health prevention messages. Finally, we discuss implications for translation to public health policy and point to needs for future research. A better understanding of the biological roots of personal risk perception and how these can be addressed via risk communication informs policymakers in designing effective public health interventions.

Keywords

psychophysiology, risk perception, risk communication, health communication, affect

Tweet

Why knowledge is not enough: Intuition's role in health risk perception and how psychophysiological measures help decipher it. #personalriskperception #PIBBS

Key Points

- Understanding the mechanisms of risk perception and risk communication is vital to policymakers because it provides the basis for scientifically sound and empirically testable public health campaigns.
- Psychophysiological science, which brings together psychology and physiology, provides theories, paradigms, and methods to examine health risk perception and effects of health and risk communication.
- Event-related brain potentials (ERPs; usually measured with surface electrodes) can tap into fast and affect-based processes related to risk perception.
- Functional magnetic resonance imaging (fMRI) can reveal responses to health messages on a moment-to-moment basis and simultaneously from hundreds of brain regions.
- The brain-as-predictor approach strives to link micro-level message effects to subsequent outcomes within the same individuals or at larger scales.
- Psychophysiology research has rich potential to better understand risk perception and improve the effectiveness of health and risk campaigns.

Introduction

Humans all over the world face a vast array of health risks. To date, the top risks for morbidity and mortality worldwide are tobacco use, high blood pressure, obesity, physical inactivity, and high blood glucose (World Health Organization, 2009, 2014). Each of these risks is linked to individual behavior, and reducing such risk behaviors has thus become a central goal for public health. In fact, the question "How can we induce people to look after their health?" has recently emerged as the first question for the social sciences in the 21st century (Giles, 2011). Answering this question obviously depends on improving risk communication, which in turn depends on understanding how people perceive the risks they face. This review presents insights from psychophysiological research on health risk perception and communication. We first illustrate the role of intuitive processes for health risk perception and how psychophysiological research is contributing to progress in this field. We then discuss the difference between absolute and comparative personal risk perception and the relationship between risk perception and health behavior change. Next, we show how psychophysiological measures

[1]Michigan State University, East Lansing, USA
[2]University of Konstanz, Germany

Corresponding Author:
Ralf Schmälzle, Department of Communication, Michigan State University, 404 Wilson Rd., East Lansing, MI 48824, USA.
Email: schmaelz@msu.edu

can capture responses to health and risk messages and how such measures can link to subsequent behavioral effects. We end with implications for translation to policy and public health.

The Intuitive Nature of Risk Perception

Experts and laypersons differ in their approaches to risk. Experts define and quantify risk by focusing on two core elements: the *probability* of a hazardous event and the *severity* of the negative consequences. The perception of risk by laypersons, however, is more complex and is influenced by characteristics beyond probability and severity. A pioneering study presented people with 30 different hazards and asked them to evaluate these on several psychologically relevant attributes (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978). Risk evaluations revealed two dimensions, termed dread risk and unknown risk. The *dread risk* factor captures aspects such as perceived control over exposure to the risk, the degree of catastrophic consequences, or global ramifications. The *unknown risk* factor refers to the degree to which a risk is predictable, observable, and understood. This landmark study in risk perception demonstrates that people's perceptions and attitudes toward risk are influenced by characteristics beyond the Probability × Severity calculus.

The dread risk factor implies a role for affect (emotions and feelings) in risk perception. However, early risk perception research still focused heavily on cognitive assessments of probability and severity. This has now changed, and risk perception research has taken a pronounced affective turn, which explains increased interest in psychophysiological approaches. For example, the risk-as-feelings model holds that feelings can influence risk perceptions independently from cognitive assessments (Loewenstein, Weber, Hsee, & Welch, 2001). Similarly, an intuitive mode of risk perception is based on feelings as opposed to a more analytic or deliberative mode (Slovic & Peters, 2006). In sum, recent models suggest that much of real-life risk perception uses rapid and largely automatic and association-based routines that are collectively referred to as intuition (Hodgkinson, Langan-Fox, & Sadler-Smith, 2008). More analytic thinking about risk, by contrast, presumably depends on effortful and serial processes (see also Loewenstein, O'Donoghue, & Bhatia, 2015; Pachur, Hertwig, & Steinmann, 2012).

Within this context, a psychophysiological approach offers theory, paradigms, and measures to tap into this intuitive mode of risk perception, which is generally difficult to study. One example of this approach in practice comes from a series of studies on intuitive risk perception that used a combination of event-related brain potentials (ERPs, measured with surface electrodes), functional magnetic resonance imaging (fMRI), and self-reports to study risk perception in the domain of HIV. The starting point for this work were surprising interviews with HIV-positive people and focus groups in which people reported to "just know" whether a potential partner was risky or safe—even though they had no information about the person's past sexual behavior (e.g., Gold, Skinner, Grant, & Plummer, 1991; M. L. Keller, 1993).

A lab paradigm examined this phenomenon, particularly to specify characteristics of intuition, such as the involvement of affect (Slovic & Peters, 2006) and judgments "reached with little apparent effort, and typically without conscious awareness" (Hogarth, 2010, p. 339). Briefly, participants saw portraits of unacquainted persons and recorded ERPs, the brain's electrophysiological responses, which are ideally suited to capture fast and frugal processes that unfold within split seconds after an image enters the visual system. Across several studies, early (<300 ms) electrocortical differences emerged between pictures of individuals deemed risky or safe in terms of HIV risk (Renner, Schmälzle, & Schupp, 2012; Schmälzle, Renner, & Schupp, 2012; Schmälzle, Schupp, Barth, & Renner, 2011). This speed precludes systematic reasoning about health risk and thus supports the notion of intuitive processing (e.g., Slovic & Peters, 2006).

Moreover, ERP differences between intuitively risky and safe partners emerged at the level of the late positive potential (LPP), an ERP component known to respond to affective significance (Schupp, Flaisch, Stockburger, & Junghöfer, 2006). Portraits of risky-looking individuals prompted larger LPPs, which may serve as an intuitive alarm signal for attentive processing (Renner et al., 2012; Schmälzle et al., 2012; Schmälzle et al., 2011). This interpretation was corroborated by a subsequent fMRI study that found increased activation toward individuals later judged as risky within the saliency network, a set of brain regions involved in attention and relevance detection (Häcker, Schmälzle, Renner, & Schupp, 2015).

Perhaps the strongest support for the intuitive nature of HIV risk perception comes from work that exposed participants to the pictures and recorded neural data without mentioning HIV risk (Häcker et al., 2015; Schmälzle et al., 2011). Neural responses were then categorized based on subsequently collected ratings of HIV risk; this implicit condition revealed similar neural differences to the explicit condition—using both ERP and fMRI recordings. This suggests that processes associated with risk unfold spontaneously, another defining feature of intuition. In sum, this work illustrates how psychophysiological approaches can help to decipher the hidden mechanisms of intuitive risk perception.

Personal Risk Perception

From a public health perspective, people not only need to be aware of a health risk ("There is a new virus, and it poses a health risk"), but they also need to feel that they are personally at risk ("I may catch the virus myself"). This distinction is the gap between general and personal risk perception.

Personal risk perception can be either *absolute* or *comparative* (Renner & Schupp, 2011; Shepperd, Waters, Weinstein, & Klein, 2015; Weinstein, 1980). Absolute risk perception refers to estimates of risk that range from low to high—typically probed via questions such as "What is the likelihood that you will get cancer?" Comparative risk perceptions, on the contrary, assess how people estimate their risk relative to the risk others face (e.g., "What do you think is your chance of getting cancer compared with the average person of your age?"). The following two case studies illustrate how the psychophysiology toolkit advances understanding these types of personal risk perception.

First, absolute personal risk perception interacts with the reception of risk-related communication. During the 2009/2010 outbreak of the H1N1 virus, a study (Schmälzle, Häcker, Renner, Honey, & Schupp, 2013) recorded brain activity, while participants viewed an entire real-world TV documentary about H1N1. Participants were selected based on their preexisting perceptions of the risk posed by H1N1. Neural responses to the H1N1-documentary within the so-called saliency network (Menon & Uddin, 2010) differed according to recipients' absolute H1N1 risk perceptions for themselves. In particular, viewers with high risk perceptions regarding H1N1 shared with each other more strongly aligned neural time courses during viewing, most notably within the anterior cingulate gyrus (ACC), a region associated with self-related processing (Schmitz & Johnson, 2007), discrepancy detection (Botvinick, Braver, Carter, Barch, & Cohen, 2001) and the appraisal of threatening information (Mechias, Etkin, & Kalisch, 2010). This constitutes evidence for a *message–receiver interaction*, for example, that the same message prompted different responding based on the preexisting risk perception among recipients. Overall, this approach is promising to study responses to real-world health and risk communication in a realistic way. The methods expose interactions between risk perception and incoming risk information that are likely to have substantial consequences in real-world settings (e.g., climate change risk, polarized public opinion during emerging health crises, or responses to pro- or counter-attitudinal health communication).

A second example concerns comparative personal risk perception, that is, when people compare their personal risk (e.g., your risk to get cancer vs. that of others). Studies on comparative risk perception reveal that people tend to compare themselves too favorably against others. This *unrealistic optimism* (Weinstein, 1980) appears for many risks and across all age-groups and education levels (Renner, Gamp, Schmälzle, & Schupp, 2015; Shepperd et al., 2015). To uncover the biological roots of this pervasive phenomenon, participants estimated the likelihood of encountering risks in their lifetime, such as becoming victim of burglary or getting Alzheimer's disease, while capturing brain responses using fMRI (Sharot, Korn, & Dolan, 2011). Next, they saw the average frequency of the risky events. In the critical condition, participants again estimated the likelihood of the same risk events. Comparing pre- and postfeedback estimates of risk probability showed an asymmetric pattern of change for over- and underestimation of risks: People updated their belief when they received desirable feedback (when they had overestimated the risk) to a greater degree compared with when they received bad news (when they had underestimated risk). This selectivity in updating beliefs was related to activity in the inferior frontal gyrus, a region implicated in linking evidence to prior knowledge and prediction-error coding (Sharot & Garrett, 2016). Together with related work on *unrealistic optimism* (Sharot et al., 2011; Sharot, Riccardi, Raio, & Phelps, 2007), this study demonstrates the potential of psychophysiological methods and paradigms to understand comparative risk perception.

The Relationship Between Risk Perception and Health Behavior

Risk perception, as a crucial factor driving protective health behaviors (Slovic, 1964), is key in virtually all major health behavior theories (Portnoy, Ferrer, Bergman, & Klein, 2014; Renner & Schwarzer, 2003; Weinstein, 2003). In general, these frameworks imply that an authentic perception of personal risk signals the need to take protective action and thus catalyzes behavior change (Loewenstein et al., 2001; Renner et al., 2015; Weinstein, 2003). This *behavior motivation hypothesis* is supported by a recent meta-analysis: Heightening risk appraisals in experiments had robust effects on intentions and behavior (Sheeran, Harris, & Epton, 2014). Moreover, the effect of heightened risk perceptions on behavior was partially mediated by intentions, but there was still a significant direct effect of risk perception. Thus, risk perception may influence behavior through pathways partially independent from reflective thought and intentional behavior (cf. Marteau, Hollands, & Fletcher, 2012). As in our previous examples, advances in psychophysiological measurement, particularly the recently proposed *brain-as-predictor* approach (Berkman & Falk, 2013), are promising to illuminate the hidden pathways between health risk messages, risk perception, and behavior.

The *brain-as-predictor* approach uses brain activity, captured at the moment of receiving health messages, to forecast subsequent changes in health behaviors (Berkman & Falk, 2013). In one of the first studies, the neural response to tailored smoking cessation messages predicted reductions in smoking behavior at follow-up intervals (Chua et al., 2011). Activation of a brain region involved in self-related processing (dorsomedial prefrontal cortex) to the smoking cessation messages predicted later successful quitting.

Other health domains—including smoking, sunscreen use, and contexts outside the health domain (Berns & Moore, 2012; Genevsky & Knutson, 2015)—show similar results. For example, sunscreen use increased after viewing health ads promoting use of sunscreen; the ad-evoked neural responses in an a-priori defined region of interest in the medial prefrontal cortex predicted increased sunscreen use at follow-up (Falk, Berkman, Mann, Harrison, & Lieberman, 2010). Furthermore, the findings replicated for smoking cessation (Falk, Berkman, Whalen, & Lieberman, 2011) and increased physical activity (Cooper, Bassett, & Falk, 2017). Overall, the brain-as-predictor approach (Berkman & Falk, 2013; Falk, Cascio, & Coronel, 2015; Weber, Huskey, Mangus, Westcott-Baker, & Turner, 2015) links neural processes during health-risk-information exposure to subsequent behavior outside the scanner, with key theoretical and translational implications (Gabrieli, Ghosh, & Whitfield-Gabrieli, 2015).

Effective Health and Risk Communication

Health and risk communication—like all communication activities—varies on a continuum between *informing* and *influencing* (Atkin & Rice, 2001; Fischhoff, 2012; Renner, Gamp, & Thaler, 2017). On the information side of the continuum, health risk communication can target the general public to make them aware of existing health risks in their lives or environment. One example is package inserts, which provide extensive, yet largely neutral information. Another example is conventional awareness campaigns. On the influence side of the continuum, health and risk communication can also strive to increase risk perception to promote protective or preventive behavior (Wakefield, Loken, & Hornik, 2010).

To achieve this, messages may provide numerical information. However, numerical risk communication is very complex because different numerical formats vary greatly in understandability and in what people take away from them (e.g., presenting risks as frequencies or as odds; Gigerenzer, 2007; Rakow, Heard, & Newell, 2015). Beyond numbers, communicators may use pictures (e.g., poster messages or graphic warning labels) and narratives (e.g., in public service announcements) to promote fear and negative emotions more broadly in an effort to accentuate felt risk (Witte & Allen, 2000). Well-designed campaigns typically provide a clear message of the desired target behavior and use mini-stories and other engaging formats to increase personal risk perception and make the message salient and believable (P. A. Keller & Lehmann, 2008; Kim, Bigman, Leader, Lerman, & Cappella, 2012).

While many factors contribute to the effectiveness of mass media health messages, a core ingredient of effective campaigns is their ability to address recipients in a personal and motivationally relevant way (Burnkrant & Unnava, 1995; Dillard & Peck, 2000; Tannenbaum et al., 2015). Neuroimaging measures have potential to reveal how such messages literally "get under the skin" and catch on in the brains of their recipients. Many variables matter for health messages, including argument strength (AS; a measure of the overall quality of the arguments within a message; Zhao, Strasser, Cappella, Lerman, & Fishbein, 2011), message sensation value (MSV; a construct related to sensory facets and the novelty and emotional arousal value of a message, Palmgreen, Stephenson, Everett, Baseheart, & Francies, 2002), and perceived message effectiveness (PME; that is, whether an ad/public service announcement is seen as powerful, believable, or convincing; Dillard, Weber, & Vail, 2007; Yzer, LoRusso, & Nagler, 2015). Health messages varying on these dimensions differentially activated medial prefrontal cortex, precuneus, anterior cingulate, and insular regions during the reception of naturalistic risk and health information—presumed to reflect the processing of self-relevant and emotionally salient stimuli (Langleben et al., 2009; Ramsay, Yzer, Luciana, Vohs, & MacDonald, 2013; Wang et al., 2013; Weber et al., 2015).

These studies mainly focused on overall activity levels within specific regions in response to the message. Another approach assesses the "collective grip" that messages exert on the brains of their recipients over time during the reception process. In a recent study, young adults—a key target group for alcohol prevention—watched more and less effective audiovisual health messages selected from a large sample of real-life anti-alcohol campaigns (Imhof, Schmälzle, Renner, & Schupp, 2017). More effective anti-alcohol messages commanded more similar neural responses, particularly in dorsomedial prefrontal cortex, insulae, and precuneus, which have been linked to narrative engagement, self-relevance, and attention toward salient stimuli. This suggests that effective messages were more successful in getting the brains of audience members to tune in to the message and thus seem to have deeper neural reach, compared with less effective messages.

When combined with the *brain-as-predictor* approach, these neural measures of audience engagement appear particularly promising to link micro-level message effects within test audiences to larger scale outcomes, such as the population-level response to campaigns. Indeed, activity in the medial prefrontal cortex, captured in a relatively small *neural focus group* during exposure to different anti-smoking campaigns, predicted the success of the campaigns at the national level, measured as call volume to the National Cancer Institute's Smoking Quit-Line campaigns (Falk, Berkman, & Lieberman, 2012). Overall, the emerging field of neuroimaging of health messages holds great potential to create new theoretical insights and have translational implications for formative and evaluative stages of research, which can in turn inform public policy about viable approaches (Falk, 2010).

Conclusions and Policy Implications

The behavior of individuals strongly influences their health, and how they perceive their risks affects whether they will be motivated to look after their health. This is good news because it provides an opportunity for leveraging the large array of modifiable risk behaviors to achieve substantial improvements in public health in the 21st century. One challenge, however, is that the majority of health-relevant behaviors is driven by automatic or intuitive processes (Marteau et al., 2012). By and large, these processes remain insufficiently understood, and this limits the effectiveness of health messages and related interventions to improve health and prevent disease.

Within this context, psychophysiological science provides theories, paradigms, and measurements to gain deeper insight into the operations of these automatic processes and their relationship to deliberate processes that influence health-related cognitions and behaviors. Despite this great potential, however, a number of issues may impede progress. First, the human brain is far from being understood, and psychological interpretations of physiological responses are fraught with challenges and caveats (Poldrack, 2006). Second, as in all science, the field needs to address reproducibility, reliability, and generalizability (Button et al., 2013; Poldrack et al., 2017), to make the underlying science sound and maximally useful for more applied purposes such as predictive modeling and biomarker identification (Abraham et al., 2014; Shen et al., 2017).

From a broader perspective, an obvious policy implication is the need for systematic research programs that develop, fine-tune, and test paradigms and tools to translate them into applied settings (Bradley, 2017). One example for this is the "Test, Learn, Adapt" approach by the U.K. government's *Behavior Insights Team*, which strives to put the effectiveness of public policies to test via clinical trials (Cabinet Office and Behavioural Insights Team, 2012). A related example more specifically geared toward psychophysiology is the recent *Science of Behavior Change* (SOBC) funding framework by the NIH's Common Fund (Riddle & Ferrer, 2015). In brief, the program supports an *experimental medicine strategy* for understanding behavior change by identifying, measuring, and finally influencing hypothesized target mechanisms that are likely to play a role for specific health behaviors. Finally, an example in a field with obvious policy relevance is the *Tobacco Regulatory Science Program* (TRSP), which coordinates collaborative efforts across NIH and FDA and funds research, including psychophysiological work, that informs tobacco regulatory policy (e.g., Lochbühler et al., 2016).

Biological measures, particularly neuroimaging, provide unique opportunities to contribute to these large-scale research frameworks by providing new means to tap into the mechanisms of intuitive risk perception, reveal inter-individual differences in personal risk, and predict behavior change at the individual and population level. Incorporating the tools of psychophysiology in these long-term research programs promises to further unpack and demystify the intuitive, automatic processes that underlie many of our health behaviors and thereby spur the development of new or more effective interventions to improve public health.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: H. T. S. and B. R. were supported in part by the German Research Foundation [DFG, FOR 2374].

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