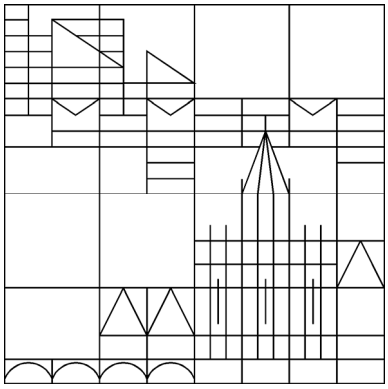
INTUITIVE RISK PERCEPTION

A NEUROSCIENTIFIC APPROACH



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Abstract

Recent theoretical models of risk perception emphasize the role of intuitive and affective processes. Empirical evidence, however, remains scarce. In the present dissertation event-related brain potentials (ERP) are used as a sensitive tool to shed light on the role of intuition in health risk perception. Three studies are presented in which participants viewed pictures of unknown persons in the context of a HIV (Human Immunodeficiency Virus) risk perception paradigm while ERPs were recorded. This strategy enabled the demonstration of key processing characteristics of intuition: speed, affective evaluation, and implicitness.

In the first study, participants judged the HIV risk of 120 persons based on facial appearance. Results showed enlarged positive brain potentials for risky faces in a time window from 350 - 650 ms. The second study added important evidence by showing that these results are not confined to facial stimuli. Using naturalistic photographs of real persons that resemble real life encounters and pictures used on internet dating platforms, it was established that risky persons prompt larger LPPs (late positive potentials), starting after approximately 300 ms. Based on the results of these two studies it is concluded that HIV risk of unknown persons is assessed intuitively. Discriminating among risky and safe stimuli in a split second provides strong evidence for intuitive processing regarding the key characteristic of speed. Furthermore, both studies provided supportive evidence for affective evaluation, another hallmark feature of intuitive processing. Risky stimuli were associated with enlarged LPPs, a component known to be sensitive to the intrinsic affective relevance of stimuli.

The third study incorporated an implicit condition, allowing risk-related processing differences to be assessed in the absence of external task demands pertaining to HIV risk judgment. By showing that ERPs from the implicit condition - obtained during a quick glimpse and with no intention to evaluate risk - are related to later reports of HIV risk, these results provide strong evidence for the intuitive and incidental character of risk perception, another key feature of intuition. Moreover, ERP results from a subsequent explicit condition replicated previous findings, providing additional evidence for the intuitive features of speed and affective evaluation.

Considering previous findings in affective neuroscience, it is proposed that persons judged as risky already attain a higher saliency early on during information processing and guide selective attention processes. These findings have implications for theoretical models of health risk perception and point to intuitive influences in everyday health risk perception.

Zusammenfassung

Aktuelle Modelle der Risikowahrnehmung berücksichtigen verstärkt die Bedeutung von intuitiven und affektiven Prozessen. Bislang liegt jedoch nur wenig empirische Evidenz für diese Modelle vor. In dieser Arbeit wird die Rolle intuitiver Prozesse für die gesundheitliche Risikowahrnehmung mithilfe von ereigniskorrelierten Potentialen (EKP) untersucht. Es werden drei Studien vorgestellt, im Rahmen derer die Teilnehmer Bilder von unbekannten Personen im Kontext eines Paradigmas zur HIV-Risikowahrnehmung (Humanes Immundefizienz-Virus) betrachteten während EKP gemessen wurden. Dieser Ansatz ermöglicht den Nachweis von entscheidenden Merkmalen intuitiver Prozesse, insbesondere im Hinblick auf die Geschwindigkeit, die Beteiligung von affektiven Evaluationsmechanismen sowie den impliziten Charakter intuitiver Verarbeitung.

In Studie 1 wurden EKP gemessen, während die Teilnehmer Gesichter von Personen betrachteten und anschließend deren HIV Risiko einschätzten. Als riskant eingestufte Gesichter führten in einem Zeitfester zwischen 350 - 650 ms nach Reizbeginn zu verstärkten positiven Potentialen. Unter Verwendung von naturalistischem Reizmaterial (Bildern von Personen in alltäglichen Szenen) konnten in Studie 2 ebenfalls erhöhte positive Potentiale für riskant eingeschätzte Personen gezeigt werden. Dies bestätigt die Befunde von Studie 1 und erweitert diese entscheidend. Ab etwa 300 ms nach Reizbeginn wiesen die EKP Unterschiede zwischen als riskant vs. sicher eingeschätzten Personen auf, wobei riskante Personen zu verstärkten LPP (late positive potentials) führten. Aus den Befunden dieser beiden Studien lässt sich ableiten, dass das HIV Risiko unbekannter Personen intuitiv erfasst wird. Die extrem schnelle Unterscheidung zwischen riskanten und sicheren Reizen steht im Einklang mit der für intuitive Verarbeitungsmechanismen typischen hohen Geschwindigkeit. Auch im Hinblick auf die Beteiligung von affektiven Evaluationsmechanismen, einem zentralen Merkmal von Intuition, liefern die Daten wichtige Evidenz. In beiden Studien zeigte sich, dass riskante Reize mit einer Erhöhung von LPP-Amplituden einhergingen. Modulationen dieser Komponente werden mit der Bewertung der intrinsischen affektiven Relevanz von Reizen in Verbindung gebracht.

Die dritte Studie beinhaltete eine implizite Bedingung, welche es ermöglicht, risikobezogene Verarbeitungsunterschiede ohne den Einfluss einer externalen

Aufgabe (z. B. HIV-Risikobeurteilung) nachzuweisen. Die Ergebnisse der impliziten Bedingung zeigen, dass selbst ohne explizite Aufgabe (d. h. nach nur kurzem Anblick der Person und ohne die Absicht, das Risiko zu beurteilen) frühe EKP-Unterschiede nachweisbar sind, die mit später abgegebenen HIV Risikourteilen in Verbindung stehen. Diese Ergebnisse belegen den impliziten oder inzidentellen Charakter der Risikowahrnehmung und weisen damit ein weiters Merkmal intuitiver Prozesse nach. Darüber hinaus werden in Studie die Befunde einer weiteren, expliziten Bedingung berichtet, in denen erneut die Merkmale Geschwindigkeit und affektive Evaluation belegt wurden.

Vor dem Hintergrund von Ergebnissen aus den affektiven Neurowissenschaften wird gefolgert, dass riskante Personen bereits früh im Verarbeitungsstrom eine höhere Relevanz zugeschrieben bekommen und zu selektiven Aufmerksamkeitsreaktionen führen. Diese Ergebnisse haben enorme Relevanz für theoretische Modelle der Risikowahrnehmung und unterstreichen die Bedeutung intuitiver Prozesse für die gesundheitliche Risikowahrnehmung.

General Introduction

World Health Organization reports indicate that around 60% of all deaths world-wide are attributable to diseases caused by behavior-related risk factors (WHO, 2002). Currently, the management of chronic diseases that are causally related to human behaviors absorbs well over half of societies' health expenses (Baum & Posluszny, 1999). Examples abound: HIV (Human Immunodeficiency Virus) is transmitted via unprotected sexual intercourse, smoking puts people at risk for lung cancer, ubiquitous cardiovascular diseases are associated with lack of exercise or nutritional habits. The behavior of individuals has thus come to be closely implicated in efforts toward risk-reduction (cf. Rothstein, 2003).

In order for people to take the initial step toward a more healthy behavior pattern, it is necessary that they acknowledge that they are at risk. A sense of being personally at risk will act as a motivator and catalyst for the initiation of risk-reducing, and health-promoting behaviors (Renner & Schwarzer, 2003b; Weinstein, 2003b). However, much evidence suggests that people often fail to change their behavior because they do not perceive themselves at risk. Understanding risk perception, our ability to sense harmful conditions, is thus of central importance.

Risk and Risk Perception

What is risk? Technical experts define risk as the product of the probability of future harm and the extent of damage caused by that harm. In order to arrive at an approximation of the amount of risk posed by a given hazard, a process called risk assessment is employed, wherein risks are calculated based on numerical estimates of probabilities and expected damage. Although experts are needed for the systematic assessment of risks, it is evident that risk-related decisions and behaviors are often people's private affairs, particularly when it comes to personal health issues (e.g., dietary choices, smoking, or the use of sexual protection).

Risk perception refers to individuals' judgments of risk, which must be differentiated from objective risk assessments performed by technical experts. At first it might seem plausible to assume that people also think about their personal risks in terms of

numbers or probabilities: after all, these are the units that define risk theoretically. However, it is revealed that individuals do not rely on accurate numerical estimates of probabilities or harm to assess their risk (French & Marteau, 2007; Renner, Schüz, & Sniehotta, 2008) and personal risk perceptions often deviate substantially from expert risk assessments (Renner & Schupp, 2005; Slovic, 1987). Systematic biases in risk perception can be observed in many important domains, ranging from large-scale technological and environmental risks to more personal health risks.

Measuring Health-Related Risk Perception

Virtually all models of health behavior and health behavior change agree that a personal perception of being at risk is a prerequisite for the motivation to change risk behaviors (Renner & Schupp, 2005; Renner & Schwarzer, 2003b). If one is not aware of the risky nature of one's actions, motivation for change cannot emerge. Accordingly, accurate estimates of health risks are crucial and perceptions of risk constitute an important target for health communications and health-promoting interventions (Sutton, Rutter, & Quine, 2002; Weinstein, Rothman, & Sutton, 1998). To measure people's risk perceptions researchers have used several methods.

When people are asked to report probability estimates for the risks of several hazards, results show a strong tendency to underestimate the risks of very common diseases (Hertwig, Pachur, & Kurzenhäuser, 2005; Lichtenstein, 1978). On the other hand, risks of rare but spectacular hazards (e.g., murder, plane crashes) tend to be grossly overestimated. These studies assess general beliefs about how common certain risks are, termed general risk perceptions.

Psychologically, however, it makes a large difference whether one is asked to give a numerical estimate for some risk or whether one reports on the belief that there may be a health risk for oneself (e.g., risk of flooding may not be very relevant to people living in off-coast areas, Renner & Schwarzer, 2003b). Most psychological investigations of health examine people's risk perception of single hazards, with an emphasis on whether one might be personally affected by some disease. These are termed personal, or self-relevant risk perceptions. To assess personal risk perception, studies have often used some variation of the question, "What is the likelihood that you will

develop X?" Here X stands for the particular disease for which the risk perception is assessed, like cancer, HIV, or stroke. Usually the response scales contain several gradations, allowing for numerical assessment of the amount of perceived risk (e.g., ranging from '1= almost certainly will not happen' to '5 = almost certainly will happen'). In addition to rating-scale-type questions, researchers use open-ended responses, such as: "What is the likelihood that you will contract the AIDS virus? Fill in any number that you think is appropriate. For example, 1 in 1 would suggest that you think that it will definitely happen. 1 in 100,000 suggests that you think that it is extremely unlikely" (Gerrard, Gibbons, & Warner, 1991).

A very consistent finding is that there is a marked tendency to misestimate many health-related risks (Dunning, Heath, & Suls, 2004; Schwarz & Vaughn, 2002). When people are asked to provide absolute, numerical estimates of their risk, these are often too high (e.g., absolute risk estimates for contracting HIV are overestimated by a factor of about 10; Pinkerton, Wagner-Raphael, Craun, & Abramson, 2000), whereas on response scales with more relative anchors, people underestimate their risk ('almost certainly will not happen'). Furthermore, the exact format used to express likelihood - whether in terms of probabilities (0.01%) or relative frequencies (1 out of 100) - has also been shown to affect people's understanding of risk (Diefenbach, Weinstein, & O'Reilly, 1993; Hoffrage, U., Kurzenhäuser, S., & Gigerenzer, 2005; Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000; Rothman & Kiviniemi, 1999; Weinstein & Diefenbach, 1997).

To circumvent some of the difficulties with people's understanding of numerical information, a different approach to tackle risk perception uses comparative questions about personal risk (Hahn & Renner, 1998; Renner & Schwarzer, 2003a; Weinstein, 1987). For example, Weinstein (1987) asked participants to give comparative risk judgments for several hazards (e.g., lung cancer, asthma, diabetes, sunstroke). For each hazard, the following was asked: "Compared to other men/women of my age, my chances of getting (problem) in the future are: much below average / below average / a little below average / a little above average / above average / much above average". Results showed that personal risks were considered to be less-than-average for many hazards. Logically, however, everyone cannot have a less-than-average risk. In conclusion, there is a marked tendency to compare oneself too favorably against simi-

lar others. This phenomenon has been labeled ‘unrealistic optimism,’ or ‘optimistic bias’ (Brown & Morley, 2007; Helweg-Larsen & Shepperd, 2001; Klein & Helweg-Larsen, 2002; Perloff & Fetzer, 1986; Renner & Schwarzer, 2003a; Sutton & Bolling, 2003; Weinstein, 1980) and has been attributed to cognitive or motivated biases in human thinking (Chambers & Windschitl, 2004; Kunda, 1990). Unrealistic optimism may lead people to feel safe and reduce their motivation for preventive action. Interestingly, unrealistic optimism has even been demonstrated in situations where the people who form the comparison standard engage in the very same activities as the participants themselves (Renner & Schwarzer, 2003a). Research further indicates that the belief that a problem is preventable by individual action, or the perception that the hazard is infrequent, moderated the amount of bias (Klein & Helweg-Larsen, 2002; Weinstein, 1980, 1987).

Studies that focus on individual health risks, rather than studying many diseases at once, echo these findings. For example, Thompson and colleagues (Thompson, Anderson, Freedman, & Swan, 1996) asked college students to indicate their chances and the chances of the average college student of their age and gender of contracting HIV. Combining the two proposed strategies of absolute and comparative personal risk assessment, students had to place a mark on two lines ranging from 0% chance to 100% chance. The first rating served as a measure of absolute personal risk, measuring the perceived chances that the students themselves might contract the virus. The second rating referred to the risks of an average college student of the same age and gender. A measure of comparative risk was then calculated from the two items by subtracting the individual’s chance from the chance of the others. The average reported personal risk for HIV was 16%. However, for an individual in one’s reference group, the average risk was judged to be 39%. There is thus a pervasive tendency for students to perceive themselves as having a significantly lower risk than their peers. Unrealistic optimism about one’s risk to fall victim to HIV has independently been confirmed (Gold & Aucote, 2003; Linville, Fischer, & Fischhoff, 1993; Moore & Rosenthal, 1991; Van der Velde, Hooykaas, & Van der Pligt, 1992). Moreover, this study demonstrates that participants used the numerical probability scale in a highly idiosyncratic fashion. Attributing a 39% chance of contracting HIV would correspond to the belief that every third student will be infected, which is obviously far too high (cf.

Blanton & Gerrard, 1997; Renner & Schwarzer, 2003a; Rothman, Klein, & Weinstein, 1996; van der Velde, van der Pligt, & Hooykaas, 1994).

Taken together, existing approaches to measure risk perception agree on the fact that individuals' risk perceptions often deviate from expert risk assessments. The most severe consequence of this misperception may be the failure to take preventive action. However, how exactly people think about personal health risks, how such thinking is translated into self-reports of risk perception (e.g., by placing a mark on a numerical risk scale), and how this fosters motivation to engage in risk-reducing behaviors has yet to be determined.

The Limitations of Traditional Views on Risk Perception

Research on risk perception has overwhelmingly focused on cognitive factors, although this is not often made very explicit. Most studies emphasize the role of the constituent dimensions of the technical risk definition: probability (perceived likelihood) and harm (perceived severity, often the severity is assumed take on fixed values, e.g., illness or death, so that only probability estimates vary; cf. Weinstein, 2000; Windschitl, 2000). With this in mind, biases in risk perception are assumed to result from flawed assessments of either probability or harm, or from a biased integration of the two into a unitary value (cf. representativeness heuristic, availability heuristic, anchoring heuristic; Gilovich, Griffin, & Kahneman, 2002).

According to the technical definition of risk, perceived probabilities and perceived severity are combined in a multiplicative manner into an estimate of risk. It is commonly assumed that the perception that one is at risk (i.e. if probabilities and severity are perceived as substantial) should motivate individuals to engage in efforts toward risk reduction. A study by Weinstein (2000) sought to determine how exactly the motivation to engage in risk-reducing behavior relates to estimates of perceived probability and perceived severity. He collected ratings of perceived probability, perceived severity, and the motivation to take preventive action for a variety of hazards (e.g., allergy to bananas, hemorrhoids, syphilis, heart attack). This study could thus test whether the multiplicative combination of perceived probability * perceived severity predicted the motivation to act, as postulated by cognitive frameworks. As

expected, if one of the factors was judged zero, there was no motivation to act. However, results also revealed that people were insensitive to variations in hazard probability when probabilities were in the moderate to high range. Motivation to take preventive action did not increase further after perceived likelihood had reached the midpoint (50:50 chance). This finding is consistent with other studies showing that the relationship between perceived likelihood, severity, and the motivation to act is more complicated than the technical risk definition suggests (Bruine de Bruin, Fischbeck, Stiber, & Fischhoff, 2002; Diefenbach et al., 1993; Fischhoff & Bruine De Bruin, 1999; Weinstein & Diefenbach, 1997; Windschitl & Weber, 1999).

That people are insensitive to variations in probability after probability has reached high levels points to fundamental problems with the use of probabilities to assess risk perception. Apparently, there is no accurate psychophysical sense for probability as there is one for perceiving size or loudness (Kahneman & Tversky, 1982; Lichtenstein & Slovic, 1971; Wright & Ayton, 1994). As discussed above, it should not be taken for granted that an estimate of a 16% chance for contracting HIV directly corresponds to a personal risk perception on the same metric (Diefenbach et al., 1993; Gigerenzer, 1989; Weinstein & Diefenbach, 1997; Windschitl, 2003; Windschitl & Wells, 1996). This demonstrates that numerical probabilities cannot be the actual units that underlie personal risk perceptions (French & Marteau, 2007; Weinstein et al., 1998; Windschitl, 2002): it appears rather that people's risk perceptions were based on more vague senses of subjective risk.

Reconsidering the above discussion, the finding that people do not calculate risks according to the principles of probability theory should perhaps come as no surprise. Daily life is full of examples that show that knowledge of probabilities and consequences is not the same as understanding one's risk. For instance, simply providing people with probability information seems to have little impact on motivating actions (French & Marteau, 2007; Renner & Schupp, 2005). People often have profound difficulties in understanding and remembering probabilities and cannot relate them to real-world experience without supplementary information (French & Marteau, 2007; Peters, Lipkus, & Diefenbach, 2006). However, even when numerical probabilistic information is understood cognitively, risk perception still comprises more than that. Smokers, for example, are currently well-versed on the dangers of their

habit (Renner & Schwarzer, 2003b). They may even know statistical numbers pertaining to the risks of smoking. However, when asked whether they feel personally at risk, they often admit that they do not (and this is not only a result of their addiction, but appears to be related to risk perception; Slovic, 2003). This shows how important it is to distinguish between more cognitive judgments about risk ("smoking is dangerous;" "smoking leads to increased lung cancer rates") and more personal, self-relevant risk perceptions ("I am at risk because I smoke;" "I feel personally at risk for contracting cancer"). Feeling at risk thus appears to be based more on factors that go beyond explicit cognitive appraisals, predictions, or expectations.

To account for such dissociations between numerical knowledge about probabilities and personal feelings of risk, many researchers now suggest distinguishing between a reported general likelihood of harm and one's perceived vulnerability (Brewer, Weinstein, Cuite, & Herrington, 2004; Renner & Schupp, 2005; Weinstein, 2003b). The latter is what is most relevant for health psychology, but also much harder to assess. By and large, traditional cognitive models of risk perception have failed to account for that. Instead, the primarily cognitive view on risk (risk = probability * severity), which stems from a decision-theoretic orientation (cf. Edwards, 1954; Steinberg, 2003), was bound to yield a conceptualization of risk perception as being based on explicit cognitive processing (i.e. thinking about risks and translating their estimated probabilities into numerical judgments). According to the more recent conceptualizations, however, risk perception is based more on feelings and intuitive processes (feeling personally at risk), which are more immediate and much less dependent on 'cold cognition' (thinking about probabilities).

Intuitive Processes in Risk Perception

Particularly under conditions of everyday life, our thoughts and actions are often guided by processes other than elaborate cognitive reflections. This idea has been quite prominent in social cognition (Bargh & Chartrand, 1999; Chaiken & Trope, 1999) and similar notions have recently inspired very influential new theories of judgment and decision making (Damasio, 1994; Kahneman, 2003; Rottenstreich & Shu, 2004). A few related and somewhat overlapping proposals have carried forth such thinking into the field of risk research.

One such development is the 'risk as feelings' model (Loewenstein, Weber, Hsee, & Welch, 2001). This model lets go of a hitherto central tenet of decision theory, namely that people explicitly assess severity and likelihood of possible outcomes and integrate this information to arrive at a decision. Instead, it is proposed that "people react to the prospect of risk at two levels: they evaluate risk cognitively, but simultaneously they also react to it emotionally, with minimal cognitive processing" (Loewenstein et al., 2001). These emotional, or intuitive reactions depend on contextual factors like immediacy of risk, the vividness with which consequences can be imagined, previous experiences with consequences, visceral states (e.g., hunger, sexual arousal), or background mood. Cognitive evaluations, by contrast, are presumed to be based on more objective evaluations of likelihood and expected damage. These may also have emotional consequences, such as desirability or worry. However, while these emotions result from anticipations, the novel idea of the risk as feelings model is that emotions can exert immediate influences without cognitive mediation. As Loewenstein emphasizes, it might be misleading to see all sorts of behavior as being caused by decisions in the strict sense of the term. To the contrary, affect or intuition may possibly circumvent, or even overwhelm deliberative decision making (in its narrow sense; cf. Chapman & Niedermayer, 2001).

A similar set of ideas has been introduced under the term 'affect heuristic' (Finucane, Alhakami, Slovic, & Johnson, 2000). The 'affect heuristic' hypothesis postulates that when asked to judge the magnitude of a risk, the mentioning of the hazard activates mental representations that are tagged with affect (cf. Zajonc, 1980). This affective pool is consulted heuristically when people make judgments about risks. Initial results that suggested the operation of an affect heuristic were obtained by Alkahami & Slovic (1994), who asked their participants to rate both the risks and the benefits of various hazards (e.g., nuclear energy, cell-phones, driving a car). It was found that judgments of perceived risks and perceived benefits tended to correlate negatively. This is noteworthy, as in the real world these two dimensions are positively correlated. High risk technologies, such as nuclear energy tend to have high potential benefits, but also are accompanied by higher risks. However, people assign relatively lower benefits and high risks to such hazards, thereby causing the correlation between benefits and risks to become negative. The affect heuristic offered an explanation for these findings. It was assumed that when people lack objective

knowledge they seek advice from their immediate affective reaction toward the stimulus object. Judgments about perceived risk and perceived benefit are thus linked via common feelings and affectively charged representations elicited by the stimulus. Indeed, it could be shown that people with more favorable evaluations of hazards perceived more benefits and less risk to be associated with them, and vice versa. Recently, it has been pointed out that the affect heuristic is defined very similarly to the concept of 'implicit attitudes' (Spence & Townsend, 2008). These are defined as "introspectively unidentified traces of past experiences that mediate favorable or unfavorable feeling, thought, or action toward social objects" (Greenwald & Banaji, 1995). In particular, both, the affect heuristic and the implicit attitudes concept, have been linked with affect, described as being spontaneous in nature, and related to the experiential system within dual process theories (Chaiken & Trope, 1999; Evans, 2008).

To summarize, the role of affect and intuition has gained momentum in theoretical accounts of risk research over the past few years. Recent models, such as the 'risk as feelings' approach or the 'affect heuristic,' suggest that people judge risk not only by how they reason about it, but also by how they feel about it. These models constitute an important theoretical development because they suggest a new conceptualization of risk and risk perception, entailing a reorientation from a restricted cognitive perspective on the phenomenon (Böhm & Brun, 2008; Kahneman, 2003; Peters, Västfjäll, Gärling, & Slovic, 2005; Wardman, 2006). Although all models have received initial empirical support (Ariely & Loewenstein, 2005; Bateman, Dent, Peters, Slovic, & Starmer, 2006; Ditto, Pizarro, Epstein, Jacobson, & MacDonald, 2006; Keller, Siegrist, & Gutscher, 2006; Siegrist, Keller, & Cousin, 2006), conclusive evidence has yet to emerge, with most publications remaining theoretical in nature. With respect to the present dissertation's focus on health risk perception, one should note that these models flow from a decision-theoretic perspective. They have thus not yet been linked to personal, health-related risk perception, but rather apply primarily to general risk perception.

The Perception of HIV Risk

Given this novel, intuitive perspective on risk perception, the most fundamental question is perhaps how this dynamic phenomenon can be captured adequately and made subject to empirical investigations. Preliminary evidence suggests that intuition may be involved in the perception of HIV risk. Consistent biases in HIV risk perception have been reported and these biases have been strongly implicated in the spread of the HIV epidemic (WHO, 2004). These results contradict findings that show comparatively high factual knowledge about transmission mechanisms and appropriate prevention strategies (Weinstock, Berman, & Cates, 2004). As discussed above, dissociations between knowledge about risks, risk perception, and behavior are suggestive of the operation of risk perception processes that go beyond the cognitive probability * severity calculus. This renders HIV risk perception a possible model system for the empirical investigation of the role of intuition for health-related risk perception.

The pandemic of the HI-virus constitutes a severe, life-threatening health risk. The unhindered spread of HIV demonstrates the unrelieved vulnerability of modern civilization to the impact of infectious diseases, which have been the most pervasive killer over the course of human history. From a normative perspective consistent condom use is considered to be an effective means of protection against HIV and other sexually transmitted infections (STIs, e.g., Chlamydia, Syphilis, etc.). In the absence of a curative treatment for AIDS, condom use appears to be the only hope for stopping the epidemic. However, reports paint an alarming picture, showing that condoms are not used consistently (cf. Gardner, Blackburn, & Upadhyay, 1999). In recent years, experts have increasingly expressed warnings about the fact that protective behavior is decreasing, possibly leading to a second wave of HIV infections (Demmer, 2003; Kalichman, Nachimson, Cherry, & Williams, 1998; White, 2004).

With HIV being a socially transmitted risk, one's perception of risk depends on an evaluation of the risk posed by the potential partner. Available data indicate that people have a well-developed and accepted set of beliefs about which potential sexual partners are risky (Williams, Kimble, Covell, & Weiss, 1992). In general, people are

convinced that their sexual partners are safe (Agocha & Cooper, 1999; Gold, Karmiloff-Smith, Skinner, & Morton, 1992; Keller, 1993; Klepinger, Billy, Tanfer, & Grady, 1993; Misovich, Fisher, & Fisher, 1997; Montoya & Bell, 2006; Thompson, Kyle, Swan, Thomas, & Vrungos, 2002; Williams et al., 1992). Furthermore, they show overconfidence in their ability to detect unsafe partners and believe that others are much more likely to get involved with risky partners (Misovich et al., 1997; Thompson, Kent, Thomas, & Vrungos, 1999; Thompson et al., 2002). Although they place such high confidence in their abilities to detect risky individuals, they frankly admit that they do not base their judgments on objective characteristics. Instead, people use implicit personality theories (Schneider, 1973; Schneider & Blankmeyer, 1983) in order to check for their potential partner's risk status. In particular, physical appearance is seen by many as providing information about others' HIV risk (Agocha & Cooper, 1999; Dijkstra, Buunk, & Blanton, 2000; Fishbein, Hennessy, Yzer, & Curtis, 2004; Keller, 1993; Kruse & Fromme, 2005; Montoya & Bell, 2006; Renner & Schwarzer, 2003a; Thompson et al., 1996; Thompson et al., 1999). Among the features of typical 'high risk persons' are smoking, a perceived lack of responsibility in sexual matters, uncleanliness, or impulsivity (Renner & Schwarzer, 2003a). In contrast, people who are seen as trustworthy, cautious, responsible, who read a lot, or who appear to be drug free, are considered to present a lower risk (Fishbein et al., 2004). One could argue that these beliefs were only present when knowledge about HIV was still low. However, the results of a recent study indicate that even in the year 2008 many individuals are relying on partner attributes and relationship characteristics when assessing the STI/HIV status of a sexual partner (Masaro, Dahinten, Johnson, Ogilvie, & Patrick, 2008).

Collectively, such strategies have been called illusory, because they do not provide reliable protection. From a rationalistic/cognitive perspective, relying on such strategies may seem utterly irrational. However, the 'risk as feelings approach' (Loewenstein et al., 2001) or the 'affect heuristic' (Finucane, Alhakami, Slovic, & Johnson, 2000) may provide explanations on why and how they are used. The 'risk as feelings' approach states that feelings can often result in direct influences on thought or behavior. Specifically, impressions or intuitive judgments may implicitly convey the message "this partner is safe" and thereby lead people to overlook the risks to which they expose themselves. Indeed, in retrospect people often report that they *just knew* that

their partner was safe, making any further protection seemingly unnecessary. A study by Keller (1993) points to very strong situational dimensions of sexual intercourse without using a condom, which is also reminiscent of the ideas coined by the 'risk as feelings' model. For example, 60% of the participants reported that intercourse was unplanned, spontaneous, or because one got carried away. Under such circumstances it is likely that people would not explicitly check for a potential partner's risk, but would rather rely on more implicit, spontaneous, and impulsive forms of cognition (Stacy, Ames, Ullman, Zogg, & Leigh, 2006), which may be subsumed under the theoretical concept of intuition (Strack & Deutsch, 2004).

Intuition: Its Nature and Measurement

In sum, initial evidence suggests that the perception of HIV risk may be based on fundamental intuitive assessments of risk or safety. However, the hypothesis that HIV risk perception is based on intuition demands the empirical demonstration of key features of intuitive processes, which are notoriously difficult to assess. Furthermore, it has been criticized that terms like feelings, affect, or intuition are rather loosely defined (Sjöberg, 2006). Given the importance ascribed to intuitive and affective processes in recent models, care should be taken to define these terms as precisely as possible.

Intuition is generally conceptualized as an ability to sense or know immediately without the intervention of reasoning processes (Bastick, 1982; Hodgkinson, Langan-Fox, & Sadler-Smith, 2008). It denotes the phenomenological experience, whereby "the thinker arrives at an answer with little, if any, awareness of the process by which he reached it" (Bruner, 1960). As a capacity for attaining direct knowledge without effort, intuition is linked to the sensation of 'hunches' (Bowers, Regehr, Balthazard, & Parker, 1990) and 'gut feelings' (Damasio, 1994). Intuition has been related to a variety of features of implicit processes (Lieberman, 2000), often coarsely subsumed under a hypothesized implicit mode of thought in dual process views of thinking (Epstein, 1994; Kahneman, 2003; Litman & Reber, 2005; Sloman, 1996). This implicit, intuitive mode of thought is viewed as an extension of the processing characteristics of perception (automatic, fast, cognitively

impenetrable) into higher-order domains of thought, particularly judgment (Kahneman & Frederick, 2002). As a rule, implicit processing - often loosely equated with intuitive, associative, or experiential processing - is described as more automatic, reflex-like, fast, and parallel (Evans, 2008). Although not mentioned in this enumeration, it should be noted that many see intuition as consisting of, or being intimately related to affective signals (Epstein, 1994; Strack & Deutsch, 2004). On the other hand, explicit processing is characterized by slower, effortful, serial, and symbolic operations.

Implicit processing is supposed to be mediated by evolutionarily conserved brain mechanisms and to be subject to relatively slow but long-lasting changes due to past experience. It is highly contextualized and relatively independent of language. It is assumed that intuition builds on implicit learning (Cleeremans, Destrebecqz, & Boyer, 1998; Kahneman, 2003; Knowlton & Squire, 1996), which establishes knowledge structures that form the basis for intuitive judgments. When activated by incoming stimuli, intuition draws from this cumulative knowledge in an implicit manner, resulting in fast evaluations that are experienced as something immediately given. In this vein, Simon (1987) characterized intuition as a kind of automatic analysis that is "frozen into habit." However, as expressed in the famous saying "I know it when I see it" (Gewirtz, 1996), intuitive processes access tacit knowledge (Reber, 1989) in introspectively inaccessible ways. Moreover, it is often assumed that implicit processing accounts for the largest share of spontaneous behavior. Unless interrupted and correctively overridden by more reflective processes of behavior control, much of moment-to-moment psychological life depends on the implicit system's rapid and impulsive assessments (Bargh & Chartrand, 1999; Gilovich et al., 2002).

In conclusion, key characteristics of intuitive processes are speed, connection to automatic, often affectively valenced evaluations, as well as their effortless, nonverbal, and incidental (i.e. implicit) nature. These features place high demands on potential measures to assess hypothesized intuitive processes during risk perception tasks. For example, traditional response-based measures may lack the sensitivity to depict the speed with which intuitive evaluations unfold. Conventional measures (e.g., those that prompt probability estimates) may not be particularly suited to tap into the more intuitive aspects, but rather may be confined to explicit and cognitive risk judgments.

Another identifying feature of implicit processes is that they influence us in a fashion not accessible to introspection. With respect to methods, this calls for the use of indirect measures. Slovic, Finucane, and colleagues (Alkahami & Slovic, 1994; Bateman et al., 2006; Finucane et al., 2000) have not yet used such measures, or any standard measures of affect (except for ratings of valence). Instead, they relied on explicit judgments in combination with time-pressure or information-manipulation methodology, which cannot completely rule out the use of cognitive strategies over implicit affective heuristics. Similarly, Loewenstein (2001) called for novel measurement approaches, or multi-modal assessments of all relevant characteristics, including, for example, physiological measures.

Modern neuroimaging technologies may be well-suited to tap into the intuitive aspects of risk perception that are difficult to observe using traditional methods. These measures can provide a detailed neural account of implicit mental processes, ranging from perception to judgment and response execution. In particular, scalp-recorded event-related potentials (ERPs; Luck, 2005) afford nonreactive measurements of implicit processes that unfold quickly and outside of conscious awareness. Presently, the investigation of processes such as attention, memory, language, or vision - to name a few - has already been greatly facilitated by the use of ERP measures. Cumulative research suggests that ERPs are sensitive to the affective content of stimuli (Schupp, Flaisch, Stockburger, & Junghöfer, 2006). These findings are relevant for the study of intuitive risk perception because they point to the biological foundations of automatic evaluations, which are assumed to be essential for intuitive risk perception. Consequently, ERP measures could provide a valuable inroad into the investigation of intuitive risk perception.

The Present Dissertation

The aim of the present dissertation is to provide evidence for the operation of intuition in health-related risk perception, which, to date is largely lacking empirical support. In particular, the domain of HIV served as a model system. Based on previous findings on HIV risk perception, one central idea is that judgments like “I just know who is safe” are informed by intuitive evaluations of other-related risk. To test this hypothesis, participants are shown photographs of persons and asked to report their

perceived risk of HIV infection for each person. In order to assess the intuitive-evaluative stage of HIV risk perception, ERPs are recorded. Specifically, later reports of perceived HIV risk are used in the analysis of ERP data with the purpose of uncovering processing differences that precede overt reports of perceived risk. Below, three studies are reported that aimed to trace out intuitive processes within this HIV risk perception paradigm.

A first study addresses the question of whether ERPs are capable of depicting intuitive processes during HIV risk perception. It was hypothesized that ERPs toward risky vs. safe facial photographs will differ systematically, and in ways pointing to intuitive influences. Specifically, this study aimed to demonstrate two key features of intuitive processes: speed and spontaneous affective evaluation.

The second study takes this idea one step further. In this study, participants are shown completely naturalistic stimuli (i.e. photographs depicting persons in daily-life scenes). This constitutes a very important extension, as ecological validity is greatly increased by using materials that closely resemble real-life conditions.

The third study was designed to address whether another feature of intuitive processing - the fact that it occurs when not explicitly probed - can be demonstrated. This objective is pursued by recording spontaneous brain reactions toward persons in an implicit condition (i.e. when the task does not require judgments of HIV risk). This strategy allows to test for incidental, implicit differences in neural processing that are associated with later reports of perceived risk.

Experiments

Study 1

The Perception of HIV Risk: An ERP Analysis of Intuitive Processes

Abstract

Recent models of health risk perception emphasize the role of intuitive and affective processes, assuming that risk perception comprises more than cognitions about probabilities and expected consequences. The present study attempted to demonstrate that health risk perception processes conform to two key features of intuition: speed and affective evaluation. As a new approach to shed light on intuitive processes in health risk perception, event-related potentials were measured while participants judged the risk of HIV-infection (Human Immunodeficiency Virus) of 120 persons based on facial appearance. Results showed enlarged positive brain potentials for risky faces over central sensor locations in a time window from 350 - 650 ms. These early differences cannot result from elaborate cognitions about risk. Furthermore, the findings support the notion that risk is perceived intuitively involving affective evaluation. Considering previous research in affective neuroscience, it is proposed that risky faces attain higher saliency already early during information processing and guide selective attention. This is the first study to show empirically that neuroscientific methods are able to trace down intuitive processes of health-related risk perceptions.

Introduction

Risky behaviors are implicated in a large number of detrimental health conditions. The pandemic of human immunodeficiency virus infection (HIV/AIDS) provides but one dramatic example. Current theories of health behavior change (Armitage & Conner, 2000; Norman & Conner, 1996; Renner & Schwarzer, 2003b; Wit & Stroebe, 2004) converge in assuming that people need to be aware of a certain health risk and feel personally at risk in order to take protective action (e.g., use condoms). It is thus important to understand how individuals perceive their personal risk of a certain health threat (Renner & Schwarzer, 2003b).

Traditionally, risk perception has been conceptualized as cognitive appraisals about probabilities of hazards (French & Marteau, 2007; Weinstein, 1999; Weinstein, 2000). More recently, the exclusive role of 'cold cognitions' for the formation of self-relevant health-related risk perceptions has been questioned and intuitive processes are emphasized (Millstein, 2003; Weinstein, 1999, 2003a). For instance, the 'risk as feelings' model (Loewenstein et al., 2001) suggests that the processing of risk-related information may be based on immediate intuitive factors, involving only minimal systematic reasoning. Intuitive processes are important determinants of behavior under real-life contexts (Ariely & Loewenstein, 2005; Ditto et al., 2006) and may override cognitions in cases of conflict (Damasio, 1994; Epstein, 1994; Loewenstein et al., 2001). The 'affect heuristic' subsumes a related set of ideas (Finucane et al., 2000; Slovic, Peters, Finucane, & MacGregor, 2005). According to the 'affect heuristic' people base judgments about the risk of stimuli or events on their immediate affective reaction toward a stimulus (cf. Pratkanis, 1989). These models suggest a new conception for the perception of risk by emphasizing the role of affect and intuition.

Intuitive processes have been previously studied in diverse areas such as judgments, moral reasoning, habit formation, and implicit learning (Hogarth, 2001; Lieberman, 2000; Myers, 2002). It is held that intuitive processes are important in guiding everyday behavior (Bargh & Chartrand, 1999; Chaiken & Trope, 1999), particularly under conditions of uncertainty or time pressure (Kahneman, 2003; Klein, 1999). Moreover, many researchers suggest that intuitive behavior is based on automatic affective evaluations (Epstein, 1994; Strack & Deutsch, 2004), which may

mediate the symptomatic 'hunches' or 'gut feelings' (Damasio, 1994; Simon, 1986). Several key characteristics of intuition are proposed to discriminate intuitive processing from a processing mode variously referred to as rule-based, systematic, deliberative or analytic reasoning. There is general agreement that intuition relates to the ability to sense or know immediately without the intervention of conscious reasoning (Bastick, 1982; Bowers et al., 1990; Bruner, 1960; Hodgkinson et al., 2008). Thus, one hallmark feature of intuitive processes is their speed. Furthermore, intuitive processes are assumed to operate spontaneously in the absence of explicit intentions or goals. In addition, presumed to reflect their implicit nature, intuitive processes may defy verbal description. These features of intuitive processes may be used to determine the role of intuition in risk perception.

In the present study, the role of intuitive processes was examined using HIV as a model system. Traditionally, HIV risk was studied from the perspective of cognitive risk models ("What is the likelihood that you will contract HIV?"). However, there is some preliminary evidence that intuitive processes may play a role in the perception of HIV risk. For HIV as a communicable risk one's personal risk perception depends strongly on the evaluation of the risk of the potential partner ('other-related risk' or 'partner-specific risk perception', cf. Poppen & Reisen, 1997). Retrospective reports from people who are infected with HIV, results from field studies, and from studies with student samples suggest that people are often convinced that their sexual partners are safe (Agocha & Cooper, 1999; Gold et al., 1992; Keller, 1993; Klepinger et al., 1993; Misovich et al., 1997; Thompson et al., 2002; Williams et al., 1992). Moreover, people tend to exhibit overconfidence in their ability to detect unsafe partners as well as underestimate their risk for contracting HIV (Misovich et al., 1997; Thompson et al., 1999; Thompson et al., 2002). One possible strategy how people might judge the risk posed by their partner is by examining his/her appearance (Donovan, 2000). Such strategies have been called 'illusory control strategies' because they do not provide reliable protection and might nurture erroneous beliefs about control over risk (Misovich et al., 1997; Thompson et al., 1999; Thompson et al., 2002). These findings suggest that people may rely on intuitive process to assess their partners' safety.

Does HIV risk perception rely on intuition? To reveal that risk perception occurs fast, the feeling of risk should be sensed immediately and without the intervention of conscious reasoning. Moreover, to perceive other people as safe or unsafe is strongly

connected to the affect system. The measurement of event-related brain potentials appears well-suited to demonstrate the operation of these two key features of intuitive processes. With regard to speed of processing, determining the point in time at which brain waves associated with risky or safe evaluations diverge is critical. Deliberate or systematic reasoning effects appear late in the processing stream, while processing that bypasses systematic reasoning is fast and should be apparent within a split second. With regard to affect, a large body of evidence shows that the amplitude of the so-called late positive potentials varies as a function of the motivational significance of pictures (Codispoti, Ferrari, De Cesarei, & Cardinale, 2006; Flaisch, Stockburger, & Schupp, 2008; Keil et al., 2002; Sabatinelli, Lang, Keil, & Bradley, 2007; Schupp et al., 2006). Furthermore, recent research detailed the interaction of explicit task relevance and intrinsic motivational stimulus significance. When explicitly paying attention to emotional and neutral stimuli, the LPP continued to be sensitive to the emotional significance of pictures. Specifically, Ferrari and colleagues (2008) observed that the effects of explicit task relevance and intrinsic stimulus significance operated additively. Somewhat different, Schupp and colleagues (2007b) showed that explicit attention effects to emotional compared to neutral contents were over-additive, resulting in potentiated LPP amplitudes. Overall, across studies, the LPP component is sensitive to emotional stimulus significance, rendering this component as primary candidate to reveal the operation of affect in risk perception. Of note, the latency (300 - 700 ms) of the LPP effect strongly suggests preconscious processing preceding systematic and deliberate reasoning.

The present study explored neural correlates of HIV risk perception. The perception of HIV risk represents a model system in which risk perceptions are based on the other person's risk. As a result, risk perceptions are self-relevant and, because the other person's risk is evaluated, judgments can be obtained to a large number of people, sufficient to measure event-related brain activity. In the present study participants viewed faces of 120 persons while dense sensor brain potentials were recorded. Immediately following each picture presentation, participants were asked to evaluate the risk of HIV-infection for the person just seen. In the main analysis explicit judgments were used to build safe (low risk) and risky (high risk) categories. Predictions regarding the hypothesis that risk perceptions are based on intuitive processes were based on previous ERP research. Considering the LPP component as a sensitive measure of intrinsic motivational significance, it is predicted that the LPP

amplitude varies as a function of risk status, being enlarged for people evaluated high in HIV risk. Moreover, considering the speed of intuitive processing, a differential ERP activity for high compared to low HIV risk is predicted, possibly even preceding the LPP component.

Method

Participants

Forty-two participants (27 women) were recruited on the campus of the University of Konstanz. All participants provided informed consent, were assured anonymity, and debriefed after completion of the experiment. All subjects had normal or corrected-to-normal vision and no known neurological diseases. Participants received either payment or course credits. Four participants were excluded from the analyses. One participant apparently failed to comply. He showed almost no variance in his risk ratings and these data were thus excluded. Three participants were excluded from the electrophysiological analyses because their data contained too few trials in one of the conditions, thus effectively preventing the calculation of an ERP. Accordingly, the resulting sample consisted of 38 persons. The age of this sample ranged between 20 and 32 years (M = 24.1, SD = 2.6).

Stimuli

The facial photographs that served as stimulus materials were taken from three databases (Due to copyright restrictions it is not possible to include examples of stimulus materials. Placeholders will be used instead.): AR Face Database (Martinez & Benavente, 1998), CVL Face Database (Peer, 2005), and CAL/PAL FacesDB (Minear & Park, 2004). In order to assure ecological validity and to eliminate the influence of confounding factors, the following criteria were used to select the stimulus materials: (1) Frontal head-portrait views, (2) neutral emotional expression, and (3) direct eye gaze. Furthermore, to be representative for the study's target population in terms of race and age, only (4) Caucasian faces (5) from young adults were included. No restrictions were imposed with regard to hairstyle, wearing make-up, or glasses. Two stimulus sets were obtained, consisting of 120 male and 120 female faces, respectively. To have appropriate stimulus materials for the heterosexual participants, males were shown pictures of female faces and females were shown pictures of males. Illumination conditions across the pictures were comparable and all were taken in front of bright backgrounds. As the area covered by the face differed among the databases, this area was equated by resizing. All stimuli were converted to a common format (768 * 576 pixel).

Task and Procedure

After arrival at the lab, participants were prepared for EEG (Electroencephalogram) recording and seated in an armchair in a dimly lit, sound-attenuated chamber. Using Presentation software (Neurobehavioral Systems, Inc., Albany, CA) the facial photographs were shown on a 21-in. CRT monitor (75-Hz refresh rate) located approximately 100 cm in front of the participant.

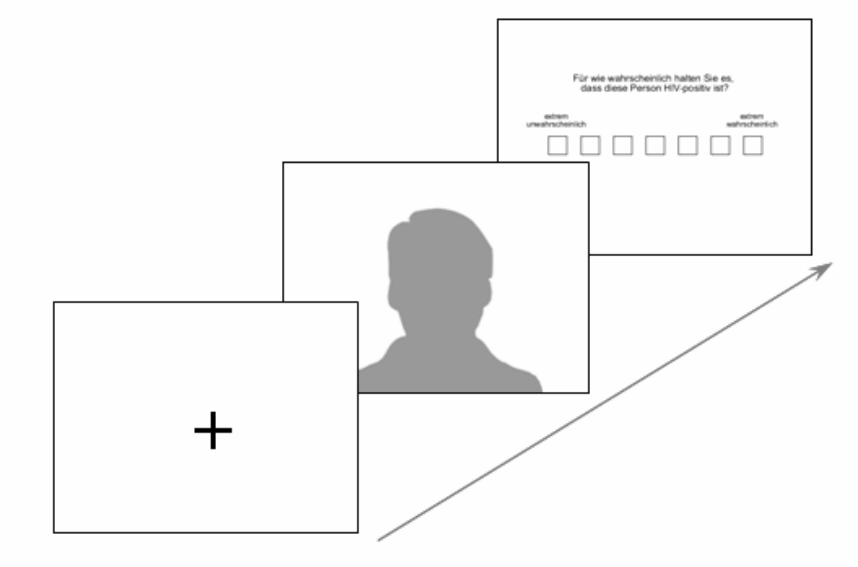

Figure 1.1: Graphical Illustration of one trial. Participants viewed face stimuli while their EEG was recorded. After displaying the face, a rating scale was shown and participants reported on their spontaneous impression of the risk that the person is HIV-positive.

Each of 120 trials consisted of the presentation of a fixation cross (1 s), the target photograph (2 s), a blank screen (1 s), and the presentation of the HIV risk rating scale (see Figure 1.1). Participants were asked to report on their first impression of HIV risk for every person (facial photograph) presented. Before the presentation of 120 trials with concurrent EEG recording was started, participants completed three test trials to familiarize them with the mouse-operated risk judgment procedure. Specifically, the perceived HIV risk was assessed by the item “How likely is it that this person is HIV-positive?” (original terms in German: "Für wie wahrscheinlich halten Sie es, dass diese Person HIV-positiv ist?"; cf. Agocha & Cooper, 1999; Malloy, Fisher, Albright, Misovich, & Fisher, 1997). A 7-point rating scale with verbal anchors for most

extreme ratings ("very unlikely" and "very likely"; German: "sehr unwahrscheinlich" and "sehr wahrscheinlich", corresponding to numerical values 1 and 7) was used to collect the ratings. After participants reported their risk perception for the face just presented, the next trial was initiated with an ITI of 6.5 s, consisting of the presentation of a blank screen. The order of the 120 pictures was varied randomly from participant to participant.

Manipulation Check: Do Faces Differ in Their Ascribed Risk?

To address the question of how perceived risk affects event-related brain responses, it is necessary to demonstrate that the risk ratings varied across the presented faces. To assess whether the faces represented the full range of perceived HIV risk, means and standard errors of the risk ratings were calculated for every individual photograph. Figure 1.2 shows these results, rank-ordered by increasing perceived risk. Since male or female participants viewed females' or males' faces, respectively, the calculations were done separately for each gender. As evident in Figure 1.2, perceived risk for the presented faces varied across the full range from low to high and this result was similarly obtained for male and female subgroups.

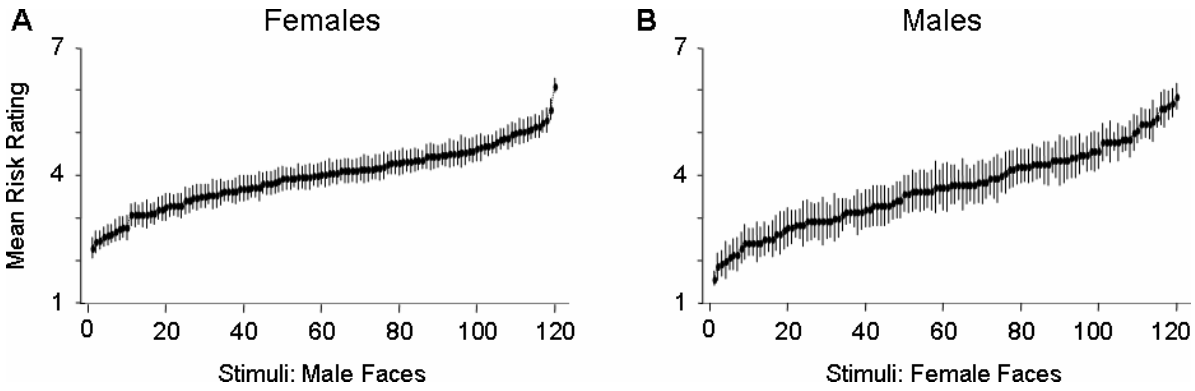

Figure 1.2: Average ratings of HIV risk (1 - low risk; 7 - high risk) and standard errors for all experimental stimuli. Faces spanned a range of perceived risk, similarly for female and male subjects. A) Risk ratings of female participants for 120 male faces, rank-ordered by increasing risk. B) Risk ratings of males for 120 female faces, sorted by increasing risk.

An alternative and more conservative way to test that the perceived risk for the presented faces varied is to demonstrate that every participant used a wide range of the risk scale. In line with this, all participants showed clear variance in their ratings. Additionally, relative frequencies for each risk category were calculated, separately for each participant. Table 1.1 presents the average of these participant-specific frequencies and their standard deviations across participants. This analysis provides confirming evidence that perceived risk varied substantially. As expected, however, the 'very low' and 'very high' risk categories were used less often.

Table 1.1: Average frequencies and standard deviations for the 7 rating categories across all participants.

Risk Rating	**1** low risk	**2**	**3**	**4**	**5**	**6**	**7** high risk
Average Frequency	11.0	16.5	24.4	18.0	27.6	17.0	5.4
SD	(13.3)	(7.1)	(8.5)	(15.3)	(9.7)	(9.7)	(6.5)

Electrophysiological Recording and Data Reduction

EEG data were recorded using an EGI system (Electrical Geodesics, Inc., Eugene, OR) consisting of 257 channel HydroCel Geodesic Sensor Nets, NetStation 4.12 software, and NetAmps 200 high-input impedance amplifiers. Impedances were kept below 40 kΩ at the beginning of the session, as recommended for this type of amplifier. The EEG was recorded with a sampling rate of 250 Hz, the vertex sensor (Cz) as reference electrode, and online bandpass filtered from 0.1 to 100 Hz. The analysis was performed using EMEGS software (Junghöfer & Peyk, 2004) and parts of the EEGLAB package (Delorme & Makeig, 2004), both running under Matlab (The Mathworks, Inc., Natick, MA). EEG data were lowpass filtered at 40 Hz using digital filtering before stimulus synchronized epochs were extracted from 100 ms before until 800 ms after picture onset. Next, for artifact rejection and correction, data were submitted to an algorithm developed by Junghöfer and collaborators (Junghöfer, Elbert, Tucker, & Rockstroh, 2000). This method uses a procedure based on statistical

parameters of the data. In a first step, recording channel artifacts are detected using the recording reference. Subsequently, global artifacts are detected using the average reference. Then, in an interactive step, distinct sensors from particular trials are removed on the basis of the distribution of their amplitude, standard deviation, and gradient. The information of eliminated electrodes is replaced with a statistically weighted spherical interpolation from the full channel set. All analyses were performed using the average reference and a 100 ms baseline correction.

Data Analysis

The main aim of the present experiment is to determine whether high vs. low risk perception is associated with ERP differences. Thus, to obtain separate ERP waveforms associated with low vs. high risk stimuli, the degree of attributed risk needs to be determined for all faces - separately for every participant. In particular, the same faces might receive dissimilar judgments from different participants. To incorporate such idiosyncratic responding in the analysis of EEG data, trial-sorting procedures were employed.

Two streams of data analysis were pursued. In a first stream of analyses, data were dichotomized along the perceived risk dimension (see below: Low vs. High Risk ERPs). This analysis, which is preferable for the analysis of ERP data[1], examined whether high vs. low risk stimuli elicit larger responses and at what time the ERP waveforms start to differentiate. A second stream of refined analyses explored whether the more gradual nature of risk ratings is mirrored in electroencephalographic data (see below: Gradual Analysis of Event-Related Brain Activity). Toward this end, electroencephalographic data were analyzed separately for each level of perceived risk via category-specific subaverages or by means of gradual single-trial ERPImages (see below).

[1] *At first sight it might seem more appropriate to analyze the data separately for every level of risk. Such a strategy, however, is associated with a very low signal-to-noise ratio in the electroencephalographic analyses.*

Low vs. High Risk ERPs

Categorization of Low and High Risk Ratings for ERP Averaging: For each participant, high risk faces (risk ratings ranging from 1-3) and low risk faces (risk ratings from 5-7) were identified[2]. ERP waveforms were then obtained for each participant by averaging across low risk and high risk trials, respectively.

Statistical Procedure for ERP Analysis: Visual inspection and single sensor waveform analyses were used in a two-step procedure to analyze the risk modulation of the ERPs. In a first step, t-tests including the factor RISK (low vs. high) were calculated for every time point after picture onset, separately for each individual sensor, in order to identify ERP components sensitive to risk status. These waveform analyses were conducted using a significance criterion of $p < 0.05$. In order to avoid false positives, significant effects were only considered meaningful when the effects were observed for at least four continuous data points (32 ms) and two neighboring sensors. The outcome of the waveform analyses suggested two ERP components that were modulated by risk. In a second step, the outcome of these waveform analyses served to collapse information according to the spatial focus and temporal characteristics of the modulation by risk status. Sensor clusters were defined and the average of the selected sensors was calculated. Similarly, the mean activity was obtained in critical time windows. This information was analyzed by repeated measurement ANOVAs[3] in order to provide a more standard ERP analysis. Greenhouse-Geisser corrections were utilized where appropriate to correct for violations of sphericity. Preliminary analyses indicated no gender differences and accordingly analyses were collapsed across gender.

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[2] *Because this straightforward scheme of forming low and high risk categories (1 - 3 = low risk; 5 - 7 = high risk) may not be particularly suited for all participants, a supplementary analysis employed a z-scoring procedure to corroborate the results from the main analysis. For each participant the risk ratings for all 120 pictures were z-transformed. Z-scores smaller than zero were categorized as 'low risk', and positive values as 'high risk'. So far this procedure equals a median split, and thus leads to equal trial numbers in both categories. However, we eliminated z-scores between +/- 0.3, resulting in an average of 48.3 trials in the low risk category and 50.0 trials in the high risk category. Thus, the z-scoring procedure established participant-specific categories of low and high risk and therefore complements the normative category definition. This analysis also allowed incorporating data from one participant who had been excluded previously on behalf of too few trials in the high risk categories. However, performing the analysis without this participant led to the same conclusions.*

[3] *With only two levels, this equates to the t-test. However, in later analyses additional factors will be incorporated. Thus, to be consistent, all t-tests will be reported in the corresponding F-notation.*

Effects between 350 - 450ms (Fronto-Central & Occipital Regions): High risk faces were associated with increased positivity over fronto-central sensor sites. Accordingly, the ERP was assessed as mean activity over a time interval from 350 - 450 ms and collapsed across a fronto-central sensor cluster comprising the following EGI sensors: # 4, 5, 6, 7, 8, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 27, 28, 29, 30, 34, 35, 36, 198, 207, 215, and 224 (Figure 1.3). The effect appeared reversed in polarity over occipital sites and was assessed by collapsing across the following sensors: # *111, 112, 113, 120, 121, 122, 133, 134, 135, 145, 146, 147, 156, 157, 165, 166, 167, 174, 175, 176, 187, 188,* and *199* (Figure 1.3).

Effects between 450 - 650 ms (Centro-Parietal Regions): Subsequent to the effect between 350 - 450 ms, high risk faces were associated with increased positivity over centro-parietal sensor sites in an interval between 450 - 650 ms. Accordingly, the ERP activity was assessed as mean activity over this time interval and collapsed across a bilateral centro-parietal sensor cluster comprising the following sensors: # *7, 9, 16, 17, 24, 42, 43, 44, 45, 50, 51, 52, 53, 57, 58, 59, 60, 64, 65, 66, 78, 79, 80, 131, 132, 143, 144, 154, 155, 164, 182, 183, 184, 185, 186, 194, 195, 196, 197, 198, 204, 205, 206,* and *207* (Figure 1.3).

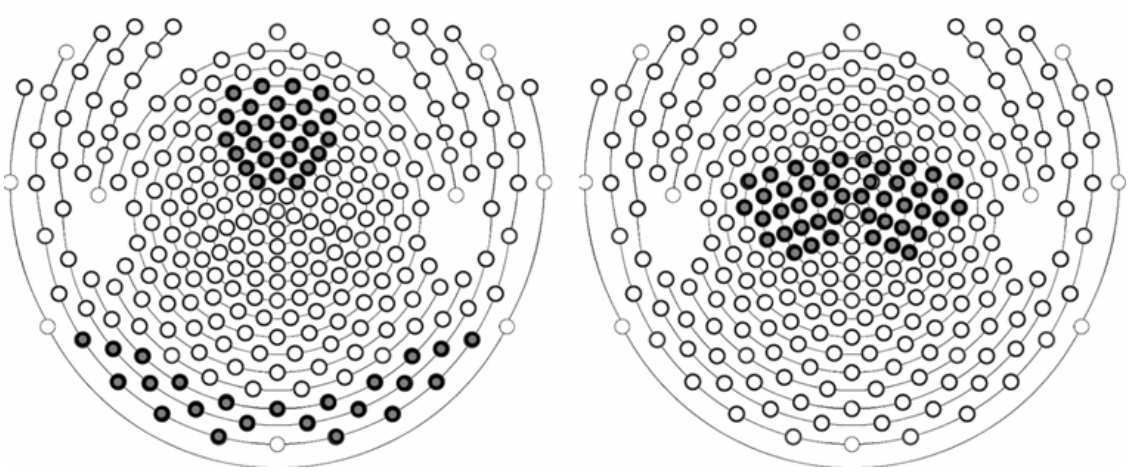

Figure 1.3: Layout of the electrode array. The marked sensor clusters were selected to form regional means. Left: Fronto-central and occipital cluster to assess the effects between 350 - 450 ms post stimulus. Right: Centro-parietal cluster to asses the effects from 450 - 650 ms.

Gradual Analysis of Event-Related Brain Activity

In order to extend the findings based on dichotomized ratings, this second stream of refined analyses explored EEG amplitudes by incorporating gradual risk ratings. The gradual effects of perceived risk on EEG amplitudes were assessed in the above-mentioned regions (fronto-central, occipital, centro-parietal) and time windows (350 - 450 ms, 450 - 650 ms).

Gradual Analysis of All Seven Levels of the Risk Scale: In a first step, for each participant, ERPs were averaged within each of the seven different risk categories. Assuming no artifacts and equal usage of all seven risk categories, this leads to approximately 17 trials per category (120/7) to calculate the ERP. However, due to artifacts and expected unequal rating distributions (cf. Table 1.1), not all categories allow a reliable calculation of ERPs for every level. This problem was addressed by implementing a criterion of at least 5 trials for every category of risk. If this was not fulfilled, the data were considered not good enough to derive a categorywise ERP and the participant's data were deleted casewise. As reported in Table 1.1, across all participants, level 1 as well as level 7, was compromised by this fact. Hence it was decided to conduct the analysis for the levels 2, 3, 4, 5, 6, which contained sufficient ratings. In addition to the restriction of categories this approach comes at the relatively high cost that due to the casewise deletion of missing values a relatively large share of data is discarded whenever a participant provided too few ratings for one category.

Gradual Analysis of All Seven Levels of the Risk Scale - Based on All Single-trials: A different procedure can also test for gradual variations, but makes use of all available data from every participant. In this analysis the single-trial EEG data from all participants were first labeled by their corresponding risk rating. Next, without paying reference to the fact that single-trial data came from the same or from a different participant, an ANOVA was run on all available trials (N = 3568), including only CATEGORY as a between-factor[4] (7 levels: ratings 1 - 7).

[4] *Thus, trials from different categories were treated as if they came from independent samples. From a statistical point of view this approach does not guarantee that all participants contribute equally to the available data for a given category. Furthermore, the omission of the repeated measures structure of the data could be criticized. On the other hand, this analysis has the advantage that enough data are available for all seven categories and that no participants need to be excluded.*

Gradual Analysis Using ERPImage Plotting: Finally, to circumvent problems associated with both 7-category-analyses, single-trial ERPImage plots (Makeig 2004, Jung 2001) were utilized. Like the seven-stepped analysis, ERPImages of single-trial EEG data can reveal gradual variations in the amplitudes of event-related responses that are otherwise hidden in total EEG variability. However, rather than collapsing them into categories, ERPImages make full use of the information contained in all available (maximally 120) brain responses. Therefore, unequal trial numbers per category are not per se a problem for this way of analyzing the data. To form an ERPImage, potentials recorded at one scalp channel or at a group of neighboring sensors are sorted trial-wise by a relevant response measure. Specifically, for the present purposes individual EEG epochs were sorted by subsequent risk rating. Next, the sorted EEG epochs are plotted as parallel, colored lines forming a rectangular image. Thus, while in classical ERP plots the ordinate represents voltage and the abscissa shows time, the ordinate of an ERPImage consists of the number of trials stacked above each other, with EEG amplitude now being color-coded so that more reddish colors correspond to higher amplitudes. The ERPImage may be displayed before or after smoothing with a narrow moving window to increase the salience of time-locked response features. Furthermore, it is also possible to create group ERPImages by taking the mean of individual participants' ERPImages (Delorme, Westerfield, & Makeig, 2007).

In sum, to account for the problems of the 7-category-analysis with unequal and low numbers of ratings on different levels between individual participants, participant-specific ERPImages were group-averaged after normalization to a common height. Because category sizes differ between participants, this procedure leads to a smearing of the category boundaries between the seven levels. However, it still preserves critical information about the gradual variation of responses. Furthermore, it ensures that all available data from every participant are used and that all participants contribute equally to the group average. To uncover gradual variations, ERPImages were created for all sensor clusters (see Figure 1.3). For the creation of a participant's ERPImage, single-trial EEG data were averaged over the respective cluster and labeled with the corresponding risk rating (1 - 7). Thereafter, the risk-labeled trials were sorted in ascending order. Finally, these trials were plotted in a stacked manner and with color-coded amplitude information. Finally, to attain group-level ERPImages, the

ERPImages of single participants were normalized to a common height and averaged together.

These three analyses were all computed using the previously identified time intervals (350 - 450 ms and 450 - 650 ms). Sensor clusters were slightly modified to capture the regions of maximum differentiation as observed in the dichotomized ERP analysis. Thus, the fronto-central effect was assessed by collapsing over a sensor cluster consisting of EGI sensor numbers # 6, 7, 8 14, 15, 16, 22, and 23. The occipital sensor cluster comprised sensors # 120, 121, 133, 134, 145, 146, 156, 165, 166, 174, 175, and 187. Finally, the centro-parietal cluster contained the following sensors: *# 9, 17, 44, 45, 53, 81, 90, 131, 132, 143, 144, 154, 155, 164, 182, 183, 184, 185, 186, 194, 195, 196, 197, 198, and 257.*

Results

Low vs. High Risk ERPs

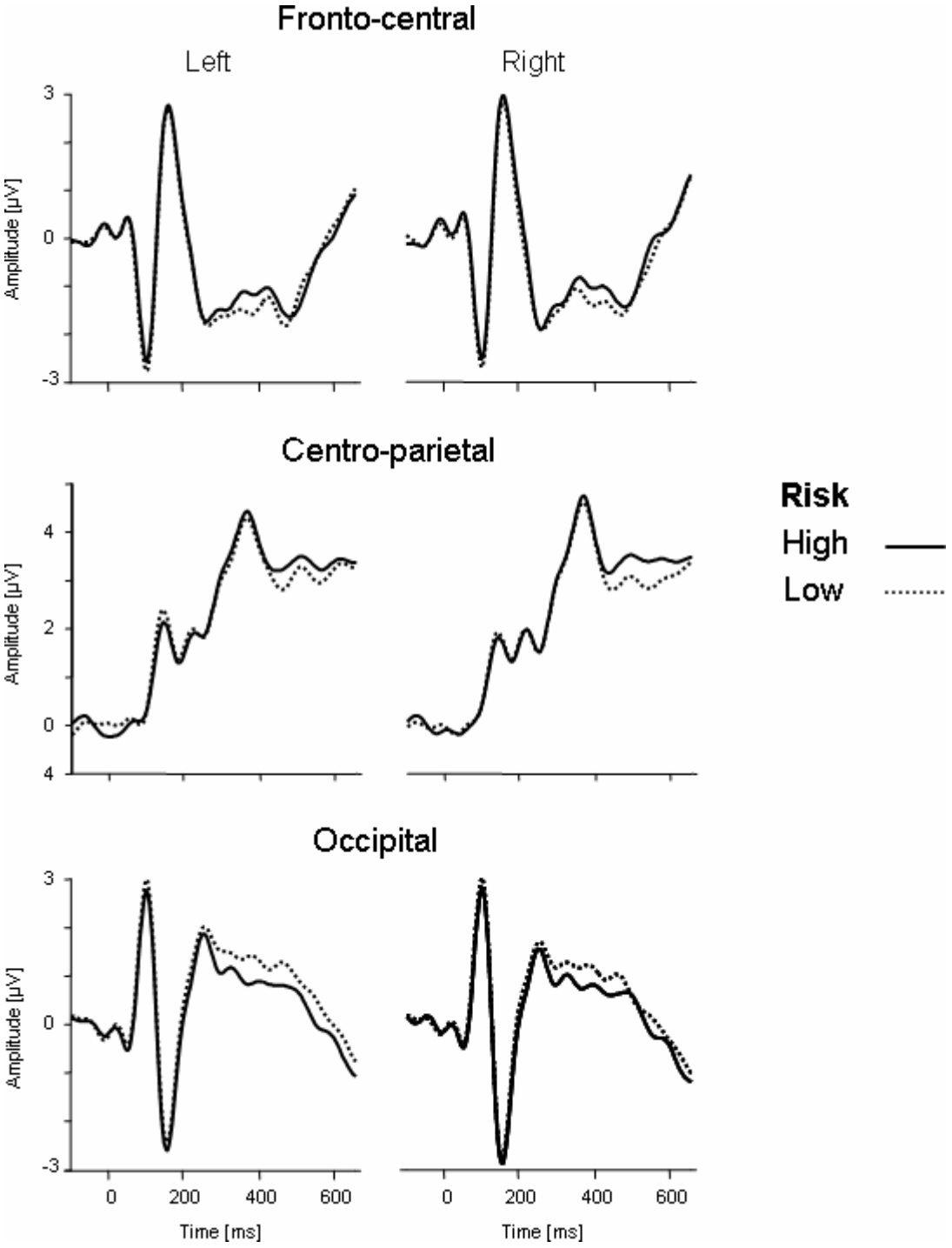

Figure 1.4: ERPs toward low and high risk faces plotted for representative bilateral pairs of sensors from fronto-central (# 36, 224), centro-parietal (# 79, 143), and occipital regions (# 134, 166).

Effects between 350 - 450 ms: The present study obtained evidence for differential ERP responses toward risky faces. Augmented amplitudes to risky compared with safe faces developed around 350 ms after stimulus onset over central and fronto-central sensors (Figure 1.4). Calculation of difference maps (ERPs toward risky minus safe faces) revealed broadly distributed effects of increased positivity and corresponding occipital negativity (Figure 1.5).

This effect was captured by calculating the mean activity over a 100 ms interval (350 - 450 ms) for fronto-central and occipital clusters and submitting these values to an ANOVA. As expected, a significant interaction of RISK × LOCATION was observed ($F_{RISK \times LOCATION}(1,37) = 6.53$; $p < 0.05$), confirming the polarity reversal of the risk-effect between fronto-central and occipital sites. Next, separate ANOVAs were calculated for fronto-central and occipital regions.

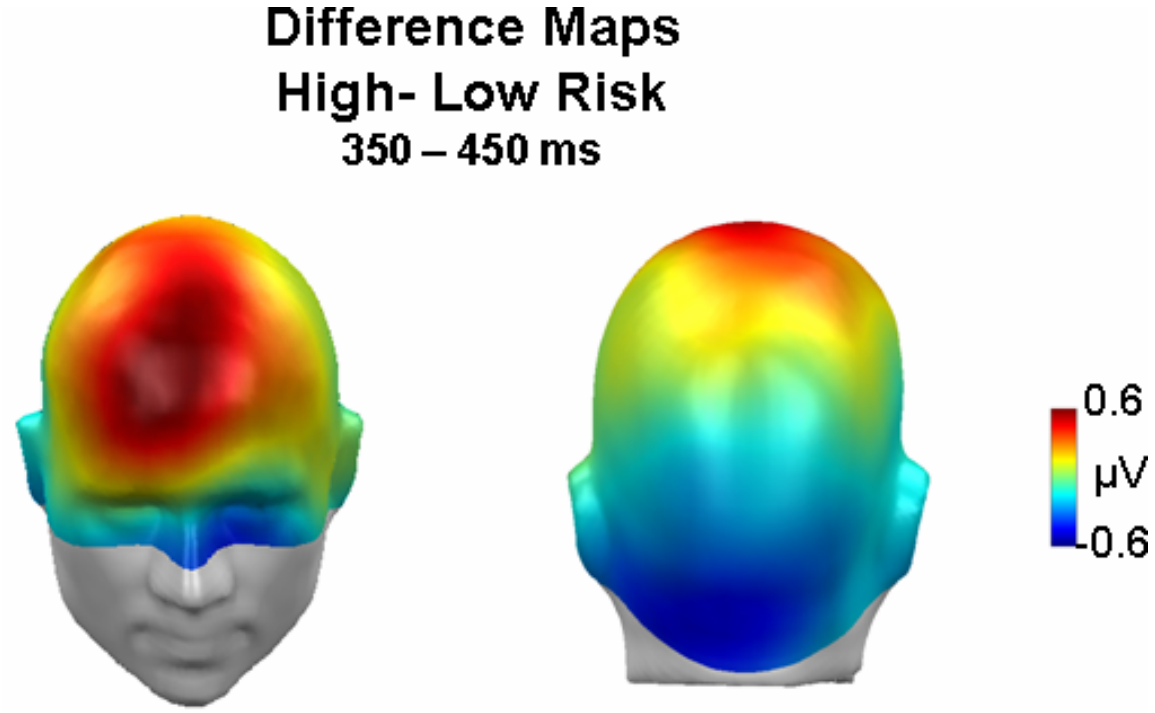

Figure 1.5: Scalp potential difference maps (high - low risk) of ERPs toward high and low risky faces for the interval used in the statistical analysis (350 - 450 ms). To derive these maps, voltages were interpolated to the scalp surface using spherical splines (Perrin, Bertrand, & Pernier, 1987).

Over fronto-central leads, this analysis revealed a main effect of RISK, consisting of an enlarged positivity for high risk as compared to low risk faces (F_{RISK} (1,37) = 5.65, $p < 0.05$; $M_{LOW\ RISK}$ = -0.93 µV; $M_{HIGH\ RISK}$ = -0.48 µV). Over occipital sites, the effect was mirrored in polarity, thus appearing as a significantly larger negativity for risky pictures (F_{RISK} (1,37) = 5.13, $p < 0.05$; $M_{LOW\ RISK}$ = 0.95 µV; $M_{HIGH\ RISK}$ = 0.58 µV).

Effects between 450 - 650 ms: Subsequent to the effect over fronto-central leads, a more posteriorly located sustained late positivity for risky faces was observed. Temporally, this effect was maximally pronounced in the time window from 450 - 650 ms, as illustrated in Figure 1.4 for representative left and right centro-parietal sensors. Topographically, a late positivity was present over bilateral centro-parietal regions, with a maximum over midline and right centro-parietal areas (Figure 1. 6).

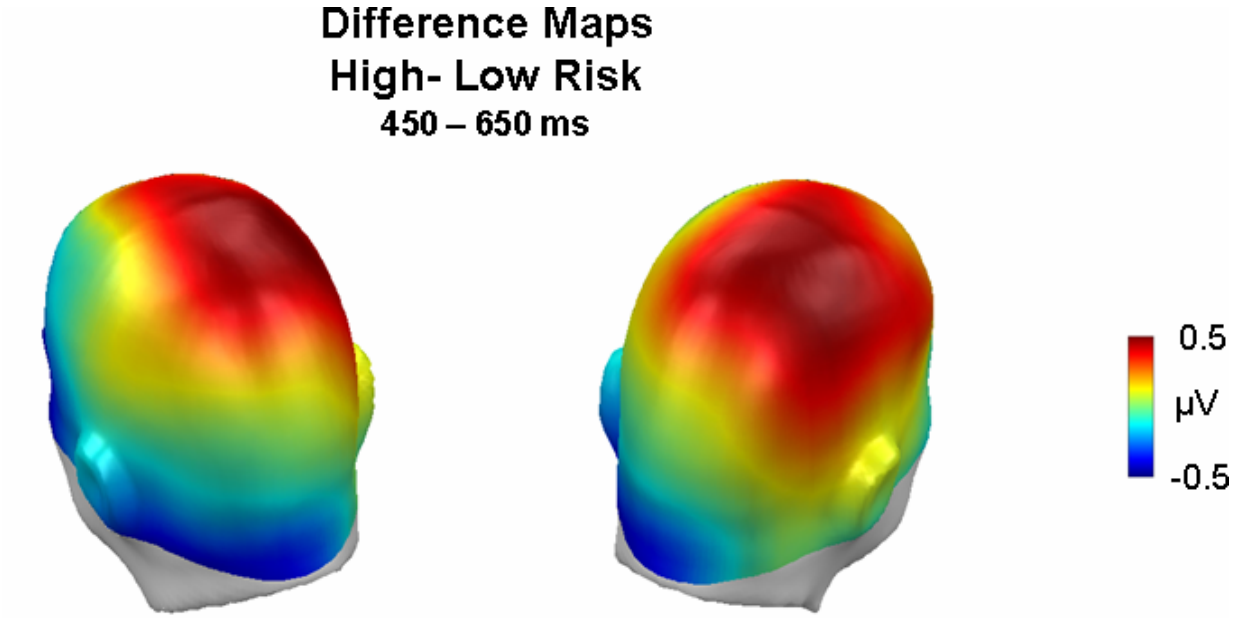

Figure 1.6: Topographical difference maps for high - low risk faces projected on the back view of a model head (mean from 450 - 650 ms).

Risky images were associated with a stronger positive shift at centro-parietal sensors, resulting in a significant main effect of RISK (F_{RISK} (1,37) = 5.17; $p < 0.05$; $M_{LOW\ RISK}$ = 1.06 μV; $M_{HIGH\ RISK}$ = 1.3 μV). The interaction of RISK × LATERALITY was not significant ($F_{RISK \times LATERALITY}$ (1,37) = 2.88; p = 0.09), although the effect was slightly more pronounced over midline and right centro-parietal regions.

Control Analysis Based on Z-Scores: For the main analysis reported above, categories of low risk faces were formed by individual risk ratings of 1, 2, and 3. Risk ratings of 5, 6, and 7 comprised the high risk category[5]. To ensure that the detected findings were not restricted to the particular categorization procedure (1 - 3 vs. 5 - 7), a subdivision of self-report ratings into low and high risk classes was carried out using a z-transformation. In the interval from 350 - 450 ms z-score based analyses resulted in a significant interaction between the RISK and the LOCATION factor ($F_{RISK \times LOCATION}$ (1,38) = 6.26, $p < 0.05$). Exploring effects of RISK separately for both regions, a main effect of RISK (F_{RISK} (1,38) = 5.58, $p < 0.05$) was observed over the fronto-central cluster ($M_{LOW\ RISK}$ = -0.95 μV; $M_{HIGH\ RISK}$ = -0.58 μV). Over occipital sensor sites the main effect of RISK was also significant, here with reversed polarity (F_{RISK} (1,38) = 4.19, $p < 0.05$; $M_{LOW\ RISK}$ = 0.93 μV; $M_{HIGH\ RISK}$ = 0.63 μV). Similarly, for the late window of interest (450 - 650 ms), a significant effect was obtained for RISK (F_{RISK} (1,38) = 4.99 $p < 0.05$; $M_{LOW\ RISK}$ = 0.97 μV; $M_{HIGH\ RISK}$ = 1.18 μV), again in the absence of an interaction ($F_{RISK \times LATERALITY}$ (1,38) = 2.83; p = 0.1). In conclusion, these analyses supported the results of the primary analysis. The observed enlarged positivity toward risky faces was not compromised by the specific way of forming low vs. high risk ERPs from idiosyncratic ratings.

[5] *By relying on this mode of categorization, the low and high risk categories contained on average 54.7 (SD = 13.8) and 59.7 (SD = 14.5) trials, respectively. A paired t-test was used to compare the number of trials per category across participants. This resulted in an insignificant difference of trial numbers (t(37) = 1.1, p = 0.27).*

Gradual Analysis of Event-Related Brain Activity

Having established that high risk is associated with increased amplitudes over central regions, one may ask whether this resulted from very high amplitudes toward the faces with highest risk ratings (e.g., 7), or whether this increase reflects a more gradual phenomenon. To answer this question, a second stream of analyses explored whether EEG amplitudes increased gradually with increasing risk or whether effects were constrained solely to the very high risk stimuli.

As outlined above (cf. Table 1.1), rating categories 2, 3, 4, 5, and 6 provided sufficient cells to assess the categorywise results statistically by means of repeated measures ANOVA. The final analysis included 19 participants for whom enough data were available for categories 2 - 6 to render a categorywise analysis feasible. As depicted in Figure 1.7 (upper plot) neither the occipital nor the fronto-central cluster revealed unequivocal results regarding gradual variations of ERP amplitudes. Testing for linear trends did not reveal significant linear relationships between perceived risk and categorywise ERP amplitudes (occipital cluster: $F_{Linear} = 0.88$; fronto-central: $F_{Linear} = 0.37$, both n.s.). For the centro-parietal effect (450 - 650 ms), however, a significant, consistent linear trend was confirmed ($F_{Linear} = 5.17$, $p < 0.05$), pointing to increasing ERP amplitudes as faces became riskier.

For the analysis reported above a substantial proportion of participants had to be excluded and the less reliable (in terms of ERP stability) categories from the margin (1 and 7) were discarded. To circumvent this, in an additional analysis every trial was treated as an individual sample point. Thus, sufficient data for all categories were available in order to allow for statistical assessment. In the ANOVA trials from different categories were modeled as independent groups[6]. Similar to the analysis reported above, for the occipital and fronto-central clusters no linear effects were observed (fronto-central : $F_{Linear} = 0.03$, occipital: $F_{LINEAR} = 1.53$, both n.s.). Supporting the earlier conclusions, the centro-parietal effect was best captured by a linear trend ($F_{Linear} = 13.14$, $p < 0.001$). Thus, this analysis yielded results very similar to those

[6]*Total numbers of trials per category: $N_1 = 358$, $N_2 = 534$, $N_3 = 743$, $N_4 = 467$, $N_5 = 816$, $N_6 = 489$, $N_7 = 161$; Mean amplitudes for the three assessed effects: fronto-central: $M_1 = 0.33$, $M_2 = -0.12$, $M_3 = -0.81$, $M_4 = 0.12$, $M_5 = -0.32$, $M_6 = -0.67$, $M_7 = 0.42$; occipital: $M_1 = -0.01$, $M_2 = 1.11$, $M_3 = 1.37$, $M_4 = 1.15$, $M_5 = 1.00$, $M_6 = 1.36$, $M_7 = 0.59$; centro-parietal: $M_1 = 1.87$, $M_2 = 1.35$, $M_3 = 1.41$, $M_4 = 1.57$, $M_5 = 1.61$, $M_6 = 2.24$, $M_7 = 2.72$.*

from the initial categorywise repeated measures ANOVA. With increasing risk, EEG amplitudes over centro-parietal regions were characterized by enlarged positivity.

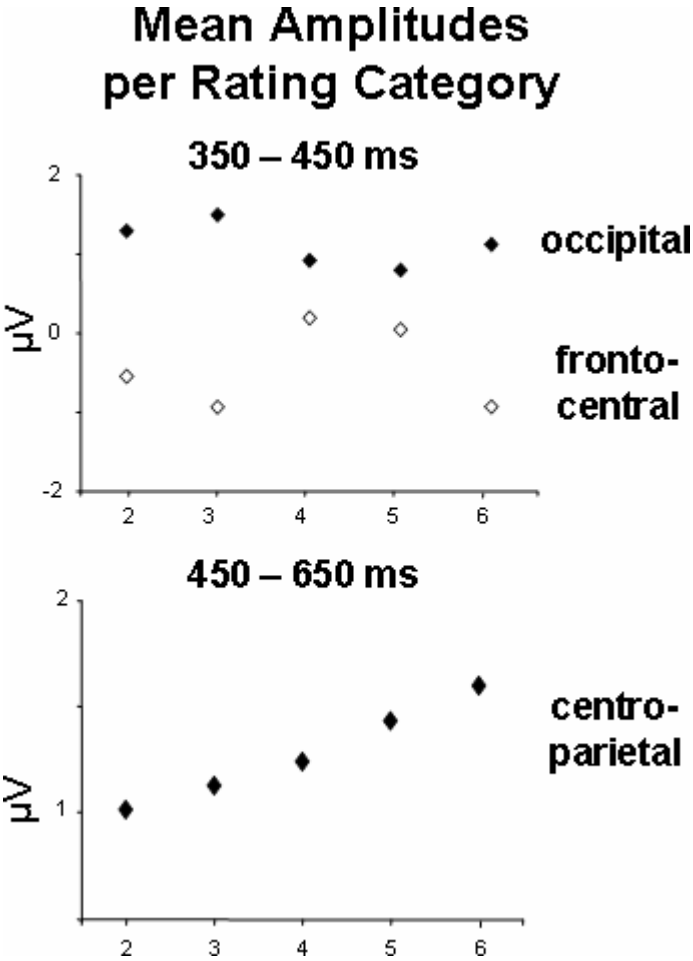

Figure 1.7: Top Panel: Mean Amplitude for fronto-central and occipital clusters in an interval between 350 - 450 ms for every level of the seven-stepped risk scale. Bottom Panel: Mean Amplitude for every level of the risk scale, calculated for the centro-parietal cluster and the critical interval between 450 - 650 ms post stimulus.

With respect to the effect between 450 - 650 ms, these refined analyses have provided evidence for a gradual variation of EEG amplitudes with increasing risk. They remain somewhat equivocal regarding the earlier effect. To further elaborate these findings, the ERPImage technique was employed to uncover gradual variations in risk-sorted single-trial EEG data. Particularly for the centro-parietal effect (450 - 650 ms) one would expect from the two categorywise analyses that single-trial EEG data are associated with higher amplitudes in the high as compared to the low

risk category. Figure 1.8 depicts a risk-sorted group ERPImage for the centro-parietal cluster, evidencing that higher EEG amplitudes from about 450 ms onwards are related to higher perceptions of HIV risk. Importantly, the pattern of results supports the notion that EEG amplitude varies gradually with risk ratings, with higher risk being gradually associated with larger amplitudes. Figure 1.9 shows ERPImages for the occipital and fronto-central clusters. For these regions the ERP analysis indicated larger negativity for risky pictures over occipital and larger positivity over frontal sensors, thus supporting the findings from the dichotomous analysis. The corresponding categorywise analyses did not provide irrevocable evidence, although the results did generally support the findings from the ERP analyses. Please note that although from Figure 1.7 it is not immediately apparent that low vs. high risk ERPs lead to significant effects, this analysis relied on a severely reduced sample and, even more important, neglected the extreme categories 1 and 7.

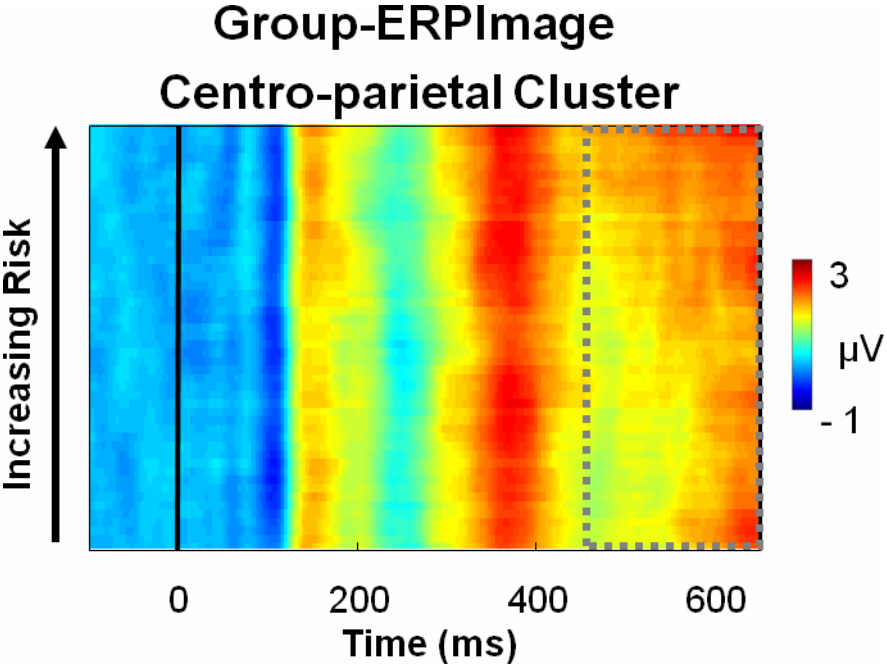

*Figure 1.8: Group ERPImage for the centro-parietal cluster, where the effect was observed in an interval between 450-650 ms post stimulus (indicated by the dotted lines). To derive the images, individual EEG epochs were first averaged over the sensor cluster, sorted in ascending order by subsequent idiosyncratic risk-ratings [1-7], and plotted as a time (x-axis) * risk-sorted-epochs (y-axis) * amplitude (color) plot. This plot shows the image obtained by group-averaging across the individual subject plots. Horizontal lines represent the color-coded voltage recorded for one pseudo-trial, with trials sorted according to the subsequent risk rating. To increase readability the plot was further smoothed by a moving average.*

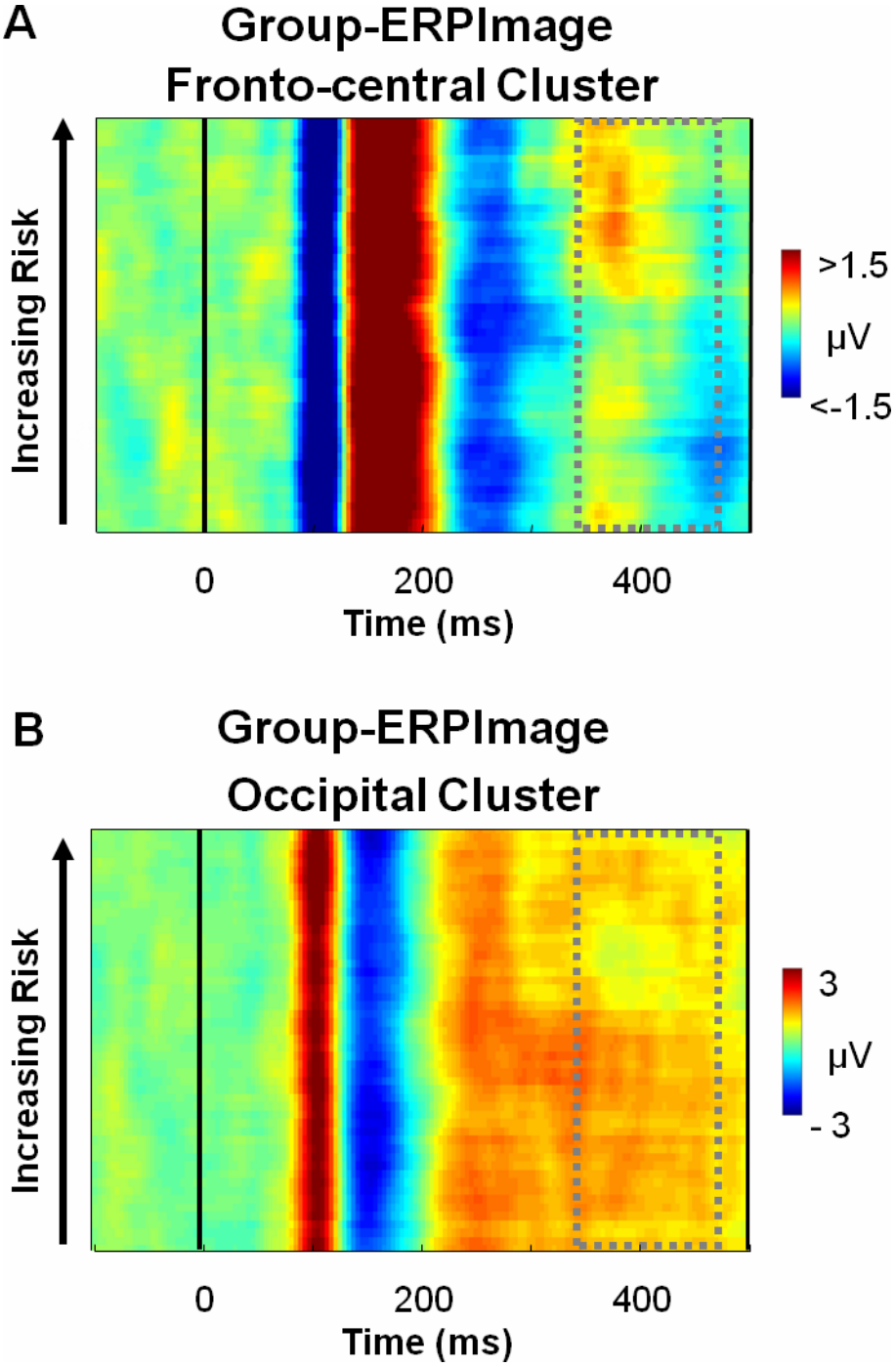

Figure 1.9: A) Group ERPImage Plot of single-trial EEG-epochs from a bilateral fronto-central cluster; B) Group ERPImage for the occipital sensor cluster.

Discussion

The present study investigated the notion that intuitive processes are involved in the perception of health risks. A premise of this perspective is that information associated with perceived health risk should be extracted fast and by means of affective evaluation. Two main findings support this assumption: First, risk-related modulations of the ERP emerged early in the processing stream (~350 ms), precluding the operation of deliberative and systematic reasoning. Second, indicative of affective evaluation, risky stimuli elicited enlarged LPP amplitudes. Results provide first empirical evidence regarding that intuitive processing is responsive to health-risk related information.

ERPs offer a high-resolution temporal measure to determine when risk status affects stimulus processing. The point in time when ERP waveforms to risky and safe stimuli reliably diverge provides an upper bound estimate of the time needed to extract risk-related health information. This information is relevant to discriminate fast and effortless processing, a hallmark feature of intuition, from effortful, deliberate, and slow reasoning (Hodgkinson et al., 2008). The first reliable differentiation among risky and safe stimuli was observed in a time window between 350 and 450 ms. Discriminating among risky and safe stimuli in a split second provides strong evidence for intuitive processing regarding the key feature of speed.

The early risk effect was observed as increased positivity over fronto-central leads when comparing risky and safe stimuli. Spatial topography and latency are reminiscent of the P3a, or novelty P3 (Debener, Makeig, Delorme, & Engel, 2005; Friedman, Cycowicz, & Gaeta, 2001). The P3a component is typically observed toward novel stimuli, which are interspersed in an oddball paradigm (with infrequent oddball stimuli and frequent distracters). From a functional perspective, the P3a has been linked to the orienting response. Novel stimuli may potentially signal danger and the P3a is considered as a first cortical component indicating increased attentional orienting to significant stimuli. The experimental design of the present study is different compared to classical oddball-based studies in that every stimulus was presented only once. Accordingly, considered from the perspective of the P3a literature, the present findings indicate that risky stimuli elicit enhanced attentional orienting presumably acting as a gateway to conscious perception of salient stimuli (Friedman et al., 2001).

Another hallmark feature of intuition is its reliance on affective processing (Plessner, 2008; Strack & Deutsch, 2004). The present finding of increased LPP amplitudes to risky compared to faces is considered to demonstrate the increased affective significance of risky stimuli. This interpretation is based on a large and consistent array of studies determining that the LPP amplitude is enlarged to affective stimuli (Schupp et al., 2006). More recently, the interaction of intrinsic stimulus and explicit task significance has been addressed. These studies have shown that task relevant affective stimuli prompt markedly larger LPP amplitudes when compared to task relevant, but neutral cues (Ferrari et al., 2008; Schupp et al., 2007b). Analogously, it is suggested that risky faces prompt larger LPP amplitudes indicating their increased motivational significance. Interestingly, whether a stimulus was perceived as risky depended solely on participants' idiosyncratic perception of risk or safety. Furthermore, task relevance was kept constant as the participants evaluated the risk of each stimulus. In addition, complementary analysis was undertaken to more closely investigate the relation of perceived risk and LPP amplitude. Specifically, single-trial ERP imaging allowed determining whether the LPP amplitude is most accentuated for stimuli perceived as highest in risk. This hypothesis builds upon previous findings demonstrating that the LPP modulation is most apparent for stimuli of high emotional intensity. As shown in Figure 1.7, a gradual increase of LPP amplitude with increasing risk was observed with largest LPP amplitudes for high-risk stimuli. This analysis provides corroborating evidence that risky stimuli are associated with increased affective significance during initial stimulus perception. In conclusion, these findings suggest the operation of affective evaluation processes pertaining to health-risk.

Alternatively, one might regard the LPP findings from the perspective of stimulus probability rather than motivational relevance. It has long been known that the P3 amplitude is sensitive to stimulus probability and rate of target occurrence (Linden, 2005; Polich, 2007). However, the present set of stimuli did not contain any obviously separable classes of faces with distinct physical characteristics. Rather, before one can categorize a face into one out of seven categories of risk, one must first evaluate it. Therefore, it appears unlikely that this evaluation should be affected by a global or local distribution of rating frequencies, which can logically only exert any influences after the faces have been categorized intuitively. Although theoretically implausible, empirical tests of the influence of probability revealed that the LPP modulations discussed here were unrelated to the frequency of category use, which corresponds to

the probability of picture categories (cf. Table 1.1 & Figure 1.7). Amplitudes toward high risk stimuli were enhanced, but the refined analyses clearly revealed that this amplitude enhancement could not be explained by probability accounts. In consequence, probability cannot account for the present findings, which are better explained by the notion of intuitive evaluations.

Complementary evidence for the intuitive nature of HIV risk perception is provided by participants' retrospective reports after completion of the experiment. Generally, they stated not being able to verbalize a clear rule to gauge HIV risk. Rather, they reported reliance on 'gut feelings' and immediate impressions, both indicative of intuition. Interestingly, this finding is reminiscent of results from field studies, in which participants report that they "just know who is safe" (Thompson et al., 1999; Thompson et al., 2002). It adds further support to the view that intuitive inferences are largely based on implicit knowledge (Cleeremans et al., 1998; Knowlton & Squire, 1996; Lieberman, 2000; Litman et al., 2005; Reber, 1989). When activated by incoming stimuli, intuition draws tacitly from cumulative knowledge that has been gathered by experience. The enhanced amplitudes of the LPP seem to reliably index this process, which must be mediated by rather complex, yet surprisingly fast information integration that results in introspectively unidentified evaluations.

By showing that HIV risk is evaluated fast and intuitively, the present results may have important practical implications. Past research has shown that in the course of sexual relationships people may use illusory strategies, such as relying on partner characteristics to decide about condom use (Agocha & Cooper, 1999; Dijkstra et al., 2000; Donovan, 2000; Fishbein et al., 2004; Henderson et al., 2005; Keller, 1993; Masaro et al., 2008; Williams et al., 1992). These strategies are illusory control strategies in that they reassure people that they have control over their exposure to HIV while not providing reliable protection (Misovich et al., 1997; Swann, Silvera, & Proske, 1995; Thompson et al., 1999). The present findings suggest that such fallible strategies may be based on fundamental intuitive processes. There is concern that under more natural conditions, with more naturalistic stimuli, or under the influence of sexual motivation (Blanton & Gerrard, 1997) or alcohol (Kruse & Fromme, 2005), reliance on such processes might be even stronger. Prevention efforts may embrace these issues and implement them into practice.

The present study is the first to demonstrate empirically that intuitive processes are involved in risk perceptions in the health domain. On a theoretical level the current study confirms predictions derived from the 'risk as feelings' model (Loewenstein et al., 2001) or the 'affect heuristic' hypothesis (Finucane et al., 2000). In particular, it provides strong and reliable evidence in support of intuitive influences on the perception of risk. This suggests that people's understanding of risk should be conceptualized broader than traditionally assumed. Although risk can be defined technically as the probabilities and consequences of adverse events (Brehmer, 1987; Knight, 1921), this definition fails to incorporate people's intuitive reactions to risk, which provide input, or may even circumvent all cognitive activities based on probabilities and consequences. Reconceptualizing risk perception in the suggested way may thus entail a healthy reorientation of the field toward the investigation of implicit processes that are ubiquitous everyday life (Bargh & Chartrand, 1999; Dijksterhuis, Bargh, & Zanna, 2001; Strack & Deutsch, 2004). Given the enormous importance ascribed to risk perception within theoretical models of health behavior change (Renner & Schwarzer, 2003b; Weinstein, 2003b), these findings constitute an important first step toward a better understanding of the determinants of health risk perception. For instance, it has been proposed that inclusion of intuitive and affective factors in theories of risk perception will greatly increase the predictive relationship between risk perception measures and protective health behaviors (Brewer et al., 2007; Brewer, Weinstein, Cuite, & Herrington, 2004).

Study 2

Brain Potentials during Risk Perception: Intuitive Judgments of HIV Risk

Abstract

Recent models of risk perception emphasize the role of intuitive and affective processes. The present study sought to provide empirical evidence for these notions by demonstrating two key features of intuition, speed and affective evaluation, in the context of a HIV risk perception paradigm. To study the neural correlates of the intuitive perception of health risks, event-related brain potentials (ERP) were measured while participants judged the risk of HIV infection (Human Immunodeficiency Virus) of 120 persons. In order to have high ecological validity, stimuli were naturalistic photographs of persons in scenes drawn from life. Risk-related modulations of the ERP emerged early in the processing stream (~300 ms), precluding the operation of deliberative and systematic reasoning and thus demonstrating the key feature of speed. Second, indicative of affective evaluation, risky stimuli elicited enlarged LPP amplitudes. This study confirms previous findings and provides an important extension by showing that intuitive risk perception can be investigated using naturalistic stimuli. These findings support the notion of intuitive health risk perception, which are regarded as a crucial prerequisite of protective behaviors.

Introduction

According to the WHO, approximately 60% of all deaths worldwide are attributable to behavior-related diseases that result from the risky behaviors of individuals. The pandemic of human immunodeficiency virus infection (HIV/AIDS) is one of the most prominent examples. In order to modify risky behaviors, people need to be aware of a certain health risk and feel personally at risk in order to take protective action (Armitage & Conner, 2000; Norman & Conner, 1996; Renner & Schwarzer, 2003b; Wit & Stroebe, 2004).

Traditionally, risk perception has been conceptualized as cognitive appraisals about probabilities of hazards (French & Marteau, 2007; Weinstein, 1999; Weinstein, 2000). More recently, however, the exclusive role of 'cold cognitions' for the formation of self-relevant health-related risk perceptions has been questioned and intuitive processes are emphasized (Millstein, 2003; Weinstein, 1999, 2003a). For example, the 'risk as feelings' model (Loewenstein et al., 2001) suggests that the processing of risk-related information may be based on immediate, intuitive factors, involving only minimal systematic reasoning. Intuitive processes are also regarded as important determinants of behavior under real-life contexts (Ariely & Loewenstein, 2005; Ditto et al., 2006) and may override cognitions in cases of conflict (Damasio, 1994; Epstein, 1994; Loewenstein et al., 2001). The 'affect heuristic' (Finucane et al., 2000; Slovic et al., 2005) subsumes a related set of ideas, arguing that judgments about the risk of stimuli or events are based on their immediate affective reaction toward a stimulus. These models suggest a new conception for the perception of risk by emphasizing the role of affect and intuition.

Intuitive processes are commonly characterized as fast, reflex-like inferences, in many instances building upon automatic affective evaluations (Hodgkinson et al., 2008; Lieberman, 2000). Empirical support for the hypothesis that risk judgments rely on intuitive processes has been provided by a recent study in the context of HIV risk perception (Schmälzle, Renner, & Schupp, in preparation-a). This study measured electrical brain activity during the processing of faces of persons and collected explicit ratings of HIV risk afterwards. Contrasting brain activity associated with high and low HIV risk judgments allowed to explore key features of intuitive processes. Specifically, addressing the speed of processing, ERPs associated with high and low

HIV risk judgments differed significantly already 350 ms after stimulus onset. Obviously, such an early differentiation cannot build upon deliberative and systematic reasoning but is consistent with the notion that intuitive processes are important for explicit risk judgments. Moreover, this study observed P3a-like and LPP effects suggestive of the operation of automatic affective evaluation. It is well known that emotionally significant stimuli elicit enhanced LPP amplitudes between 300 and 700 ms (Schupp et al., 2006). The finding that risky faces elicited enlarged LPP amplitudes suggests the increased motivational significance of stimuli associated with high risk. Overall, these findings provide critical first evidence regarding the role of intuitive processes in risk perception. Brain potentials show that the brain is sensitive to the risk status conveyed by stimuli early in the processing stream.

A possible limitation of the previous study concerns the stimulus material. Specifically, photographs of neutral faces, taken from publicly available data bases, were presented. As a result, the stimulus materials were homogeneous in terms of their physical characteristics and many possible social cues were missing. Appearance, attire, and behavior residuals (costume, hair-cut, make-up) provide expressive signals which people might use as information when evaluating HIV risk. Ample evidence from social psychology and a large literature on personality judgment consistently demonstrate the importance of features beyond isolated, context-free facial information (Ambady & Skowronski, 2008; Aviezer et al., 2008; de Gelder et al., 2006; Gosling, Ko, Mannarelli, & Morris, 2002; Righart & de Gelder, 2008; Rule, Ambady, Adams, & Macrae, 2008; Russell, Bachorowski, & Fernandez-Dols, 2003). Consistent with this assumption, available evidence from HIV risk research suggests that people rely on superficial partner characteristics when assessing a partner's HIV risk (Agocha & Cooper, 1999; Masaro et al., 2008; Thompson et al., 1996). Moreover, as the role of internet dating market is becoming more and more relevant (Bull & McFarlane, 2000; Epstein, Klinkenberg, Scandell, Faulkner, & Claus, 2007; Hospers, Harterink, Van den Hoek, & Veenstra, 2002; McFarlane, Bull, & Rietmeijer, 2002), such information is likely to gain even more importance. In chats and on dating sites people deliberatively choose to provide telling pictures of themselves in order to shape their public appearance. Overall, under conditions of daily life people appear under much more naturalistic conditions than those provided by pictures of neutral faces.

The present study explored whether the operation of intuitive processes within health-related risk perception can be demonstrated with ecologically more relevant stimulus materials. To obtain stimuli varying in appearance, attire, and behavioral residuals, photographs were acquired from a popular online photo-sharing community (www.flickr.com). Flickr.com contains billions of photos depicting people in scenes drawn from life, with attire, context, or other cues all being visible. Furthermore, photos are often taken in the absence of the depicted person's awareness, thereby increasing the ecological validity of the photographs. A systematic search according to pre-defined criteria (e.g., pictures with single persons in the foreground, appropriate age for the study's target population, see Methods) was undertaken to obtain a large database of suitable naturalistic pictures. For example, scenes contained in the final picture set showed 'a man drinking coffee', 'a woman sitting in the kitchen', 'a man sitting in a restaurant', 'a woman drinking a glass of wine', or 'a man riding a bike'. The experimental procedure was similar to the previous study (Schmälzle et al., in preparation-a). Participants were shown naturalistic photographs of persons while their EEG was recorded. After viewing each photograph, participants estimated the perceived risk of being HIV-infected for each depicted person. Based on these idiosyncratic HIV risk judgments, ERPs were analyzed to uncover initial processing differences associated with the perception of high vs. low risk. Using these novel stimuli, the present study asked whether ERP modulations pointing to intuitive influences will also be observed using more relevant, naturalistic stimuli. Based on the assumption that the intuitive detection of high risk constitutes a motivationally relevant event and on results from the previous study, it was predicted that risky pictures should prompt larger amplitudes over central areas early after stimulus onset.

Method

Participants

Forty volunteers (12 males) were recruited from the University of Konstanz community. Participants provided informed consent, were assured anonymity, and debriefed after completion of the experiment. They were either paid for their participation or received course credit. All participants had normal or corrected-to-normal vision, and no known neurological diseases. Three participants were excluded from the analyses of electrophysiological data. Two were excluded because of very asymmetric distributions of the risk ratings and one participant because of heavy artifacts and an asymmetric rating distribution. Accordingly, the resulting sample consisted of 37 persons (aged 20 - 32 years, $M = 23.4$, $SD = 3$).

Stimuli

The stimulus set used in this study comprised 240 photographs of single persons in daily life scenes. One set of 120 photographs contained male persons, another set consisted of 120 pictures of female persons. As in the previous study, male participants were shown pictures of females and female participants saw pictures of males, respectively. The photographs were retrieved from a popular online photo-sharing community (www.flickr.com). Permission for use in research was obtained for all photographs but for copyright reasons it is not possible to depict the stimulus material here. In order to gain ecological validity, the main goal during stimulus search was to sample person pictures from a wide array of backgrounds and situations. Stimuli were selected based on the following criteria: (1) Single persons in the foreground, (2) faces clearly visible. In contrast to the first study, where only frontal head shot views were employed as stimuli, depicted persons had no consistent position, or orientation within the image. (3) All photographs were fully colored. To be representative for the study's target population in terms of age and race, only photographs of (4) young (estimated 18 - 35 years old), (5) Caucasian persons were included. (6) Attire, other socioeconomic status cues, or situational context features were purposely shown in order to resemble naturalistic viewing conditions and to facilitate impression formation. However, people with exceptional appearance cues were not included (e.g., members of specific subcultures or people with ostentatious hairstyles). After

compilation of a large database of suitable pictures, all photos were edited to a common format (768 * 576 pixel) and catalogued for later use by the stimulation software.

Task and Procedure

Participants were seated in a recliner in a dimly lit, sound-attenuated room. After filling out the informed consent form the geodesic sensor net was attached and task instructions were given. In the instruction participants were asked to report their first impression of HIV-risk for every person presented and completed three test trials. Naturalistic photographs of persons were presented for two seconds, preceded by a fixation cross (1 s) and followed by a blank screen (1s). Next, the HIV risk rating scale appeared and lasted until a risk perception had been stated. After the participant had reported perceived risk by using the mouse-operated rating scale, a blank stimulus was shown during the intertrial interval for 6.5 s. Perceived HIV risk was assessed on a 7-point rating scale by the item "How likely is it that this person is HIV-positive?" (original terms in German: "Für wie wahrscheinlich halten Sie es, dass diese Person HIV-positiv ist?", cf. Agocha & Cooper, 1999; Malloy et al., 1997). Presentation software (Neurobehavioral Systems, Inc., Albany, CA) was used to present the pictures and to collect ratings via a mouse-operated rating scale. The facial photographs were shown on a 21-in. CRT monitor (75-Hz refresh rate) located approximately 100 cm in front of the participant. The presentation order of pictures was varied randomly between participants.

Manipulation Check: Do Stimuli Differ in Their Ascribed Risk?

To confirm that the stimuli showed substantive variation ranging from low to high risk, mean risk judgments were calculated for every stimulus item. As illustrated in Figure 2.1, the stimuli spanned across a broad range of perceived HIV risk. This was the case for female and male participants, who were shown pictures of males or females, respectively. Both sets of photographs thus represented the full range of perceived HIV risk.

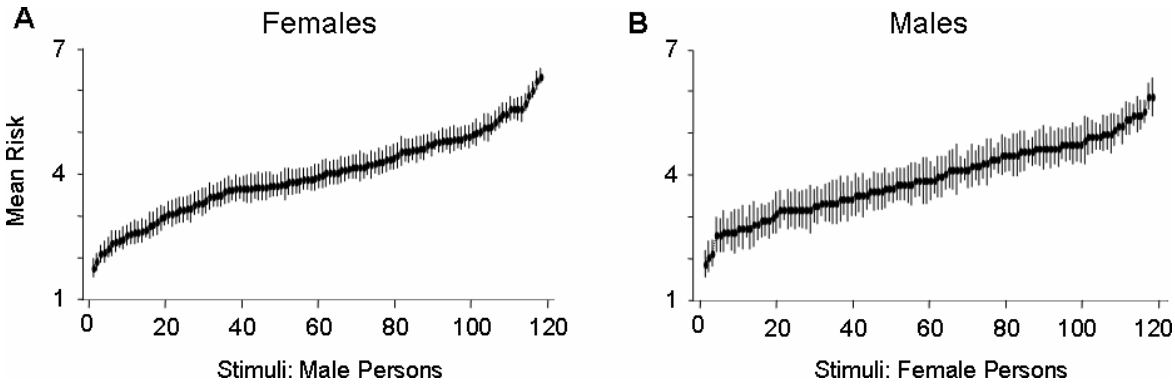

Figure 2.1: Average ratings of HIV risk (1 - low risk; 7- high risk) and standard errors for all experimental stimuli, rank-ordered by ascending risk. A) Risk ratings from female participants for pictures of males. B) Risk ratings from male participants for pictures of females.

To provide additional evidence for substantial variance in perceived risk, the distribution of 120 risk ratings was examined for all participants on an individual level. All participants covered a range of at least 4 scale points. For every participant the relative frequency of each risk category was calculated. Table 2.1 presents the average and standard deviations of these rating frequencies across all participants. This analysis provides confirming evidence that perceived risk varied substantially. In sum, it can be concluded that the new set of naturalistic photographs was successful in inducing broadly varying perceptions of HIV risk. Although stimuli were completely naturalistic, the results for individual stimuli (Figure 2.1) and distributions of participants' ratings (Table 2.1) showed an extraordinarily high similarity to the results from the previous study.

Table 2.1: Average frequencies and standard deviations for the 7 rating categories across all participants.

Risk Rating	**1** low risk	**2**	**3**	**4**	**5**	**6**	**7** high risk
Average Frequency	10.4	18.4	22.3	16.9	29.9	17.3	4.8
SD	(7.8)	(7.2)	(8.5)	(12.7)	(8.8)	(8.0)	(4.7)

EEG Recording and Analysis

Electrophysiological data were collected from the scalp using a 257-channel system (Electrical Geodesics, Inc., Eugene, OR). Scalp impedance for each sensor was kept below 40 kΩ, as recommended for this high input impedance amplifier system. The EEG was recorded continuously with a sampling rate of 250 Hz, the vertex sensor as reference electrode, and on-line bandpass filtered from 0.1 to 100 Hz. Continuous EEG data were lowpass filtered at 40 Hz before stimulus synchronized epochs were extracted from 100 ms before until 800 ms after picture onset. Because of the more naturalistic nature of the stimulus material, the issue of ocular artifacts arises. To guard against potential contamination of the EEG by ocular artifacts, the algorithm proposed by Gratton et al. (1983) was employed. Artifact rejection and correction was based on an automatized method for statistical control of artifacts (Junghöfer et al., 2000). Data reported here are based on an average reference and have been baseline-corrected using the 100 ms interval before stimulus onset.

The present experiment determined whether the perception of risk is associated with ERP differences preceding overt reports. To pursue this objective, idiosyncratic ratings of HIV risk perception were used in the analysis of EEG data in order to obtain ERPs associated with low vs. high risk. Specifically, data were dichotomized along the perceived risk dimension. For each participant, high risk persons (risk ratings ranging from 1 - 3) and low risk persons (risk ratings from 5 - 7) were identified. ERP wave-forms were then obtained for each participant by averaging across low risk and high risk trials, respectively.

Effects over Centro-Frontal and Occipital Regions: Effects of RISK were observed over centro-frontal regions and scored as mean activity in seven successive 50 ms time intervals from 300 - 650 ms, collapsed over a sensor cluster with EGI sensor numbers # *5, 6, 7, 16, 17, 23, 24, 29, 30, 36, 41, 42, 43, 44, 51, 52, 184, 185, 196, 197, 198, 206, 207, 214, 215,* and *224* (see Figure 2.2). Over occipital areas, the effects were assessed in an interval from 300 - 380 ms over two bilateral sensor clusters consisting of sensors # *95, 96, 97, 104, 105, 106, 107, 108, 109, 112, 113, 114, 115, 116, 117, 118, 120, 121, 122, 123, 124, 125, 127, 133, 134, 135, 136, 138, 139, 140, 145, 146, 148, 149, 150, 151, 156, 157, 158, 159, 160, 161, 165, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 187, 188,* and *189* (see Figure 2.2).

Preliminary analyses indicated no gender differences and accordingly analyses were collapsed across gender.

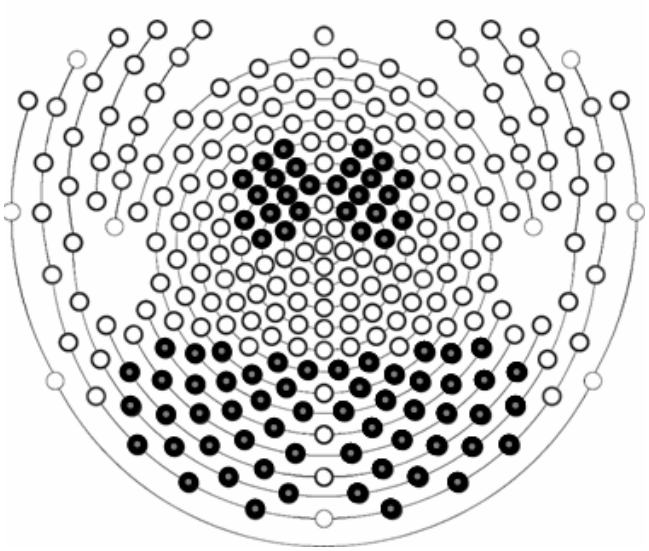

Figure 2.2: Illustration of the centro-frontal and occipital sensor clusters entering statistical analysis.

Results

Low vs. High Risk ERPs

Centro-Frontal Positivity and Occipital Negativity toward Risky Persons: Viewing pictures of high risk as compared to low risk was associated with a larger positive deflection of the event-related potential. This effect was maximally pronounced over centro-frontal sites, starting around 300 ms after stimulus onset and lasting for several hundred milliseconds. As shown in Figure 2.3, the increased centro-frontal positivity for risky pictures emerged on the rising slope of a P3-like waveform that developed around 300 ms after stimulus onset, with positive polarity over central and parietal sensor sites and a peak at about 380 ms. Over inferior posterior sites the effect was reversed in polarity, thus appearing as a negative difference between high - low risk ERPs. Supplementing the temporal information, Figure 2.4 illustrates the spatial topography of the scalp field potentials, represented as the mean activity of two time windows ranging from 300 - 450 ms and 450 - 600 ms, respectively. These maps are based on the differences between risky and safe ERPs. They reveal a distributed and sustained central positivity for risky compared with safe images. The observed differentiation between high and low risk stimuli seemed slightly more pronounced over central-left areas for the centro-frontal regions.

For statistical evaluation of the observed effects, the data for seven successive 50 ms time windows (300 - 650 ms) were entered into an ANOVA with repeated measures on the factors LOCATION (centro-frontal vs. occipital sensor cluster), LATERALITY (left vs. right), INTERVAL (300 - 350, 350 - 400, 400 - 450, 450 - 500, 500 - 550, 550 - 600, 600 - 650 ms), and RISK category (low vs. high risk). As expected, a significant interaction of RISK with LOCATION was observed ($F_{RISK \times LOCATION}$ (1,36) = 4.84; $p < 0.05$), confirming the polarity reversal of the effect between centro-frontal and occipital sites. Effects of RISK were followed up separately for centro-frontal and occipital clusters.

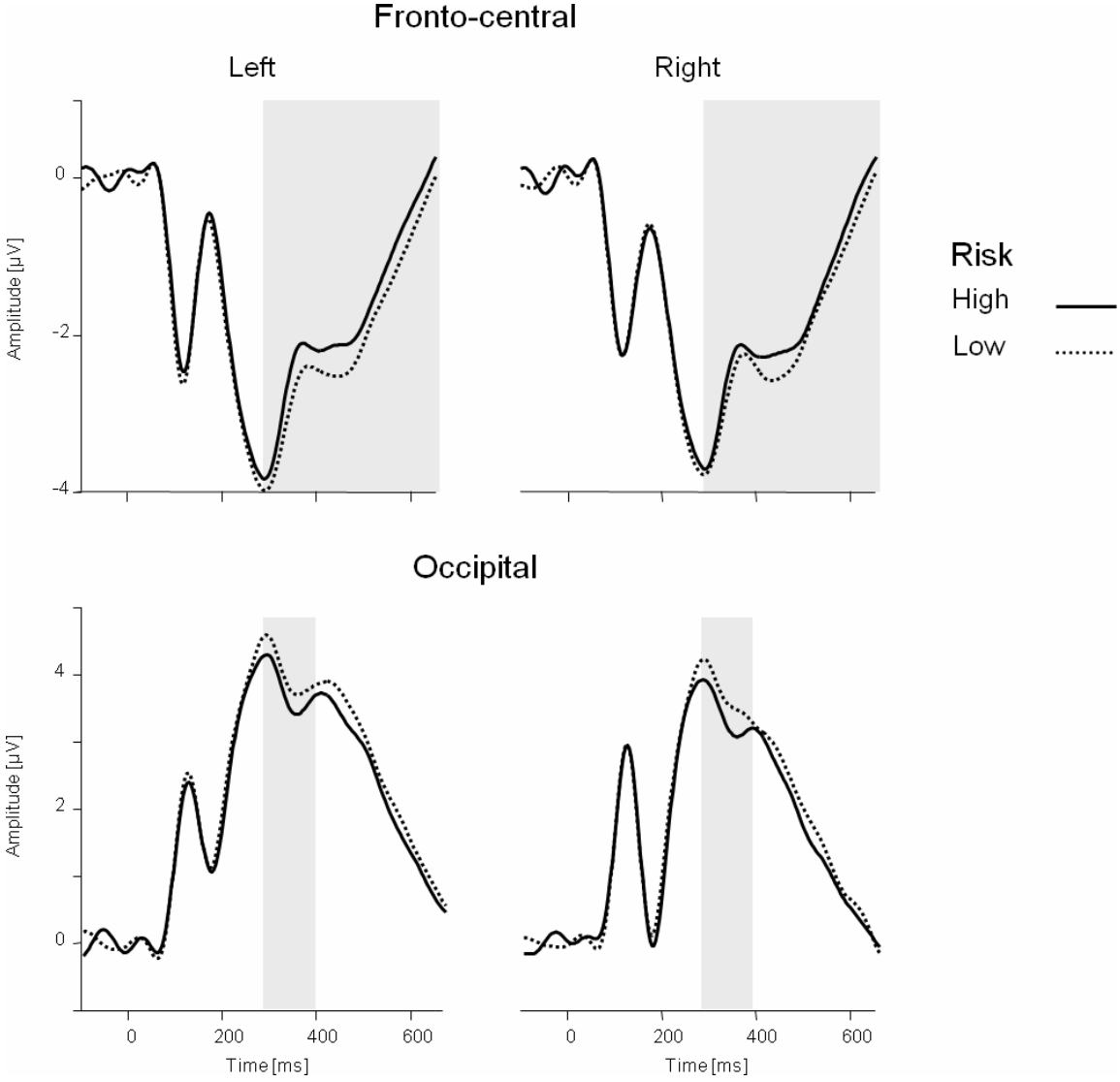

Figure 2.3: Grand-averaged ERP waveforms toward low and high risk stimuli at centro-frontal (# 24, 207) and occipital sensors (# 105, 177).

For the centro-frontal cluster this analysis revealed significant main effects for the factors RISK (F_{RISK} (1,36) = 4.92, $p < 0.05$) and INTERVAL ($F_{INTERVAL}$ (6,210) = 51.5, $p < 0.001$), but no interactions ($F_{RISK \times INTERVAL}$ (6,216) = 0.23; $F_{RISK \times LATERALITY}$ (1,36) = 0.68; both n.s.)[7]. The mirroring occipital effect was tested over a bilateral sensor cluster in the time window from 300 - 380 ms post stimulus (see Figure 2.3, lower

[7] *300-350: $M_{LOW\ RISK}$=-3.15 µV; $M_{HIGH\ RISK}$=-2-96 µV 350-400: $M_{LOW RISK}$=-2.32 µV; $M_{HIGH\ RISK}$=-2.14 µV*
400-450: $M_{LOW\ RISK}$=-2.36 µV; $M_{HIGH\ RISK}$=-2.15 µV 450-500: $M_{LOW\ RISK}$=-2.25 µV; $M_{HIGH\ RISK}$=-2.01 µV
500-550: $M_{LOW\ RISK}$=-1.72 µV; $M_{HIGH\ RISK}$=-1.59 µV 550-600: $M_{LOW\ RISK}$=-1.11 µV; $M_{HIGH\ RISK}$=-0.90 µV
600-650: $M_{LOW\ RISK}$=-0.46 µV; $M_{HIGH\ RISK}$=-0.23 µV

panel). A significant main effect of RISK was revealed at these occipital sites (F_{RISK} (1,36) = 4.87, $p < 0.05$; $F_{LATERALITY}$ (1,36) = 0.39, n.s.; $F_{RISK \times LATERALITY}$ (1,36) = 0.3, n.s.), confirming more negativity toward risky pictures over these areas ($M_{LOW\ RISK}$ = 5.23 µV; $M_{HIGH\ RISK}$ = 4.94 µV).

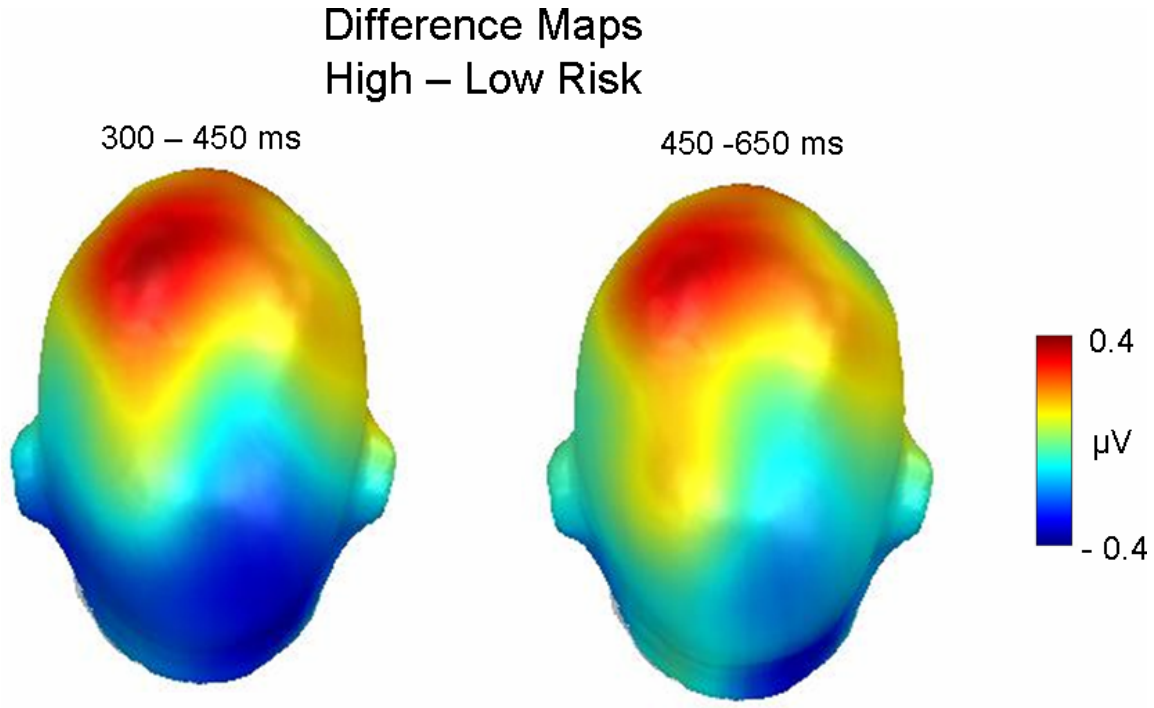

Figure 2.4: Topographical scalp potential maps of the difference waves (high - low risk) for the intervals between 300 - 450 ms and 450 - 600 ms reveal the topographical distributions of the effects of risk.

Supplementary Analyses

Pictures were assigned to belong to low vs. high risk groups on the basis of idiosyncratic ratings (low risk: 1, 2, and 3; high risk: 5, 6 and 7). While this way of forming categories preserves essential aspects of self report information, it may come at the cost of unequal frequencies for ERP averaging[8] or may not perfectly reflect how individuals made use of the scale to express lower or higher perceived risk. To guard

[8] *However, in the present analysis this was not the case, as indicated by mean category frequencies of M = 52.6 (SD = 15) for the low risk category and M = 52.2 (SD = 13.2) for the high risk ratings.*

against the possibility that the obtained results might not hold out against such peculiar circumstances, the following supplementary analyses were conducted.

Control Analysis Based on Z-Scores: First, the data were reanalyzed using a z-scoring procedure. This analysis confirmed the findings reported above, which were obtained with the primary categorization procedure, by revealing a significant main effect of RISK ($F_{RISK}(1,36) = 6.35$, $p < 0.05$) in the absence of any interactions ($F_{RISK \times INTERVAL}$ and $F_{RISK \times LATERALITY}$ both < 1). Risky images prompted more positive waveforms. In sum, the main findings of the initial analysis (i.e. enhanced ERP amplitudes toward risky persons) were supported by an analysis that used a different sorting scheme to categorize participants' individual ratings.

Frequency of Category Use: Furthermore, it was explored whether participants who used the high risk categories less often did show larger amplitudes with respect to the central effect between 300 and 650 ms. To contrast a 'risk hypothesis' with a 'probability/frequency hypothesis', the data set was reanalyzed. For 16 out 37 participants the high risk category contained fewer ratings than the low risk category. These participants were placed into one subgroup ('low frequent'), while participants with frequent high risk and rare low risk ratings comprised a second group ('high frequent'). Critically, the main effect of risk did not interact with the group-variable ($F_{RISK \times GROUP}(1,36) = 1.01$, $p = 0.32$). Effects of RISK even contradicted an oddball explanation since they were evident in both groups and nominally were even stronger in the 'high frequent'-subgroup ('high frequent'-subgroup: $M_{LOW\ RISK} = -1.68\ \mu V$; $M_{HIGH\ RISK} = -1.41\ \mu V$; 'low frequent'-subgroup: $M_{LOW\ RISK} = -2.20\ \mu V$; $M_{HIGH\ RISK} = -2.11\ \mu V$). Thus, independent of the frequency of category use, risky persons elicited significantly larger LPP amplitudes.

Discussion

The current study examined the hypothesis that the perception of health risks involves intuitive processes. Toward this end, HIV risk judgments were obtained to photographs depicting people in naturalistic settings while event-related brain potentials were recorded. Compared to traditional models conceiving risk as cognitive appraisals about probabilities of hazards (French & Marteau, 2007; Weinstein, 1999; Weinstein, 2000), the intuitive risk perception approach makes distinct assumptions regarding the role of speed, conscious awareness, and immediate affective evaluations. With regard to speed, intuitive processes are considered to reflect parallel rather than serial information processing, allowing effortless and fast processing (Bowers et al., 1990; Hodgkinson et al., 2008). Supporting this hypothesis, brain potentials revealed that risk-related modulations of the ERP emerged early in the processing stream (~300 ms). Furthermore, intuitive risk perception may build upon immediate affective evaluation, raising the prediction that information about risk is represented early in the processing stream. Consistent with this notion, the LPP amplitude is enhanced for risky compared to safe stimuli providing a reliable measure of early affective discrimination. Intuitive processes often defy verbal explanation and the analysis of verbal reports supports this assumption. Overall, these findings support the notion that intuitive processing is responsive to health-risk related information.

Event-related brain potentials provide a high-resolution measure of the speed of processing when risky and safe stimuli are discriminated. A recent study revealed the differentiation among risky and safe stimuli approximately 350 ms after stimulus onset (Schmälzle et al., in preparation-a). In this study facial stimuli were presented allowing to control for low-level physical differences. Providing strong support for the notion of effortless and fast risk discrimination, the use of a homogenous stimulus set raised the concern to what extent these findings apply to naturalistic stimuli varying in attire, dress, posture and many other expressive cues. Importantly, studying naturalistic stimuli drawn from real life revealed the extraction of risk-related health information early in the processing stream. If at all, the onset latency of differential ERP activity to risky persons appeared somewhat earlier (~50 ms) when people show expressive cues. Discriminating among risky and safe naturalistic stimuli early in the processing stream provides evidence for intuitive processing regarding the key feature of speed.

In the realm of health risk perception, immediate affective evaluation is an important facet of intuitive processing. A previous study revealed increased positive potentials to risky compared to safe stimuli in a time window from 300 - 650 ms post stimulus. These findings were conceptually replicated in the present study. A large body of evidence links positive potentials to immediate affective evaluation (Cacioppo, Crites, Berntson, & Coles, 1993; Schupp et al., 2006). Specifically, between 300 and 650 ms post stimulus, pleasant and unpleasant picture contents (e.g., mutilations, threat, fear, erotica) as well as facial emotional expressions (i.e. fear and threat; Leppänen, Kauppinen, Peltola, & Hietanen, 2007; Schupp et al., 2004) elicit an increased positive potential compared to neutral stimuli. Moreover, this brain signature is obtained when stimuli are passively viewed and when the stimuli are explicitly task-relevant (Ferrari et al., 2008; Schupp et al., 2007b). Analogously, it is suggested that increased LPP amplitudes to risky stimuli indicates increased affective/motivational significance. Obtaining similar effects for images depicting the face and images depicting people in naturalistic settings demonstrates the robustness of these findings.

In comparison to a previous report (Schmälzle et al., in preparation-a), important similarities and differences were observed regarding the topography of the positive potentials. Across both studies, a first risk effect was observed as increased positivity over centro-frontal leads when comparing risky and safe stimuli. Considering latency and topography, this component is reminiscent of the P3a, or novelty P3 (Debener et al., 2005; Friedman et al., 2001). Functionally, the P3a has been related to the orienting response, presumed to reflect increased attentional orienting to affectively significant stimuli. A difference, however, concerns the topography of the late positive potential. Rather than appearing over centro-parietal regions as it was observed in the previous study, the effect was seen in the present study over centro-frontal leads. This difference is presumably due to the use of different stimulus materials across both studies. In higher-order visual-associative cortex, presentation of face stimuli has been shown to activate category-specific brain regions (e.g., Schwarzlose, Swisher, Dang, & Kanwisher, 2008). Stimuli depicting people in naturalistic contexts provide a richer source of information including body representation, clothing, and attire, presumably engaging more distributed brain activations. Overall, awaiting more conclusive evidence, it is suggested that differences in the topography of the LPP component may relate to different activation patterns in higher-order brain regions.

One might be suspicious that the ERP effects might result from physical differences between low and high risk stimuli. However, this alternative explanation seems unlikely for several reasons. Most importantly, the fact that effects of risk evaluation were restricted to modulations of the LPP is incompatible with interpretations based on physical confounds. If risky and safe pictures differed on low-level physical stimulus dimensions, this should have affected ERP components preceding the LPP (e.g., P1, N1, P2). In line with this reasoning, control analysis of the processing of IAPS pictures revealed that physical stimulus differences primarily affected early ERP components (< 150 ms; Junghöfer, Bradley, Elbert, & Lang, 2001). Furthermore, the sensitivity of the LPP to affective significance has been shown with regard to emotional hand gestures tightly controlling for differences in physical stimulus characteristics (Flaisch, Schupp, Renner, & Junghöfer, under review). Finally, ERP averages of low and high risk stimuli were based on idiosyncratic ratings. Accordingly, across individuals there were many instances in which the same stimuli were represented in both ERP averages. Overall, it seems unlikely that physical stimulus differences can account for the reported findings.

A further concern is that the differential effects of risk on the ERP reflect unequal frequencies of high and low risk categories. In cognitive research it is a hallmark finding that under conditions of unequal stimulus probability stimuli from the less frequent class elicit larger P3 responses (Johnson, 1988). However, this factor cannot provide a valid explanation for the present results because interpretations based on stimulus probability are questionable on theoretical grounds. Before unequal stimulus probabilities can take effect, stimuli must have been categorized into classes. In classical studies stimuli are clearly separable into different classes by means of low-level characteristics, such as color (e.g., 20% red stimuli among 80% blue stimuli), form, or size. In the present study, however, the stimuli consisted of very heterogeneous photographs of people in various situations. Although probability-based interpretations leave the notion of fast risk perception unchallenged, one might argue that the LPP enhancement may result from unequal probabilities after classes have been intuitively identified. However, on a group level there were no significantly different frequencies between low and high risk categories. Second, when participants were regrouped into two subgroups according to their distribution of rating frequencies (i.e. risk-frequent and safe-frequent responders), there were no larger LPP responses toward the less frequent category. Finally, and perhaps most importantly,

the present experiment did not require a categorization of stimuli into two groups (low vs. high risk), but allowed for more continuous responding (1 - 7). In conclusion, stimulus probabilities are unlikely to account for the present findings.

The present findings may have important implications for theories of risk perception. It has been noted that people are unlikely to evaluate risk solely by means of 'cold cognitions', such as those required to perform probabilistic calculations about risk likelihood (Bruine de Bruin et al., 2002; Fischhoff & Bruine De Bruin, 1999; Renner & Schupp, 2005; Windschitl & Weber, 1999; Windschitl & Wells, 1996). Rather, intuitive thinking seems to mediate the experience of risk as a more vague entity, which is experienced rather than calculated (French & Marteau, 2007; Peters et al., 2006; Renner & Schupp, 2005; Weinstein, 2003b). Across two studies, event-related brain potential measures provide empirical evidence that the brain is responsive to health risk information early in the processing stream and tags risky stimuli as affectively significant. Thus, the challenge to provide robust measures of key characteristics of intuitive processes has been addressed allowing to detail the role of intuition in risk perception in future research. Measuring brain potentials appears well-suited to determine other key features of intuitive processes, such as their implicit nature, which is very difficult to assess using traditional methods.

Beyond their contribution to theoretical conceptions of risk perception, examining the perception of HIV risk is of high practical importance since risk perception is an essential prerequisite for the initiation of protective health behaviors. However, rational gauging of probabilities and consequences appears to be only part of the story. It has been suggested that people may rely on their intuitive impression about people's physical appearance for assessing the HIV risk status (Donovan, 2000; Malloy et al., 1997; Thompson et al., 1996; Williams et al., 1992). Not surprisingly, people may fail severely when determining HIV risk based on physical appearance. Interestingly, undermining the reliance on intuition by given failure feedback about one's capability to estimate the HIV risk status is one of the few effective avenues to increase condom use (Thompson et al., 2002). One may speculate that the intervention realized by Thompson and colleagues (2002) might have challenged intuitive processes and their associated feeling of being a competent judge. Measures of intuitive processes might thus extend the understanding of motivational processes in

health behavior change and thereby possibly contribute to the development of more effective treatment programs.

Study 3

Implicit and Explicit Assessment of Intuitive Risk Perception: An ERP Study

Abstract

Recent studies revealed that the perception of risk involves intuitive processes. The goal of present study was to extend this line of research by testing for another salient feature of intuitive processing, namely its implicit nature. In the first part of the experiment participants viewed 120 pictures of persons while ERPs were recorded using high-density electroencephalography (implicit condition). Following this part ERPs were again measured in response to all persons, now under the explicit instruction to report on perceived risk of HIV (Human Immunodeficiency Virus) infection for each person presented (explicit condition). Results re-prove key features of intuitive processes and provide first evidence for their implicit nature. In particular, in the implicit condition risky persons were associated with an early posterior negativity (240 - 300 ms), suggesting fast and implicit processing. The implicit and explicit condition similarly showed enlarged positive potentials toward risky persons (430 - 530 ms), indicative of affective evaluation. In the explicit condition this LPP modulation by picture risk status developed into a sustained positivity (550 - 800 ms), which replicates previous findings. Furthermore, the relationship between HIV risk perception and attractiveness was determined and it was ruled out that ERP results were secondary to effects of attractiveness. These results strongly support notions of intuitive risk perception, which demands a theoretical reconceptualization of health risk perception and points to vitally important consequences in real-world risk situations.

Introduction

The ability to perceive risk enables us to respond adaptively to risk by initiating appropriate precautions. This is particularly apparent in the field of personal health, where risk perception is regarded as a pivotal precondition for the initiation of preventive health behaviors (Armitage & Conner, 2000; Norman & Conner, 1996; Renner & Schwarzer, 2003b; Wit & Stroebe, 2004). For example, with respect to HIV it has been assumed that the perception of risk influences motivation toward safer sex behaviors (e.g., condom use, cf. Gerrard, Gibbons, & Bushman, 1996). Considering the pressing need to contain the spread of diseases that are related to risky behaviors it appears of vital importance to shed light on the mechanisms of health-related risk perception.

The majority of risk perception research has been guided by a cognitively oriented perspective. From that perspective the units that define risk technically - probabilities and expected consequences - were also regarded as primary determinants of people's perceptions of risk and typically assessed via summary judgments of perceived probability and perceived severity (cf. Rosenstock, Strecher, Becker, DiClemente, & Peterson, 1994). In the context of health and safety issues, however, risk involves apparently more than just cognitions about probabilities and consequences: knowing cognitively about risks is not sufficient in order to understand one's risk and to motivate behavior change (Millstein, 2003; Renner & Schwarzer, 2003b; Weinstein, 2003b). Rather, to be regarded as self-relevant and to fuel motivations to engage in precautionary behavior, risk perception requires additional processes that go beyond 'cold cognitions' about probabilities and expected consequences. Recent theoretical approaches have proposed a decisive reconceptualization, assuming that intuitive processes may be involved in personal risk perception (Loewenstein et al., 2001; Peters et al., 2006; Renner & Schupp, 2005; Slovic & Peters, 2006; Weinstein, 2003b).

To confirm that risk perception involves intuition it is necessary to demonstrate that risk-related processes conform to key features of intuitive processes. Intuition is generally assumed to arise through rapid, affectively charged, automatic evaluations which occur implicitly, i.e. without intentions or goal to perform them (Hodgkinson et al., 2008; Lieberman, 2000). Two recent studies (Schmälzle, Renner, & Schupp, in preparation-a in preparation-b) used event-related brain potentials (ERPs) to

demonstrate two key features of intuition, speed and affective evaluation, thus providing first empirical evidence for intuitive risk perception. In particular, both studies measured ERPs in response to pictures of persons and collected explicit ratings of HIV risk afterwards. Contrasting brain activity associated with high and low HIV risk judgments allowed to assess the speed of risk-related information processing. ERPs toward risky persons began to differentiate at about 300 ms after stimulus onset. Such early processing differences cannot result from deliberative and systematic reasoning but rather appear to reflect the operation of rapid intuitive processes. Moreover, the observed ERP effects are suggestive of automatic affective evaluation. Consistent with previous studies demonstrating enhanced LPP amplitudes between 300 and 700 ms in response to emotionally significant stimuli (Schupp et al., 2006), both studies revealed that risky persons elicited enlarged LPP amplitudes. This finding suggests the increased motivational significance of stimuli associated with high risk. Overall, these findings provide critical first evidence regarding intuitive risk perception by demonstrating key processing characteristics of intuition.

A further salient key feature of intuition is that it operates implicitly, that is in an incidental, spontaneous manner and without intentions or explicit instructions. Accordingly, the main goal of the present study was to systematically extend this line of research by investigating whether risk-related processing differences can be demonstrated under implicit conditions. The assumption that risk perception operates implicitly is also suggested by recent models, like the 'risk as feelings' model (Loewenstein et al., 2001) or the 'affect heuristic' (Slovic et al., 2005). Both frameworks assume that risk perception is linked to the affect system, which largely operates in an implicit manner (i.e. affective reactions occur fast and automatically; Codispoti et al., 2006; Schupp et al., 2006; Zajonc, 1980). For example, the literature on emotional perception shows that the preferential detection of motivationally relevant stimuli (Lang & Davis, 2006; Schupp et al., 2006; Vuilleumier, 2005) is ensured by deeply rooted evaluative mechanisms which are carried out in an obligatory, implicit manner. Similarly, considered from a theoretical perspective, the primary function of risk perception is to provide continuous vigilance by monitoring the environment for the appearance of risky stimuli or events. Moreover, daily-life situations, during which risk perception naturally takes place, typically lack explicit focal task demands. Under naturalistic conditions it may thus be advantageous to relay these assessments onto implicit processes.

In the previous studies (Schmälzle et al., in preparation-a, in preparation-b), risk perception was investigated by means of an explicit task, which required participants to evaluate the HIV risk of all stimuli. This task helped to maintain control over participants' task set (i.e. to constrain their task set to HIV risk perception) and thus facilitated the demonstration of risk perception's speed as well as its relation to affective evaluation. This task, however, did not allow for the examination of implicit intuitive risk perception. The assessment of implicit processes poses a methodological challenge because task instructions or the measurement processes itself might interact with the to-be-measured implicit process (De Houwer, 2006; De Houwer & Moors, 2007). With regard to this issue, a convenient property of the ERP technique is that it enables the nonreactive measurement of stimulus related processing (cf. Olsson, Phelps, Wittenbrink, & Schwarz, 2007). The present study made use of this advantage in order to investigate whether risk affects the ERP in the absence of the explicit task of judging HIV risk. Toward this end, participants' brain responses in reaction to pictures of persons were recorded during an implicit task that did not mention anything related to HIV risk.

The 'risk as feelings' model (Loewenstein et al., 2001) and the 'affect heuristic' framework (Slovic et al., 2005) both assume that affect plays an informational role in risk-related thinking and relate the notion of affect to implicit liking- and disliking-reactions to a stimulus. In the context of the present HIV risk perception paradigm, which hinges on evaluations of the risk posed by the potential partner, this liking or disliking may thus be expected to be related to a person's attractiveness (cf. the discussion about a 'what is beautiful is good' stereotype in social psychology; Dion, Berscheid, & Walster, 1972; Eagly, Ashmore, Makhijani, & Longo, 1991; Feingold, 1992). In line with this reasoning, previous studies of HIV risk perception found evidence for a negative association between risk and attractiveness (Blanton & Gerrard, 1997; Gold & Skinner, 1996; Henderson et al., 2005; Hennessy, Fishbein, Curtis, & Barrett, 2007). On the other hand, one might also argue that attractive people have more sexual opportunities and hence have an above-average risk, or that perceived HIV risk may be related to more specific dimensions than global attractiveness, such as cleanliness and color of skin or via intermediary constructs such as willingness to interact (cf. Agocha & Cooper, 1999; Dijkstra et al., 2000; Kruse & Fromme, 2005; Shuper & Fisher, 2008; Zaromatidis, Carlo, & Racanello, 2004). Taken together, attractiveness may be an important variable to consider in the present

study because it is a salient social signal (Etcoff, 1999; Hatfield & Sprecher Susan, 1986; Zebrowitz, 1997) and is regarded as important for partner selection and sexual behavior (Fink & Penton-Voak, 2002; Thornhill & Gangestad, 1999). Another argument for the inclusion of attractiveness in the present study derives from the assumption that assessments of a person's attractiveness might also affect ERP responses (Oliver-Rodriguez, Guan, & Johnston, 1999; Werheid, Schacht, & Sommer, 2007). Thus, to deliver insight into the fine structure of intuitive HIV risk perception, the present study extended the HIV risk perception paradigm by collecting additional ratings of the persons' attractiveness.

The main goal of the present experiment was to test whether risk-related ERP differences would also emerge during an implicit condition. Toward this end, participants viewed pictures of persons under the instruction to memorize them and high-density ERPs were recorded concurrently (implicit condition). Following the implicit condition, participants performed explicit judgments of HIV risk and ERPs were again recorded (explicit condition). To assess whether ERP responses during the implicit condition contained information related to subsequent reports of perceived risk, risk ratings from the explicit condition were used in the analysis of ERPs from the implicit condition. This strategy allows uncovering ERP differences between risky and safe stimuli during the implicit condition. Critically, nothing related to HIV needs to be mentioned until spontaneous brain reactions have been assessed. Assuming that risk perception reflects an implicit process, it is predicted that ERP differences between low and high risk stimuli are present in the implicit condition. Additionally, based on the proposed features of speed and affective evaluation, it was hypothesized that during both conditions (implicit and explicit) ERP differences will be observed at points in time too early for elaborate reasoning (< 500 ms). Considering the LPP as a sensitive measure of intrinsic motivational significance, the LPP amplitude should vary as a function of risk status, being enlarged for risky persons. A second goal of this study was to determine the covariation between risk and attractiveness and to explore effects of attractiveness on brain responses. Ratings of attractiveness were thus collected in addition to HIV risk ratings.

Method

Participants

Forty-two volunteers (23 female, age range: 20 - 28 years, M = 23.7, SD = 2.4) participated for either course credit or a financial bonus. Criteria for participation were normal or corrected-to-normal vision and no known neurological diseases. All participants were assured anonymity, signed a detailed consent form, and were debriefed after the end of the experiment. Four participants were excluded from the analyses of electrophysiological data because of excessive artifacts, or too few trials in one of the conditions, thus resulting in a sample size of 38 subjects.

Stimuli

Experimental stimuli consisted of two sets of naturalistic photographs. Each set contained 120 pictures of males or females, respectively. The naturalistic photographs of persons were obtained with permission from a popular online photo-sharing community (www.flickr.com; for copyright reasons it is not possible to depict the stimulus material here) in order to increase ecological validity. At the same time, a systematic search according to predefined criteria assured that the final stimulus set conformed to the following standards: (1) Single persons in the foreground, (2) faces clearly visible (but no constraints in terms of posture or orientation within the picture), and (3) all photographs were fully colored. To be representative for the study's target population in terms of age and race, only photographs of (4) young (estimated 18 - 35 years old), (5) Caucasian persons were included. (6) Attire, other socioeconomic status cues, or situational context features were purposely shown in order to resemble naturalistic viewing conditions and to facilitate impression formation. Each set of 120 pictures was complemented by 15 additional pictures to serve as distracters in the memory condition (see below: Implicit Condition).

Task and Procedure

After arrival at the lab participants were told that this was a study about person perception, consisting of several parts. Next, the EEG-nets were applied and participants were led into the acquisition chamber.

Implicit Condition (Memory Task): To make sure that participants viewed the stimuli attentively, the first part of the study was presented to as a person memory task. One run consisted of a series of 13 photographs. The photographs were presented for 2000 ms each, with grey screens lasting for 3500 ms and a 1000 ms fixation cross in between. After each run participants were shown one photograph that had either been contained in the previous run or consisted of a new distracter stimulus. Their task was to make a choice whether the person depicted on the photograph had been presented during the previous run. A schematic illustration of one run is depicted in Figure 3.1. After the choice was made the next run was started. Of the 10 runs, 5 runs contained the critical comparison photograph, whereas for the other 5 runs a new distracter was shown. The sequence of picture presentation was fully randomized for every participant. This task took about 15 minutes and included one demonstration run. Throughout this condition EEG was continuously recorded as described below. The photographs were shown on a 21-in. CRT monitor (75-Hz refresh rate) located approximately 100 cm in front of the participant. Presentation software (Neurobehavioral Systems, Inc., Albany, CA) was used to present the pictures and to collect responses via a mouse.

Explicit Condition (HIV Risk Rating): In the second part of the study, which immediately followed the first part, participants performed explicit ratings of HIV risk for all photographs. In the instruction participants were asked to spontaneously report their first impression of HIV-risk for every person presented and completed three test trials (Schmälzle et al., in preparation-a). Photographs of persons were presented for 2 seconds, preceded by a fixation cross (1 s) and followed by a blank screen (1s). Next, the HIV risk rating scale appeared and lasted until a risk perception had been stated. Perceived HIV risk was assessed on a 7-point rating scale by the item “How likely is it that this person is HIV-positive?” (original terms in German: "Für wie wahrscheinlich halten Sie es, dass diese Person HIV-positiv ist?", cf. Agocha & Cooper, 1999; Malloy et al., 1997). These ratings were used to categorize the associated EEG data from this explicit and from the preceding implicit condition into low and high risk categories.

After the participant had reported perceived risk, a blank stimulus was shown during the inter-trial interval for 3.5 s. Photographs appeared in a different, random order than in the preceding implicit condition, and presentation order varied randomly across participants. This part of the study lasted around 25 minutes. Figure 3.1 gives a schematic overview of both parts (implicit and explicit condition).

Collection of Attractiveness Ratings: In addition to perceived HIV risk participants were asked to rate all 120 experimental stimuli in terms of attractiveness. These data served as a control for alternative explanations of the ERP results. Collection of attractiveness ratings was based on the same stimulation protocol as the HIV risk judgment (7 point rating scale).

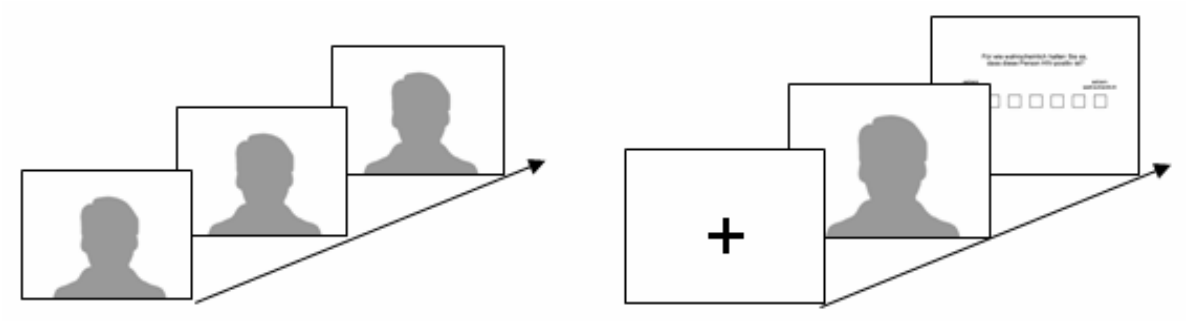

Figure 3.1: Examples of two trials from the incidental/implicit and explicit task. Left: A schematic trial from the implicit condition. Participants viewed a series of 13 photographs, presented in slow succession while their EEG was recorded. During this task participants were unaware that the study targeted at HIV risk perception. Right: Example trial from the explicit condition. After viewing the person, a rating scale was shown and participants reported on their perception of risk that the person is HIV-positive.

Manipulation Checks

Memory Performance: Performance of all participants in the person memory task was excellent. Performance averaged at 93% correct responses. The primary goal of including this task as compared to a simple passive viewing condition had been to ensure that a constant level of attention was maintained during the presentation. The high performance level observed suggests that this manipulation was successful.

Do Stimuli Differ in Their Ascribed Risk? Ratings from the explicit condition were inspected to confirm that the stimuli represented the full range of perceived HIV

risk. As in the previous study, which utilized the same set of stimuli, self-reported risk perceptions varied considerably between individual stimuli (see Figure 3.2).

An alternative and more conservative way to test that the perceived risk for the presented persons varied is to demonstrate that every participant used a wide range of the risk scale. In line with this, all participants showed clear variance in their ratings. Additionally, relative frequencies for each risk category were calculated, separately for each participant.

Table 3.1 presents the average of these participant-specific frequencies and their standard deviations across participants. This analysis provides confirming evidence that perceived risk varied substantially. As expected, however, the 'very low' and 'very high' risk categories were used less often.

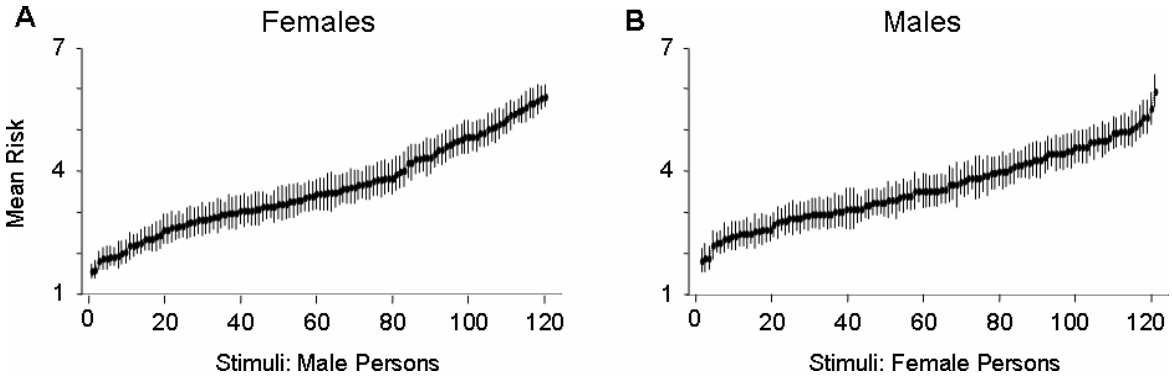

Figure 3.2: Means and standard errors of risk ratings for all stimulus items, rank-ordered by ascending risk. The left plot (A) shows the results for the group of females, the right plot (B) shows the results obtained for male participants.

Table 3.1: Average frequencies and standard deviations for the 7 categories of risk across all participants.

Risk Rating	**1** low	**2**	**3**	**4**	**5**	**6**	**7** high
Average Frequency	21.2	22.8	20.6	11.5	21.5	15.1	7.3
SD	(14.8)	(9.5)	(10.7)	(12.1)	(10.0)	(8.8)	(6.8)

Do Stimuli Differ in Their Ascribed Attractiveness? Similar to risk, ratings of attractiveness varied substantially along the perceived attractiveness dimension. As shown in Figure 3.3, the pictures spanned the full range of attractiveness. To provide

additional evidence for substantial variance in perceived attractiveness, the distribution of 120 attractiveness ratings was examined for all participants on an individual level. As for perceived risk, Table 3.2 presents the average and standard deviations of attractiveness rating frequencies across all participants.

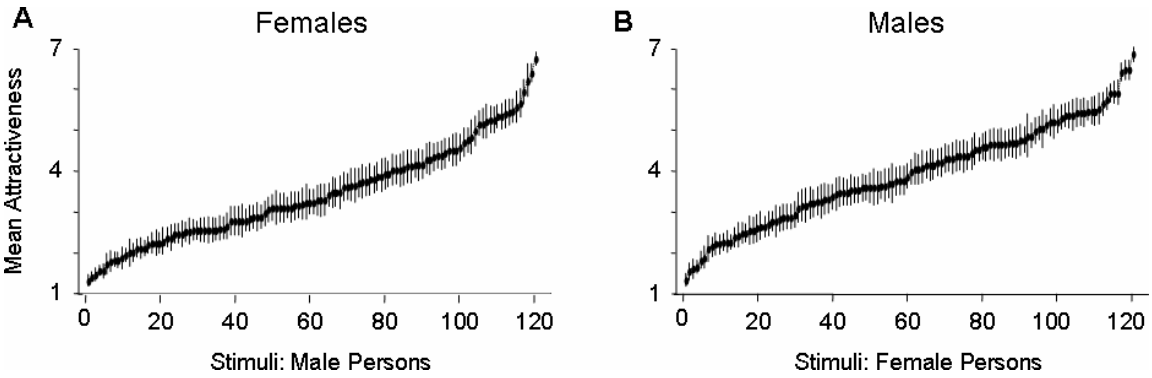

Figure 3.3: Means and standard errors of attractiveness ratings for all stimulus items, rank-ordered by ascending attractiveness. The left plot (A) shows the results for the group of females, the right plot (B) shows the results for male participants.

Table 3.2: Average frequencies and standard deviations for the 7 categories of attractiveness across all participants.

Attractiveness Rating	**1** low	**2**	**3**	**4**	**5**	**6**	**7** high
Average Frequency	19.8	22.6	21.4	13.1	22.4	13.9	6.8
SD	(15.4)	(9.3)	(7.6)	(12.1)	(8.9)	(6.5)	(5.5)

Electrophysiological Recording and Data Reduction

Electrophysiological data were collected from the scalp using a 257-channel system (EGI; Electrical Geodesics, Inc., Eugene, Oregon, USA). Scalp impedance for each sensor was kept below 40 kΩ, as recommended for this type of high input impedance amplifier. The electroencephalogram was collected continuously in the 0.1 - 100 Hz frequency range, with a sampling rate of 250 Hz. EEG data were low-pass filtered at 40 Hz before stimulus synchronized epochs were extracted from 100 ms before until 800 ms after picture onset. To guard against potential contamination of the EEG by ocular artifacts, the algorithm proposed by Gratton et al. (1983) was

employed. A statistical approach was applied for artifact correction, including the transformation of the ERP data to an average reference (Junghöfer et al., 2000).

Data Analysis

The rationale of the present study was to record spontaneous brain responses in an implicit condition (memory task) during which participants were unaware that depicted persons would have to be evaluated in terms of HIV risk later during the session. In order to determine whether high vs. low risk is associated with ERP differences, data from the implicit and explicit condition were both analyzed according to the ratings provided during the ensuing explicit condition. Specifically, for each participant and within each condition (implicit vs. explicit), high risk persons (risk ratings ranging from 1 - 3) and low risk person (risk ratings from 5 - 7) were identified. ERP waveforms were then obtained for each participant by averaging across low risk and high risk trials, respectively. This procedure resulted in a set of four ERPs for every participant: low risk and high risk ERPs for the implicit condition (memory task), and low and high risk ERPs for the explicit condition (HIV risk perception), respectively.

Statistical Procedure for ERP Analysis: Visual inspection and single sensor waveform analyses were used in a two-step procedure to analyze the risk modulation of the ERPs. First, repeated measures analyses of variance (ANOVAs), including the factors Task (implicit, explicit) and Risk (low, high), were calculated for each time point after picture onset separately for each individual sensor in order to identify the temporal and spatial characteristics of ERP modulation by picture risk status. Second, to provide a more conventional ERP analysis, temporal windows and spatial regions of interest were defined and the average of the selected sensors was calculated. This information was analyzed by repeated measurement ANOVAs using Greenhouse-Geisser corrections to correct for violations of sphericity. Preliminary analyses indicated no RISK × GENDER or TASK × RISK× GENDER interactions, hence the results were collapsed across the GENDER factor for statistical reporting.

Effects between 430 - 530 ms and 550 - 800 ms (Central & Occipital Regions): Effects of risk over central areas, with polarity reversed effects over inferior occipital sites, were observed by inspection of individual waveforms and difference maps. To statistically assess these effects, mean amplitudes from representative central and

occipital sensor clusters were averaged over two separate time intervals (430 - 530, 550 - 800 ms) and subjected to conventional ANOVAs. The same sensor cluster that served to assess the effect of risk in the interval ranging from 430 - 530 ms was used to analyze the time window from 550 - 800 ms. The bilateral central clusters consisted of EGI sensors # *6, 7, 9, 16, 17, 23, 24, 30, 41, 42, 43, 44, 45, 50, 51, 52, 53, 58, 59, 60, 65, 66, 71, 72, 76, 77, 78, 79, 80, 86, 87, 88, 89, 98, 99, 100, 110, 128, 129, 130, 131, 132, 141, 142, 143, 144, 152, 153, 154, 155, 162, 163, 164, 172, 173, 181, 182, 183, 184, 185, 186, 195, 196, 197, 198, 205, 206, 207, 214,* and *215*. Effects over occipital scalp were evaluated using a bilateral cluster of sensors (EGI sensor numbers # *102, 103, 104, 105, 111, 112, 113, 114, 115, 120, 121, 122, 123, 124, 133, 134, 135, 136, 145, 146, 156, 157, 158, 159, 148, 149, 165, 166, 167, 168, 174, 175, 176, 177, 187, 188, 189, 199, 200,* and *208)*. A schematic overview of these sensor locations plotted on the sensor net layout is shown in Figure 3.4.

Effects between 240 - 300 ms (Occipital Regions): Since inspection revealed an additional earlier effect over occipital sensors between 240 - 300 ms, this early posterior effect was explored in two bilateral channel groups including EGI sensors # *106, 107, 108, 113, 114, 115, 116, 117, 121, 122, 123, 124, 125, 134, 135, 136, 138, 139, 146, 148, 149, 150, 151, 156, 157, 158, 159, 160, 166, 167, 168, 169, 175,* and *176* (see Figure 3.4).

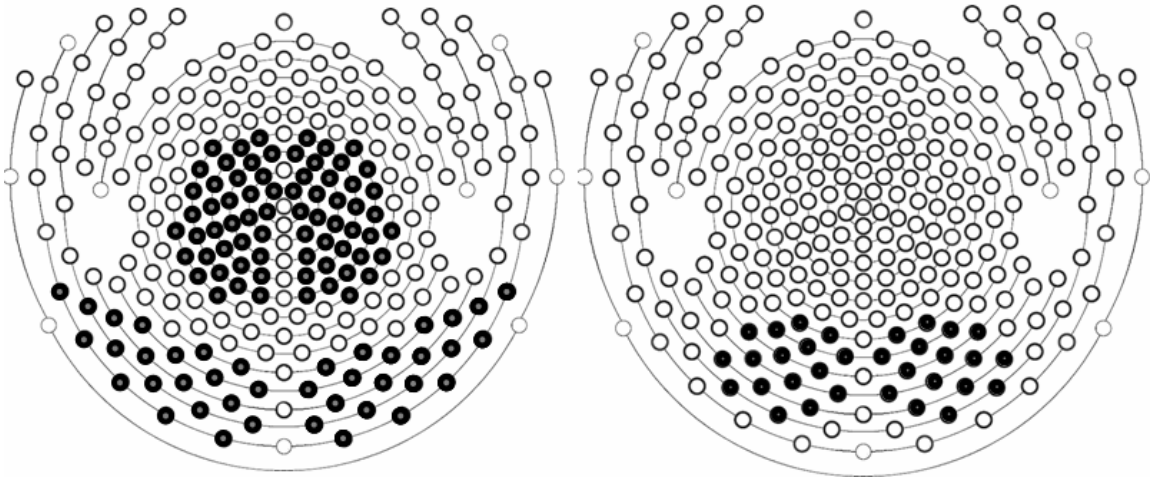

Figure 3.4: Illustration of the bilateral central and occipital sensor clusters entering statistical analyses. Left: Clusters for assessing the effects in the interval between 430 - 530 ms and 550 - 800 ms. Right: Occipital cluster for the assessment of effects between 240 - 300 ms.

Results

Low vs. High Risk ERPs

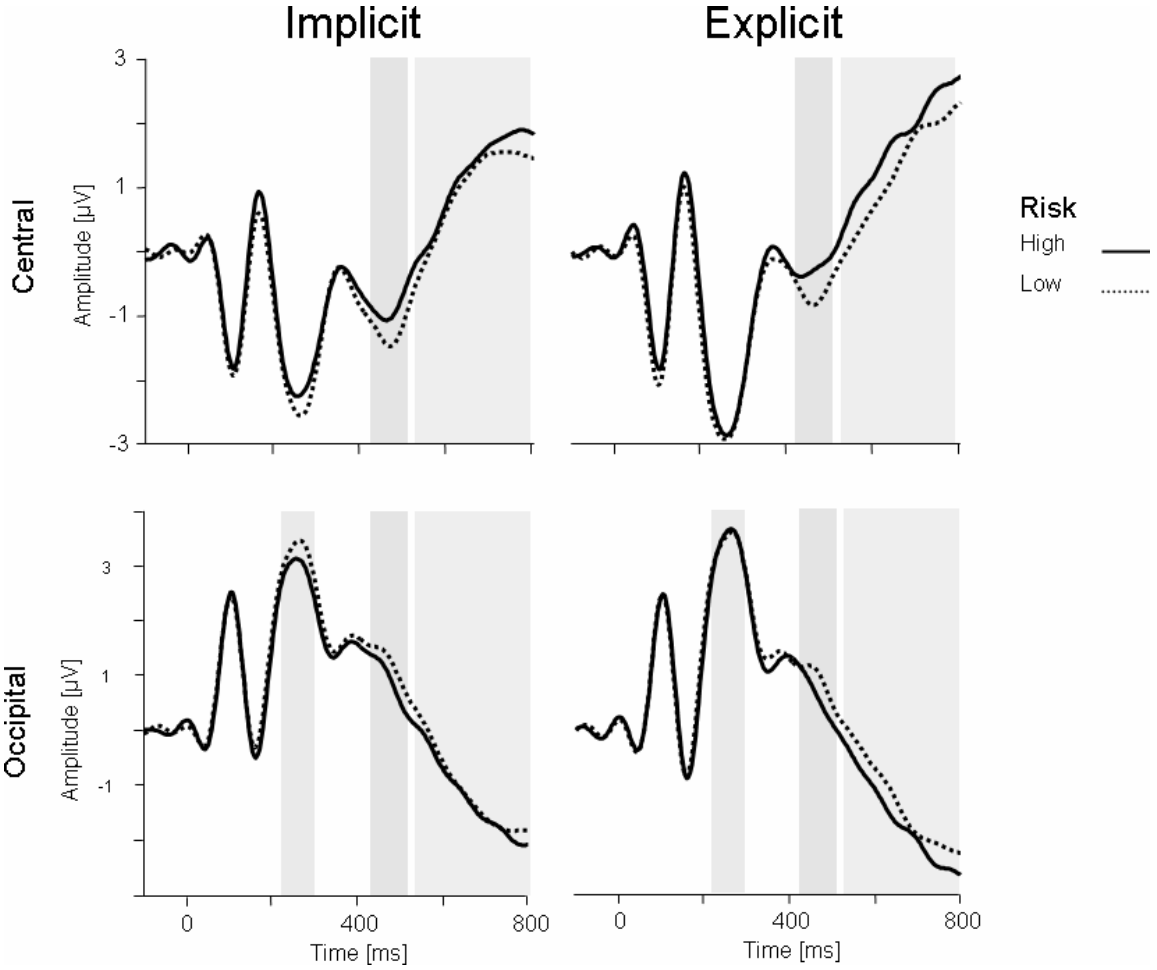

Figure 3.5: ERPs toward low and high risk persons for representative central and occipital sensors (# 17 and # 175). ERPs from the implicit condition are plotted on the left side, those from the explicit condition on the right.

Central Positivity toward Persons during the Implicit and Explicit Condition: **N**europhysiological responses in the explicit task (HIV risk perception judgment) were characterized by an enlarged positivity toward high risk persons. Looking at the effect of risk in the explicit task, risky as compared to safe pictures were associated with a larger positivity over central sensors (assessed in two intervals between 430 - 530 ms and 550 - 800 ms), with polarity reversals at inferior sites. Figure 3.5 illustrates the pattern of results by depicting representative waveforms. Topographical plots of the difference between ERPs toward risky - safe individuals for both intervals are shown in Figure 3.6.

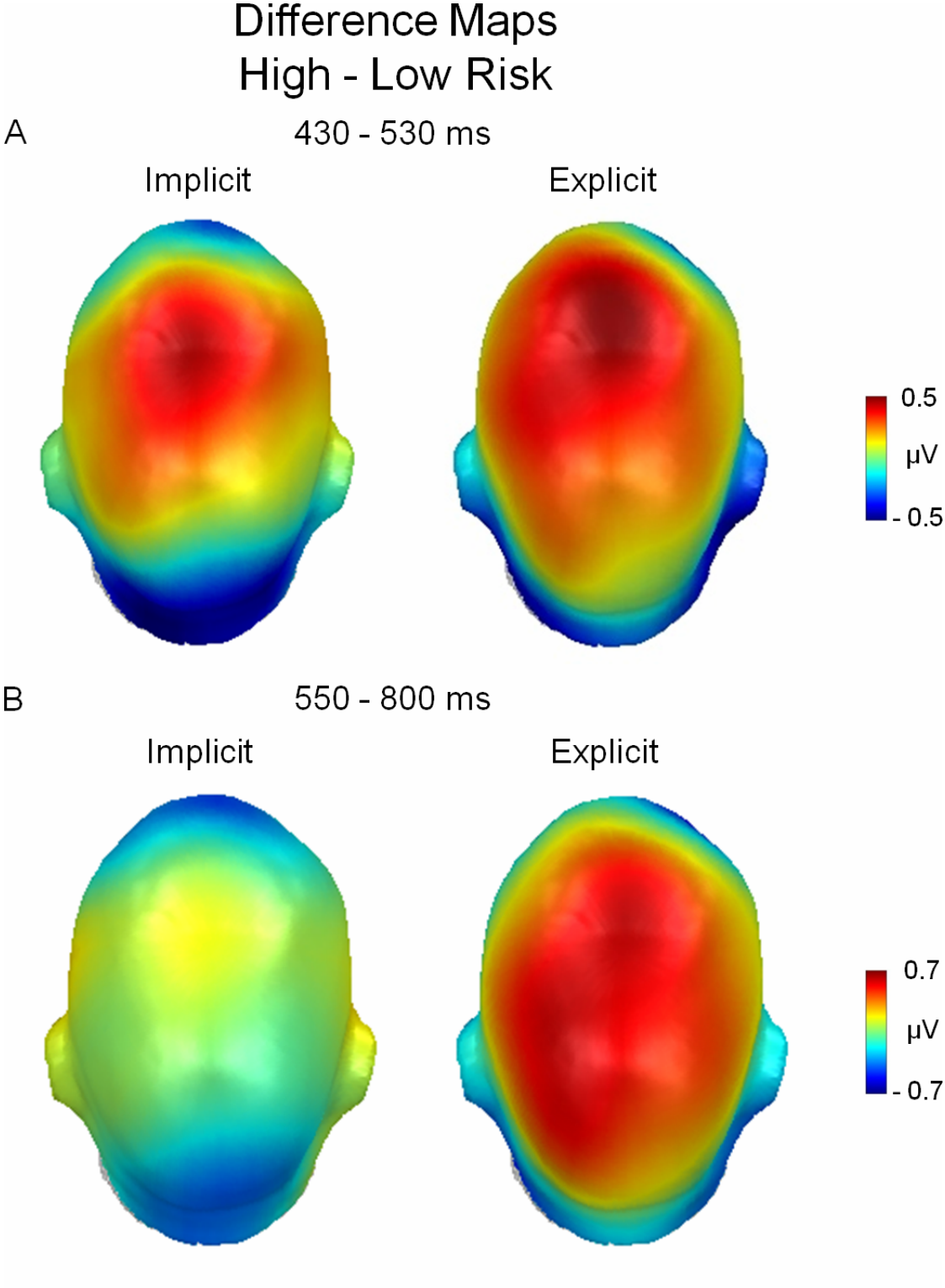

Figure 3.6: A) Scalp potential difference maps (high - low risk, Top View) of ERPs toward risky and safe persons from the implicit (left) and explicit (right) condition. Differences are calculated in the interval between 430 - 530 ms post stimulus. B) Same graphs for the 550 - 800 ms interval.

Of most interest, a highly similar effect was also observable during the implicit task in an interval between 430 and 530 ms (see Figures 3.5 and 3.6). Critically, whereas between 430 and 530 ms the observed ERP differences were only affected by picture risk status independent of the task, a significant sustained positivity (550 - 800 ms) for risky persons developed only during the explicit task. The modulation over central areas was accompanied by a corresponding negativity over more inferiorly located sites.

Statistical significance of these observations was determined in tow intervals (430 - 550 ms and 550 - 800 ms) by repeated measures ANOVAs with factors TASK (implicit vs. explicit), RISK (high vs. low), LOCATION (central vs. occipital), and LATERALITY (left vs. right). In the interval between 430 and 530 ms RISK specifically modulated the processing of pictures appearing with opposite polarity over occipital and central sensor clusters ($F_{RISK \times LOCATION}$ (1,37) = 13.6, $p < .001$). This interaction was followed-up by separate analyses for central and occipital sensor clusters.

ERP amplitudes over central regions were similarly accompanied by enlarged positive potentials toward risky stimuli in both conditions ($F_{TASK \times RISK}$ (1,37) = 0.20, p = 0.65, n.s.). The main effect of RISK was highly significant (F_{RISK} (1,37) = 8.43, $p < 0.01$) and equally present over right and left cluster regions ($F_{RISK \times LATERALITY}$ (1,37) = 0.29, p = 0.59). A main effect of TASK status (F_{TASK} (1,37) = 12.16, $p < 0.001$) was due to stronger ERPs in the explicit task.

Calculating this analysis for occipital sites also yielded similar, but polarity-reversed results, i.e. a significant main effect of risk during the time window between 430 and 530 ms (F_{RISK} (1,37) = 9.08, $p < 0.01$), with . The interaction was insignificant, thus confirming the observation of significantly more negativity toward risky persons over occipital areas in both conditions ($F_{TASK \times RISK}$ (1,37) = 0.11, p = 0.74).

In the interval of interest between 550 - 800 ms effects of RISK appeared with reversed polarity over central and occipital sites ($F_{RISK \times LOCATION}$ (1,37) = 9.9, $p < .01$) and were followed up separately for both clusters.

For the central cluster ANOVA revealed differential effects of RISK in the implicit and explicit condition, as indicated by a significant interaction of factors TASK and RISK (550 - 800ms; $F_{TASK \times RISK}$ (1,37) = 11.22, $p < 0.01$). When analyzed separately for

both tasks, the implicit condition showed an absence of the effect of RISK ($F_{RISK:\ IMPLICIT}$ (1,37) = 0.04, p = 0.84). In contrast, during the explicit task the early (430 - 530 ms) differentiation developed into a sustained central positivity lasting from 550 to 800 ms post stimulus ($F_{RISK:\ EXPLICIT}$ (1,37) = 16.8 $p < 0.001$). No higher order interactions with the LATERALITY factor were significant.

For the occipital sensor cluster, analysis of the later interval (550 - 800 ms) revealed a significant main effect of RISK (F_{RISK}(1,37) = 5.98, $p < 0.05$). Although the interaction between TASK and RISK was not significant as one would have expected from the findings over central areas, separate exploratory analyses were conducted for both task levels (implicit and explicit). From that it appeared that the effect was mainly driven by the stronger effect of RISK in the explicit task (F_{RISK} (1,37) = 4.58, $p < 0.05$). Only in the implicit condition alone this effect did not attain significance ($F_{RISK:\ IMPLICIT}$ (1,37) = 2.03, p = 0.16).

Occipital Negativity toward Risky Persons Confined to the Implicit Condition: Interestingly, during an earlier interval (240 - 300 ms) a consistent neural differentiation between low and high risk pictures was observed bilaterally, indicative of early attentional selection processes (see Figure 3.7). Only present in the implicit condition, the difference was observed as a relative negativity for risky vs. safe persons. In the same time window no comparable difference emerged during the explicit condition.

To test whether these effects were reliable, data from both occipital clusters for the interval between 240 - 300 ms were submitted to an ANOVA with factors TASK (implicit vs. explicit) and LATERALITY (left vs. right). The early (240 - 300 ms) neural differentiation between low and high risk pictures in the implicit condition was statistically significant ($F_{RISK:\ IMPLICIT}$ (1,37) = 8.0, $p < 0.01$), but absent in the explicit condition ($F_{RISK:\ EXPLICIT}$ (1,37) = 0.003, p = 0.96; $F_{TASK \times RISK}$ (1,37) = 4.39, $p < 0.05$). This effect was not further qualified by higher-order interactions invoking LATERALITY, or GENDER.

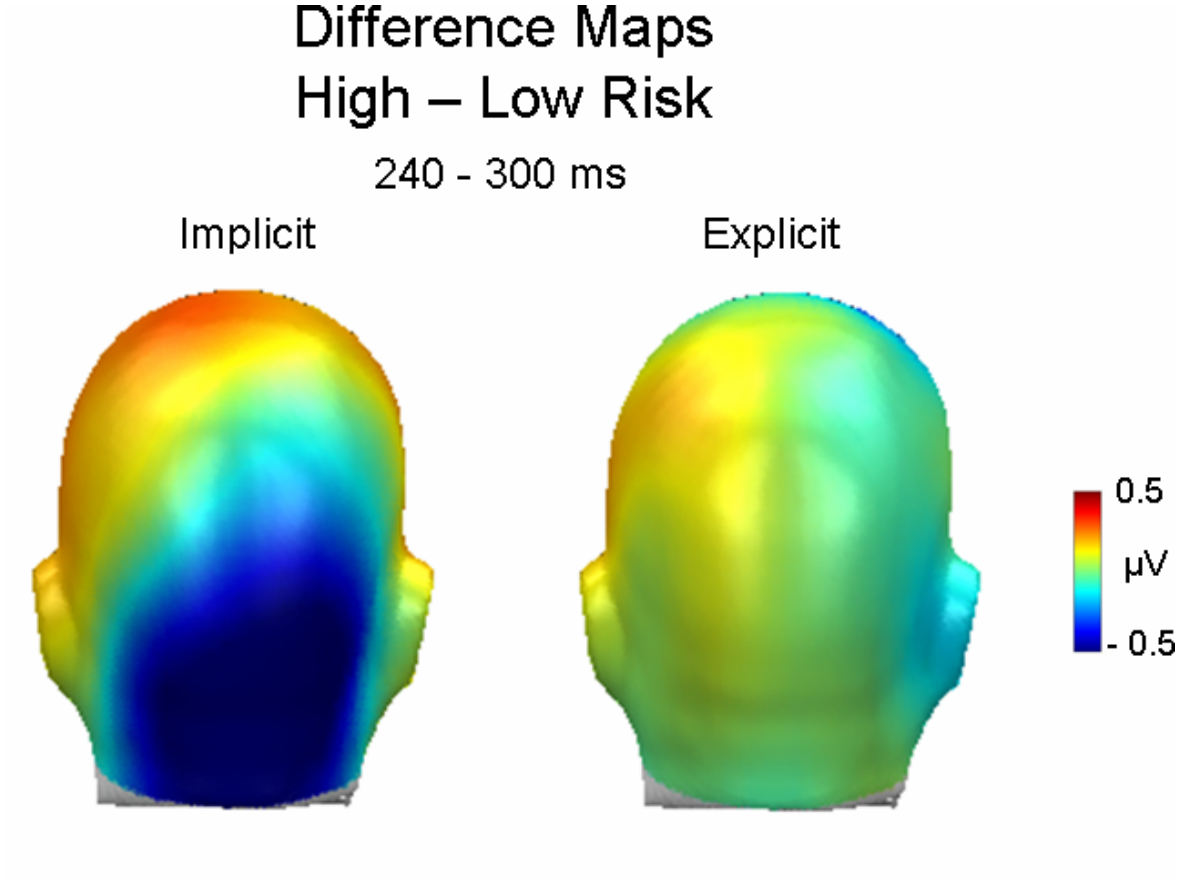

Figure 3.7: Difference maps of ERPs toward risky and safe persons from the implicit (left) and explicit (right) condition. Differences are calculated in the interval between 240 - 300 ms post stimulus.

Although the primary goal of this study was to detail the temporal dynamics of intuitive risk perception, high-density ERP recordings allowed tentative inferences about the localization of likely neural generators via Minimum-Norm source localization (Hauk, 2004; Hauk, Keil, Elbert, & Müller, 2002). The calculation was based on a source model consisting of a spherical isotropic volume conductor head model with four shells and 3 (radial, azimuthal, and polar direction) x 197 evenly and spherically distributed dipoles. As a trade-off between depth sensitivity and spatial resolution, a source shell radius of 6 cm was chosen. Using these parameters, the differential activity in the tested time window was indicated to originate from bilateral occipital cortices (Figure 3.8), with slightly stronger modulation in the right hemisphere.

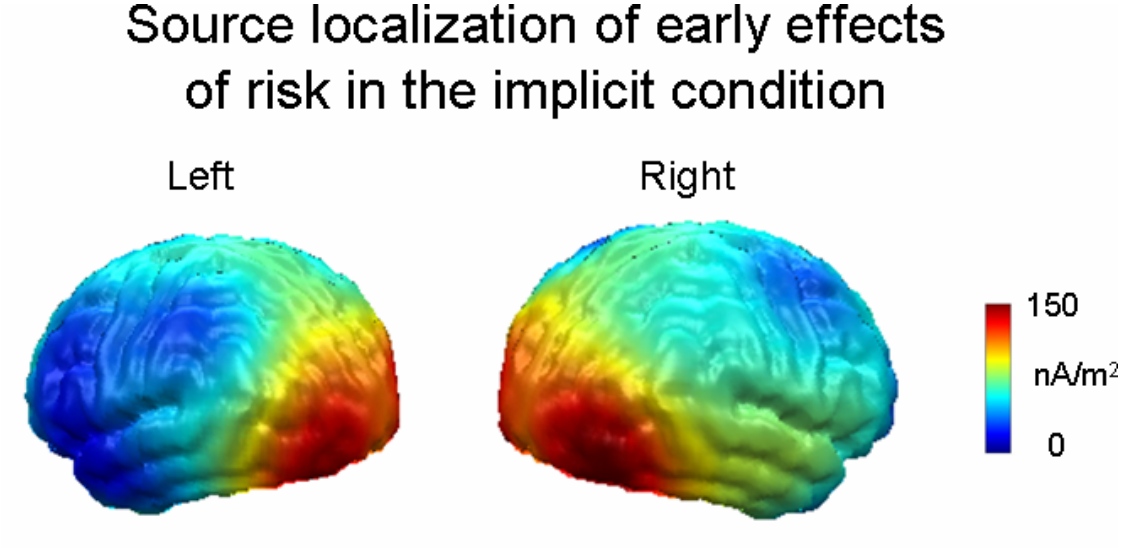

Figure 3.8: Left and right back view of the L2-Minimum-Norm estimate in the 240 - 300 ms time interval for the difference waves comparing risky and safe stimuli.

Supplementary Analyses

Influence of Risk-Coding Procedures: Further analyses were performed to corroborate these findings. Partitioning of risk ratings by means of z-scores instead of fixed categories (see above) did essentially yield the same results[9]. Overall, similar results were obtained using three categories of risk[10] (i.e. low, medium, high risk, obtained by trichotomizing the risk ratings).

Stimulus Probability and Frequency of Category Usage: The fact that participants saw all stimuli for the first time, all stimuli had equal target status, and could not be divided into classes of unequal probabilities by any clear-cut categorization rule, makes interpretations based on stimulus probability unconvincing. This is particularly the case for the implicit condition, where no kind of categorization had to be performed whatsoever. However, to empirically test for effects of stimulus probability in the explicit condition, the group of participants was subdivided into two groups, consisting of participants with more (10 out of 38) or less frequent (28 out of 38) high

[9] Z-Scoring (central clusters): 430 - 530 ms, $F_{TASK} = 11.3$, $p < 0.01$; $F_{RISK} = 9.62$, $p < 0.01$; $F_{TASK \times RISK} = 0.22$, $p = 0.64$; 550 - 800 ms, $F_{TASK} = 7.3$, $p < 0.01$; $F_{RISK} = 8.75$, $p < 0.01$; $F_{TASK \times RISK} = 6.85$, $p < 0.05$;

[10] 3-Category-Split (central clusters): 430 - 530 ms, $F_{TASK} = 11.8$, $p < 0.001$; $F_{RISK} = 5.09$, $p < 0.01$; $F_{TASK \times RISK} = 2.87$, $p = 0.063$; 550 - 800 ms, $F_{TASK} = 7.02$, $p < 0.01$; $F_{RISK} = 10.37$, $p < 0.05$; $F_{TASK \times RISK} = 8.6$, $p < 0.001$;

risk ratings. Between-subjects ANOVA revealed that this did not result in any significant group-effects. Only a marginally significant interaction effect between RISK and the ODDBALL dummy-variable (central cluster, 428 528 ms, $F_{RISK \times ODDBALL} = 4.04$, $p = 0.052$) showed a trend toward larger positivity for high risk pictures in the group with less frequent low risk ratings, which is contrary to an assumed high-risk oddball effect.

Gradual Single-Trial Analysis: Figure 3.9 illustrates an analysis of continuous ratings across all participants by means of ERPImages (Delorme et al., 2007; Jung et al., 2001), which complements and supports categorical ERP data reported above. As can be seen from this figure, the implicit and explicit condition both show an increased positivity for risky stimuli in the time interval between 430 - 530 ms (or rather a less strong negativity, since the absolute values are in the negative voltage range, see Figure 3.9). The ERPImage for the explicit condition, consisting of single-trial data for sensor 17, shows that the sustained positivity (550 - 800 ms) is only present for risky persons.

Effects of Attractiveness: The average of all idiosyncratic correlations between risk and attractiveness amounted to $r = -0.09$. Thus, as a group the participants did not use one common and strong attractiveness-based strategy to infer HIV risk (e.g., a 'what is beautiful is good stereotype', Dion et al., 1972). Because ERP averaging relied on participants self report to form categories, the absence of a consistent relationship between risk and attractiveness ratings makes it highly unlikely that risk effects on ERP amplitudes were secondary to high attractiveness. To explore separate effects of low vs. high attractive stimuli on the ERP responses, single-sensor statistics were calculated for those intervals in which effects of risk-status were observed. For the analyses of attractiveness effects, individuals' attractiveness ratings were split to form categories of low vs. high attractiveness in the very same way as for the analysis of risk effects (ratings of 1, 2, or 3 comprising the low attractiveness category and ratings of 5, 6, or 7 for the high attractiveness category). Next, EEG epochs that were associated with low or high attractiveness categories were averaged to obtain low vs. high attractiveness ERPs for each participant. These ERPs were the used to calculate an ANOVA for every sensor and time point. Results of these analyses are illustrated graphically in Figure 3.10. For the interval between 240 - 300 ms, a strong negativity toward risky stimuli was obtained, while an analysis on the factor ATTRACTIVENES yielded no significant effects. In the later interval, when risk effects were present in

the implicit and explicit condition, the effects of attractiveness were weaker and topographically distinct. Thus, these results confirm the persistence of risk- dependent ERP modulations.

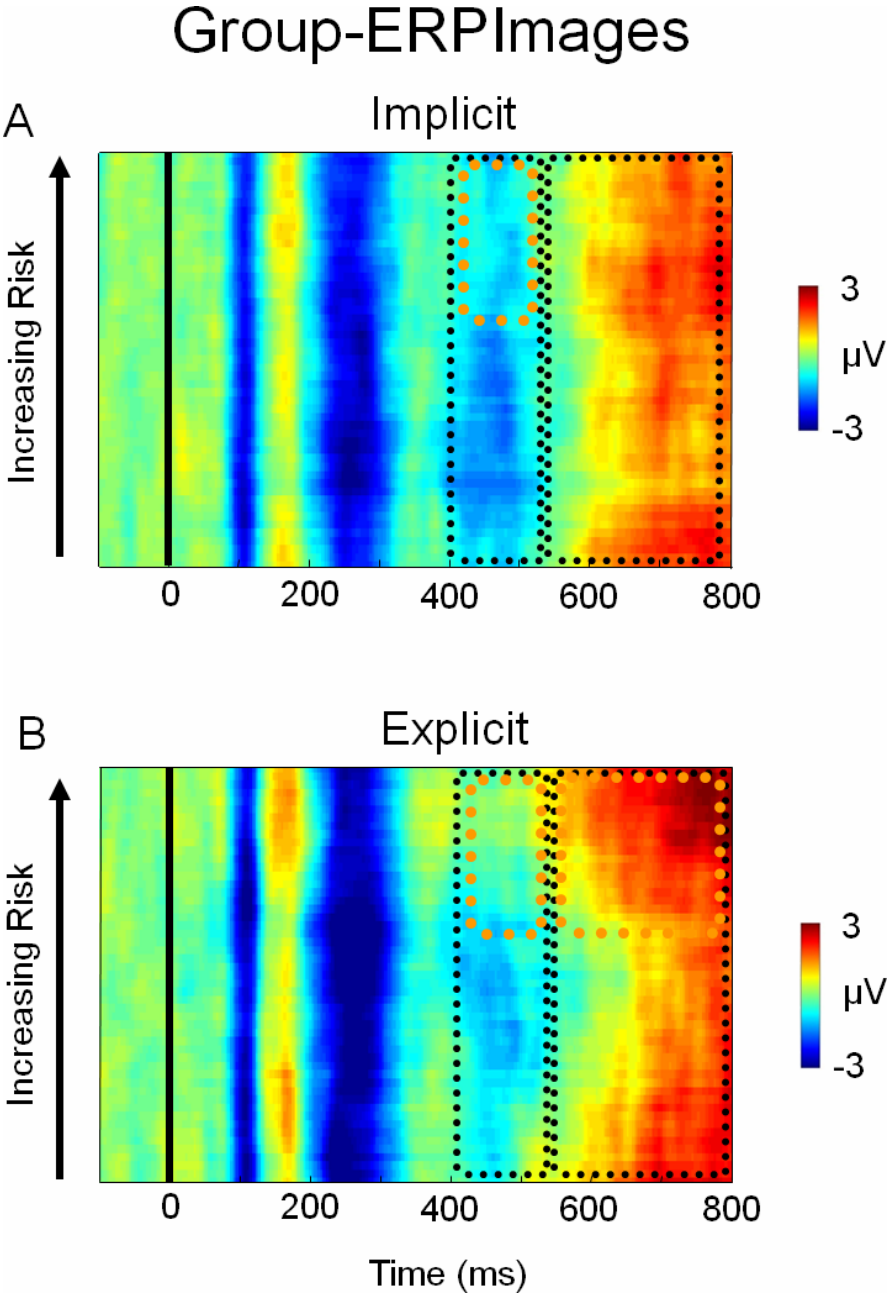

Figure 3.9: Group-ERPImages for central sensor # 17 during implicit (A) and explicit (B) risk perception. Black dotted lines indicate the time frames of interest, orange lines indicate critical differences.

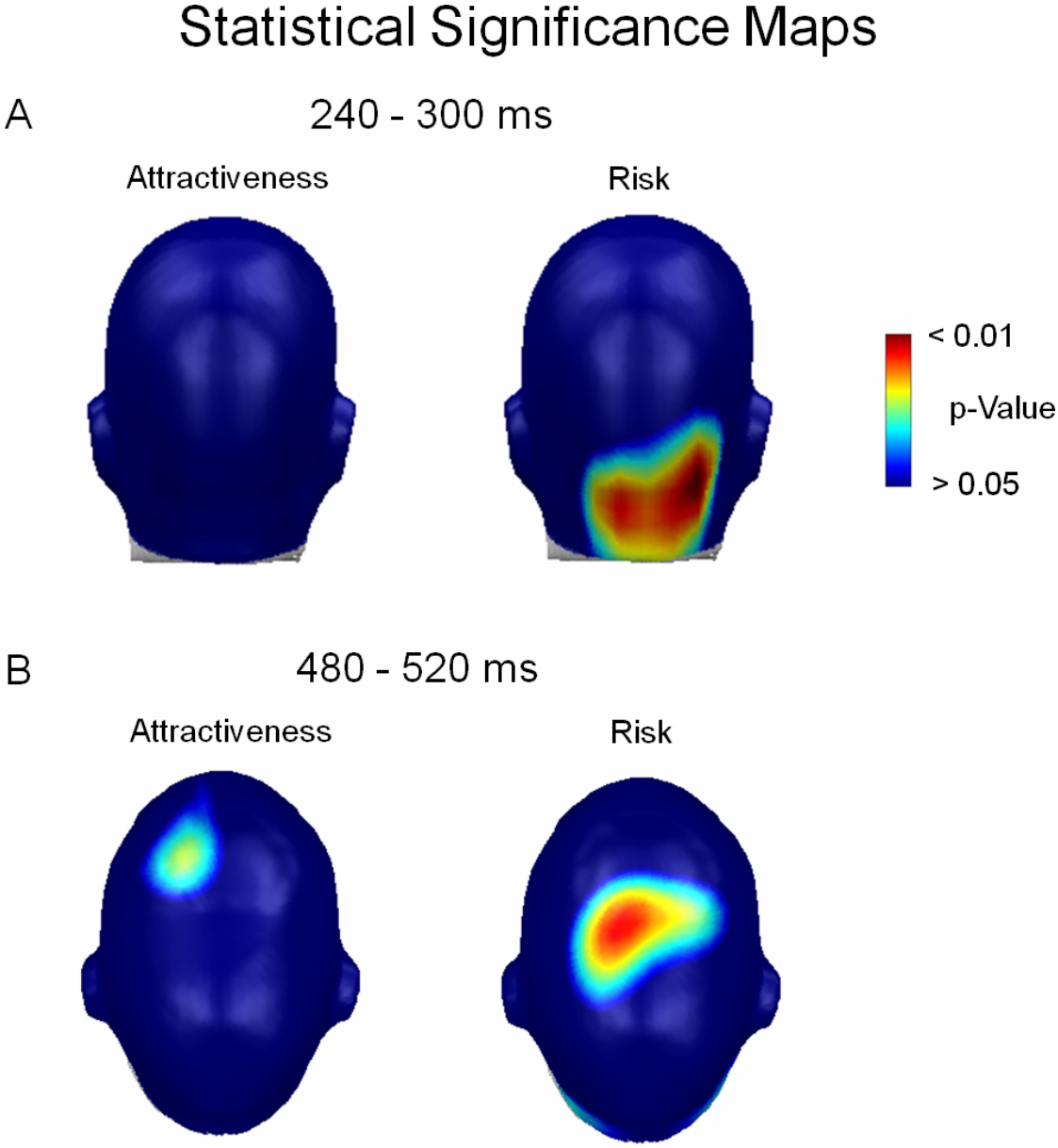

Figure 3.10: Topographical plots of significant effects from the reanalysis of EEG data by low vs. high attractiveness ratings (left plots). On the right, the effects of risk are shown in the corresponding intervals.

Discussion

The main goal of the present study was to examine whether risk perception operates in an implicit manner. A premise of the assumption that risk perception occurs implicitly is that differences between ERPs toward risky vs. safe persons should not be confined to the presence of an explicit task but rather be observable under implicit or incidental conditions. In line with this, the major novel finding is that results confirm the implicit nature of intuitive risk perception: When EEG trials from the implicit condition were categorized and averaged into ERPs by relying on later reports of high vs. low HIV risk, reliable ERP differences emerged. The principal finding of ERP differences between risky and safe persons, even without any risk perception instruction, provides the strongest support to date for the hypothesis of intuitive risk perception.

Only present in the implicit condition, an early negativity (240 - 300 ms) was detected for the comparison of risky vs. safe persons. Latency and topography of this effect are reminiscent of results from studies on affective picture perception. When ERPs toward affective are contrasted with those toward neutral stimuli, an early posterior negativity (EPN) can be observed in an interval between 200 - 300 ms post stimulus (Schupp et al., 2006). The EPN has been suggested to reflect the facilitated encoding of visual scenes depicting information of emotional significance. Moreover, although in the present study effects of laterality were not significant, the effect was slightly more pronounced over the right hemisphere, which is also consistent with findings from studies on affective picture perception (Schupp et al., 2007a). One might ask why such early differentiations were confined to the implicit condition and not similarly expressed in both tasks? A very slight but statistically insignificant negativity over occipital regions was still detectable in the explicit condition, and similar negativities also seemed to be present in the previous studies (Schmälzle et al., in preparation-a, in preparation-b). As can be seen in Figure 3.5, the explicit task prompted larger absolute ERP responses, resulting in significant effects of the task factor. This could have obliterated differentiations in the explicit condition. In sum, one can conclude that differential processing between risky and safe pictures must have occurred even in the implicit condition and that these differences were systematically related to later reports of HIV risk. Moreover, modulations of ERP waveforms by picture risk status emerged on ERP components (central positivity,

430 - 530 ms) that have been previously associated with affective evaluations (Schupp et al., 2006).

The finding of enlarged amplitudes toward risky persons in the explicit condition replicates previous findings (Schmälzle et al., in preparation-a, in preparation-b). With only the results from the explicit condition, however, one may have argued that the instruction to report on perceived risk activated HIV-related knowledge structures (Bishop, 1991; Renner & Schwarzer, 2003a). Furthermore, the explicit instruction to report on HIV risk may have led to preparatory processing prior to stimulus presentation. Finding similar effects of risk in implicit and explicit conditions argues against such an explanation. The effect in the explicit condition may thus neither depend on explicit instruction but rather reflect an obligatory phenomenon related to affective evaluation based on the intrinsic significance of stimuli.

The later effects of risk (550 - 800 ms) were much stronger in the explicit condition. These effects could be partly due to task-related processes. This interpretation is consistent with recent studies on affective picture perception (Ferrari et al., 2008; Schupp et al., 2007b) exploring the combined effects of explicit (instructed) and implicit (stimulus-intrinsic) affective relevance on ERPs. These studies demonstrated that task-relevant affective pictures elicit particularly enlarged ERPs. On that view, stimulus-intrinsic implicit processes may form the basis upon which task related processes exert further amplifying influences (after explicit instruction).

Previous research has suggested that perceptions of HIV risk may be related to perceived attractiveness (Blanton & Gerrard, 1997; Dijkstra et al., 2000; Epstein et al., 2007). Accordingly, the present study collected ratings of attractiveness and related these to perceptions of HIV risk. Results revealed hardly any relationship between perceived HIV risk and attractiveness. The correlation between risk and attractiveness averaged to -0.09. Thus, as a group the participants did not use one common and strong attractiveness-based strategy to infer HIV risk (e.g. a ‘what is beautiful is good stereotype’, Dion et al., 1972). This result is similar to the findings of Agocha and Cooper (1999), who found only a moderate relationship between physical attractiveness and perceived risk ($r = -0.12$), indicating that attractive people were perceived as somewhat less risky (but see Dijkstra et al., 2000, where males believed that more attractive women had been more promiscuous in the past and thus carried a

higher risk). In line with the finding that the risk-attractiveness correlation averaged to r = -0.09, higher amplitudes toward high risk stimuli were not secondary to attractiveness effects (cf. Figure 3.10). Overall, effects of attractiveness were rather weak and affected the effects of risk on ERP amplitudes within the relevant intervals or sensor clusters. The modest main effect of attractiveness obtained in the present study pointed to slightly enhanced ERP amplitudes. Previous ERP research has revealed enlarged amplitudes toward pictures of high attractive people (Oliver-Rodriguez, Guan, & Johnston, 1999; Werheid et al., 2007). However, these studies did only study facial attractiveness (in part using computer-generated stimuli) and contradictory results have also been reported (Roye, Höfel, & Jacobsen, 2008). Moreover, a recent study cast doubt on the assumption that attractiveness is assessed automatically (Schacht, Werheid, & Sommer, 2008). In conclusion, effects of risk are not explained by the hypothesis that they are driven by attractiveness, neither on the behavioral level, nor with respect to the ERP measures.

The observed modulations of the ERP by perceived risk suggest an increased attentional orienting to risky stimuli. This poses the question as to the regulation of these reactions, in particular their origin from attentional control structures (Posner & Petersen, 1990). Recent studies have revealed that affective cues activate a number of brain structures, including the amygdala, anterior cingulate and orbitofrontal cortex, which have been implicated in the exertion of attentional control over stimulus processing (Pessoa, Kastner, & Ungerleider, 2002; Vuilleumier, 2005). There is evidence that evaluations of other persons also recruit the brain's emotional circuitry. For example, Winston et al. (2002) showed an increased response in the amygdala when participants viewed faces rated as untrustworthy. Further studies have extended these basic results, thus providing more conclusive evidence for the involvement of the amygdala and perhaps insular cortex in implicit face evaluations and spontaneous trait inferences (Engell & Haxby, 2007; Engell, Haxby, & Todorov, 2007; Said, Baron, & Todorov, in press; Spezio, Huang, Castelli, & Adolphs, 2007; Spezio et al., in press; Todorov, Said, Engell, & Oosterhof, in press). Future studies might thus address this issue by exploring HIV risk perception in an fMRI environment allowing to detail the structures involved in implicit and explicit risk perception. One may predict that the amygdala or other regions involved in affective evaluation are responsive to risk.

In sum, the present findings demonstrate the intuitive nature of risk perception by demonstrating three key features of intuition: speed, affective evaluations based on nonconscious information integration, and implicitness. To our knowledge, this is the first study providing evidence for intuitive risk perception in an implicit task. The results of this study suggest that HIV risk perception recruits automatic processes that are also carried out spontaneously during initial sight of other people and thus provide convincing evidence for the ease with which erroneous beliefs about partners may be formed during first encounters. Informing people about these facts may lead to more effective strategies to promote the adoption of effective precautionary behaviors. On a theoretical level this study provides strong empirical support for notions of intuitive risk perception, such as the 'risk as feelings' approach (Loewenstein et al., 2001), postulating that risk involves more than only expectation-based cognitive calculations and that such processes may often shape behaviors under real-life contexts. Of course, real-life HIV risk behavior is regulated in a number of ways, and many intermediate steps may change ultimate behavior, but it seems possible that early processing differences may exert powerful impulsive effects on downstream processes (Strack & Deutsch, 2004). Public health efforts may thus include interventions designed to promote an enhanced awareness of the intuitive aspects of risk perception and seek out ways to address this type of risk perception in order to motivate preventive behaviors.

General Discussion

The aim of the present dissertation was to explore the impact of intuition on health risk perception. This goal was pursued with three experimental studies investigating intuitive influences on the perception HIV risk. The three studies are unified by the general hypothesis that the perception of health risk involves intuitive processes that are (1) extremely fast (speed); (2) based on affective evaluations derived from nonconscious information integration; and (3) performed in an implicit manner (i.e. incidentally).

The goal of study 1 was to test for key features of intuitive processing in the context of a risk perception paradigm while using highly controlled stimulus materials. Participants viewed unknown faces and reported the perceived risk of HIV infection for each face. ERP differences between risky and safe faces started as early as 350 ms after stimulus onset over centro-frontal recording sites (Figure 4.1). These effects later developed into a more sustained LPP, particularly pronounced over centro-parietal regions.

Study 2 added important evidence by showing that risk-related ERP modulations are not confined to highly standardized stimuli but extend to naturalistic photographs. Importantly, study 2 replicated the finding that risky persons prompt larger LPPs over central areas, starting after approximately 300 ms. Compared to study 1, the ERP morphology (Figure 4.1) was slightly different. For example, the supposedly face-specific vertex positive potential (positive peak over central regions around 170 ms, (Jeffreys & Tukmachi, 1992; Joyce & Rossion, 2005) is much more pronounced in study 1 than in study 2. Thus, waveform differences between the studies are likely due to the different stimulus materials in study 2, which may recruit different or additional brain areas.

Study 3 incorporated an implicit condition, enabling for the assessment of risk-related processing differences in the absence of external task demands imposed by the instruction to report on perceived HIV risk. Additionally, the same explicit HIV risk perception task as in study 2 was carried out. The results can be summarized as follows: First, there was an early negativity for risky as compared to safe persons, which was constrained to the implicit condition. Second, risky persons prompted a

central positivity. This effect was similarly expressed in the implicit and explicit condition. Finally, in the explicit condition the central positivity developed into a sustained positive potential. Compared to study 2, ERP waveforms and the differential effects of risk in the explicit condition were highly similar (Figure 4.1). Most likely due to the different task demands, the ERP waveforms from the implicit condition were smaller; the overall morphology, however, closely paralleled the explicit condition.

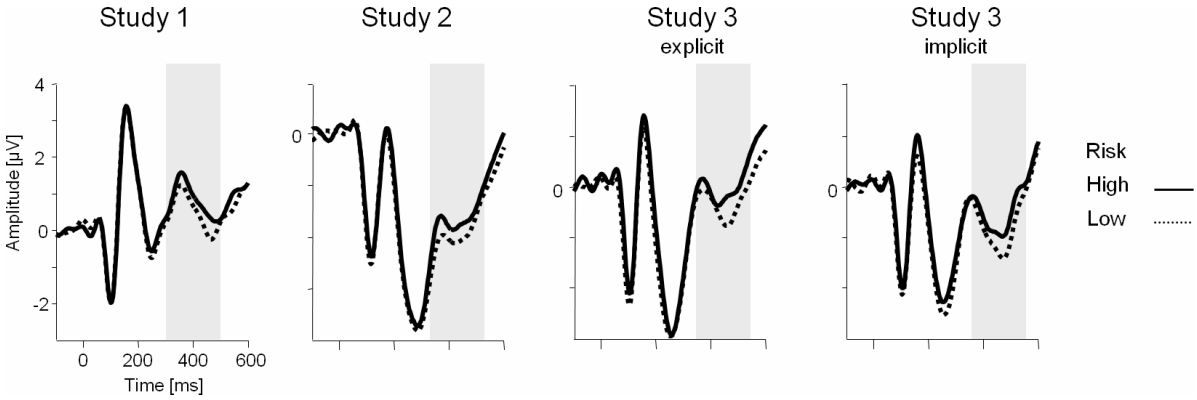

Figure 4.1: Synopsis of the onset of differences between ERPs toward high and low risky stimuli across three studies (EGI Sensor # 17). Note that global differences between the waveforms in studies 1, 2, and 3 arise from the independent samples of participants and from different stimulus sets. While studies 2 and 3 used naturalistic photographs of persons as stimulus material, pictures of faces served as stimuli in study 1. The morphology of the waveforms is thus more similar in studies 2 and 3.

The picture that emerges from these findings is consistent across all three studies. Figure 4.1 depicts the main results of the three studies by displaying ERPs toward risky and safe persons at one representative sensor (# 17). With respect to the demonstration of key features of intuitive processes (speed, affective evaluation, and implicitness), these results support three overarching assertions:

(1) Speed: If one accepts that finding ERP differences between high and low risk persons after about 300 ms cannot be a result of elaborate cognitions, then the feature of speed has been consistently demonstrated across the three reported studies. This adds supportive evidence to notions of intuitive risk perception by demonstrating that risk perception involves more than slow and effortful cognitive processes.

(2) Affective Evaluation: Regarding the link between risk perception and affective evaluation, all three studies revealed enlarged amplitudes toward risky persons over central areas. Modulations of this ERP component have been linked to the evaluation of stimuli based on their intrinsic affective/motivational relevance (Nieuwenhuis, Aston-Jones, & Cohen, 2005; Schupp et al., 2006; Schupp et al., 2007b). This suggests that results may be integrated when considering them from the perspective of stimulus-intrinsic affective evaluation processes that determine the amount of attention deployment.

(3) Implicitness: As for the implicit character of intuitive risk perception, study 3 revealed differential brain responses toward risky and safe stimuli during a completely implicit task. This finding strongly supports the view that risk-related processing differences are also operative under implicit, naturalistic conditions, thereby further corroborating the intuitive nature of health risk perception.

In sum, perceived HIV risk showed systematic relationships with ERP components pointing to early influences of intuition in assessing partner-specific risk. The reported findings provide strong empirical evidence for intuitive risk perception and suggest that these notions should be incorporated into theories of health risk perception.

From a broader perspective, health behavior theories posit that health-protective actions are influenced by risk perceptions. Which mechanisms enable this ability, however, remains a matter of debate (Millstein, 2003; Weinstein, 2003a). Building on the foundation laid by decision theory, traditional models of decision-making have placed a strong emphasis on cognitive processes that can be described as reflective, systematic, effortful, and slow (see Steinberg, 2003, for a general discussion; see Wright, 1998, for a discussion focusing on HIV). Although these perspectives are certainly not without their merits, they have arguably resulted in an oversight of many other factors that influence risk perception under conditions of daily life. Over the years, complementary views have emerged within the decision-making literature, first emphasizing intuition (Gilovich et al., 2002) and, recently, affect and emotion (Plessner, 2008; Weber & Johnson, 2009). These models propose that many real-life decisions (including choices, judgments, and inferences) do not involve effortful cognition.

More recent models of risk perception, such as the 'risk as feelings' framework (Loewenstein et al., 2001) or the 'affect heuristic' (Slovic, Peters, Finucane, & MacGregor, 2005), have taken up these arguments and now stress the role played by intuitive factors in risk-related thinking. These models assume that intuition or affect can be directly linked to risk, without cognitive interventions. Without going into detail, they all shift the emphasis away from effortful cognitions that are performed in central, reflective evaluation/decision stages (cf. Fellows, 2004) toward earlier, intuitive and more perception-like affective processes. However, the 'risk as feelings' approach and the 'affect heuristic' both stem from a decision-theoretic tradition and were not developed with the intent of addressing primarily health psychological issues. Currently, theories of individual health behavior largely fail to account for immediate affective and intuitive factors in risk perception and have only incorporated anticipated emotions (i. e. worry or regret; Cameron & Reeve, 2006; Chapman & Coups, 2006; Lerner & Keltner, 2001; Richard, de Vries, & van der Pligt, 1998). Furthermore, although theoretical models have received initial empirical support and are bolstered by many anecdotal findings, conclusive evidence for intuitive risk perception has been lacking. The results of the present dissertation thus provide the first empirical evidence in support of intuitive health risk perception. The three studies confirm that HIV risk is assessed intuitively and demonstrate how intuitive risk perception can be made subject to empirical investigation using sensitive neuroscientific measures. Thus, the present thesis constitutes an important first step toward a novel perspective on health risk perception.

The theoretical reconceptualization of health risk perception as an intuitive process may entail a more experiential and less abstract and analytic view on risk perception. When risk is conceptualized solely as probabilities and consequences it remains a rather abstract concept that is difficult to grasp and is detached from experience. Consequently, if risk estimates are derived from purely cognitive analyses, they are often not accompanied by feelings of personal vulnerability. Conversely, intuition and affect may entail that risks are perceived as self-relevant and connected to real life experience. This view is similar to that of Peters, Lipkus, and Diefenbach (2006) who have described four functions of affect in risk communication (not risk perception): affect as a conveyor of information, as an attentional spotlight, as a motivator of behavior, and as a common currency to evaluate different options. From the standpoint of affective neuroscience, a discipline grounded in biology and evolutionary

psychology, one may theoretically locate health-related risk perceptions and cognitions as being part of a functional behavior system organized around fostering the physical intactness of the body. From that perspective, intuitive risk perceptions might be understood as an everyday phenomenon, consisting of fundamental evaluations of personal risk and safety. Risk perception may operate as a kind of natural assessment that is carried out automatically, spontaneously, and without conscious reflection (e.g., exercising caution when crossing a street; observing the terrain when walking, etc.). This view may help to integrate disparate health psychology and affective neuroscience/evolutionary psychology literatures into a common framework that could possibly foster new research and insights about the factors influencing health risk perception.

Risk, in its most basic form, has to do with harm and aversive events. When the probability of harm is high or almost certain, risk becomes indistinguishable from danger, which is characterized by imminent threats to our personal well-being, accompanied by fear and anxiety. Risky situations, in contrast, are more remote in terms of temporal vicinity of the adverse event and less certain in terms of probability. Along these lines, Kahneman and Frederick (2002) note that "the perception of a stranger as menacing is inseparable from a prediction of future harm. Intuitive thinking extends perception-like processing from current sensations to judgment objects that are not currently present". When summarizing the theoretical undertaking for which the present dissertation provided empirical substantiation, one can say the following: Under conditions of daily life people come to sense health risk intuitively, presumably by relying on our embodied mechanisms of intuitive risk assessment. This is supported by the present results, showing that in the service of HIV risk perception intuitive and affective brain processes were recruited quickly and effortlessly, and in the third study even without explicit instruction.

HIV risk served as a model system for the present dissertation, allowing to explore the role of intuition for health risk perception by means of neuroscientific methods. HIV belongs to a larger group of life-threatening contagious diseases. Historically, pandemics of contagious diseases that were transmitted between people have been among the major causes of death. One may thus assume that humans could have adapted to this constant threat by applying automated heuristics to check for

others' risk status (cf. Schaller, 2006), perhaps similar to the implicit, intuitive risk perceptions proposed above.

Bishop and colleagues (Bishop, Alva, Cantu, & Rittiman, 1991; Bishop, Briede, Cavazos, & Grotzinger, 1987) propose that knowledge about diseases is organized around prototypical internal representations of diseases and that this knowledge guides thinking and behavior when confronted with instances of disease or novel diseases. They further showed that perception of contagiousness is one of the main organizing principles that people used in thinking about diseases and strongly predicts willingness to interact with a disease victim. People seem to have a relatively undifferentiated concept of contagious disease, defining it as being simply a disease that can be passed from one person to another and most frequently identifying transmission as occurring through casual contact. This led Bishop to suggest that negative reactions toward people with AIDS may result from a misapplication of prototypic properties of infectious diseases to the domain of HIV/AIDS (Bishop, 1991; cf. Rozin, Markwith, & McCauley, 1994; Rozin, Markwith, & Nemeroff, 1992).

From an evolutionary point of view it makes much sense to err on the side of caution, so that people may overgeneralize from subtle cues that are moderately predictive of low health status and apply these in their judgments about HIV risk. By pursuing this path HIV risk may be linked to general approach/avoidance responses that reflect humans' evolved mechanisms in dealing with the risk of infectious disease. There are, however, many different diseases and these vary widely in terms of seriousness (deadly vs. moderate harm) contagiousness (contagious vs. non-contagious), mode of transmission (e.g., via sexual contact, such as Chlamydia and Syphilis, or via casual contact, such as the flu), and visibility (e.g., skin diseases are visible whereas HIV viruses are not). This brings up the question of how people deal with this variety and, in particular, whether they have different strategies to check for different diseases. For future studies it may thus be very interesting to explore whether implicit differentiations between risky and safe persons are also detectable when probing for other diseases, some infectious, some not. This may further our understanding of people's implicit illness theories, their automatic strategies of risk avoidance, and will ultimately lead to a more precise picture of the complex processes underlying intuitive risk perception.

The studies discussed here lay the groundwork for future experimentation by demonstrating the importance of intuitive processes for health-related risk perception and exploring their basic characteristics. However, much remains to be learned, and the work done to date barely scratches the surface of the phenomena associated with intuitive risk perception. Before concluding, I would like to suggest potential avenues for follow-up research.

An issue that remains to be addressed relates to the specificity of the present results to HIV. As discussed above, HIV is part of a broader array of infectious diseases. A thorough testing of correlations between risk perception among several diseases for the same persons would allow to determine whether the present results are confined to HIV risk. Alternatively, they may generalize to a wider field of diseases, such as a prototype or cluster of life-threatening infectious diseases. If this hypothesis is correct, then effects of risk should be absent for people who are ascribed high risk for non-contagious diseases but low risk for HIV. Such a research strategy may ultimately fulfill Bishop's request for more research on processes and mechanisms that activate disease representations (Bishop et al., 1991).

Much of risk perception research is carried out in risk communication frameworks. In these contexts, event-related potentials might also provide a valuable tool to assess the presumably 'hot' phases after receiving self-relevant health risk feedback, which, so far are largely inaccessible using traditional methods (Renner et al., 2008). The HIV risk perception paradigm may be extended to include verbal descriptions of persons, either before their photographs are shown or afterwards. For example, one may provide information about a person's sexual history or other characteristics and test how these manipulations affect early neural processing. Alternatively, feedback about a person's HIV status could be provided to test how this further affects the response to the person.

The perception of other-related risk provides a logical starting point for understanding risk perception because it allows assessing brain responses in reaction to discrete external events, such as the onset of another person's photograph. However, social risks, where risk perception is contingent on the risk of the other person, constitute only a subset of health risks. Therefore, future research should attempt to extend the present approach by searching for ways to bring non-social health risks into the psychophysiological laboratory. For example, Sharot and colleagues (2007) show

how emotional reactions pertaining to optimistic views about the future may be investigated in an fMRI environment. Supposedly, intuitive and affective reactions also play a large role in the perception of non-social health risks (e.g., smoking).

In order to get an integrated picture of the complex interactions among neural systems taking place during risk perception, we need techniques that allow us to observe the entire human brain with high resolution in both space and time. FMRI provides a useful complimentary method to study the neural mechanisms of intuitive risk perception with high spatial resolution. The present paradigms can be adapted for fMRI research without much modification. Such an experiment would provide insight into which brain structures are involved and may thus help to disentangle the precise nature of the neurocognitive processes underlying health risk perception.

Conclusion

The main conclusion that can be drawn from the present research is that risk perception involves intuitive processes beyond the severity * probability calculus. Until now, no study has demonstrated intuitive influences on health risk perception. This dissertation showed that methods from affective neuroscience are able to trace down intuitive processes of health risk perception, which are difficult to observe using traditional methods. The results suggest that the systematic study of the impact of intuition will ultimately facilitate the development of new theoretical models of health risk perception. A deeper understanding of the functions of intuition in health risk perception might lead to better strategies for risk communication and more effective health prevention efforts.

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