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Neural correlates of perceived risk: the case of HIV

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Research indicates that many people do not use condoms consistently but rather rely on illusory control strategies for avoiding an infection with HIV. Preliminary evidence suggests that people form impressions of a partner's HIV risk based on his or her physical appearance. To examine the neural correlates of such appearance-based HIV risk impressions, event-related potentials were recorded while participants viewed portraits of unacquainted persons. Participants' explicit HIV risk ratings for each of the presented unacquainted persons were used to form categories of low and high HIV risk persons. Results showed that risky, compared to safe persons elicited distinct event-related potential (ERP) modulations. Viewing risky persons was associated with an increased positivity over right frontal regions between 180 and 240 ms. This suggests that impressions related to HIV risk occur rapidly, presumably reflecting automatic person evaluations eluding introspection. In a time window between 450 and 600 ms, risky persons elicited an increased late positive potential. Consistent with previous findings reporting augmented late positive potentials (LPP) amplitudes to affectively significant stimuli, the results support the assumption that risky faces draw more attention resources. These findings are in accordance with the 'risk as feeling' notion.

Keywords: risk perception; affect; intuition; ERP; P3; late positive potential

INTRODUCTION

HIV, the virus that causes AIDS, constitutes one of the world's major risks to human health (UNAIDS/WHO, 2008, 2009). Every 9.5 min, on average, someone in the USA is infected with HIV (Hall *et al.*, 2008) and recent studies point to an increase in infection rates (RKI, 2009). Numerous campaigns have informed the public that unsafe sexual behavior is the primary way of contracting HIV and that consistent condom use is the most efficient way to prevent the risk of HIV infection (UNAIDS/WHO, 2008, 2009). As a result, most people are well informed about HIV and protection against HIV risk. However, knowing the facts seems insufficient to motivate consistent protective behavior. Studies on condom use have painted a rather sobering picture, revealing high rates of negative condom attitudes (e.g. embarrassment and discomfort; Civic, 2000; Lust and Bartholow, 2009) and infrequent use of condoms (Chandra *et al.*, 2005, Martinez *et al.*, 2006).

People appear to employ an array of strategies to circumvent condom use, such as 'getting to know the partner' or 'learning about his or her sexual history' (Swann *et al.*, 1995; Thompson *et al.*, 1999; Donovan, 2000). Unfortunately, these strategies are not effective but rather induce a false sense of control over the risk. One particularly concerning finding from interviews and focus group research is that people seem to form an immediate impression about others' HIV risk status. Specifically, people report that they often 'just know' whether a person is risky or safe—even when they do not know much about the respective person's past sexual behavior or personality (Maticka-Tyndale, 1991; Gold *et al.*, 1992; Keller, 1993; Klepinger *et al.*, 1993). Moreover, people who are infected with HIV often report that they were convinced that their partners were safe (Gold *et al.*, 1992). Thus, it appears that HIV risk perception is at least partly based on spontaneous impressions of others, and that 'safe' impressions can override the reliance on effective protection strategies (i.e. condom use).

In the present research, we hypothesize that impressions of HIV risk are based on an intuitive mode of reasoning (Lieberman, 2000; Loewenstein *et al.*, 2001; Slovic and Peters, 2006). Research in various areas of psychology has shown that intuitive processes loom large in everyday cognition and often affect judgments and decisions (Lieberman, 2000; Hodgkinson *et al.*, 2008). For instance, heuristic inferences, of which we are mostly unaware, account for many intuitive judgment biases (Gigerenzer and Goldstein, 1996; Kahneman, 2003). Similarly, intuitive inferences of competence or childishness based on appearance have been shown to influence political elections (Todorov *et al.*, 2005) and sentencing decisions (Zebrowitz and McDonald, 1991). Accordingly, intuition may cause deviations from 'rational' or 'normative' judgment and behavior, not unlike the decision to refrain condom use because of the impression of a partner's safety.

The goal of the present study was to substantiate the notion drawn from behavioral research that HIV risk perception relates to appearance-based snap judgments. Event-related brain potentials were recorded to uncover neural correlates of HIV risk perception that remain hidden from introspection and precede overt responding.

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Similar to previous behavioral research (cf. Agocha and Cooper, 1999; Thompson *et al.*, 2002), participants viewed a series of portraits of unacquainted persons. Each picture was presented for 2 s while event-related potentials (ERPs) were recorded. Immediately after viewing each person, participants provided a rating of perceived HIV risk on a 7-point rating scale. We assumed that participants' explicit ratings of HIV risk would demonstrate pronounced variation across the persons presented. Alternatively, the notion of spontaneous impressions of HIV risk would be refuted if participants assign a similar level of risk to all presented persons. For the analyses of the neural correlates of risk perception, the explicit risk ratings were allocated into a low and high HIV risk category. In contrast to deliberative processing, which is characterized as being serial and time consuming, intuitions are assumed to build upon parallel, fast processing (Strack and Deutsch, 2004; Evans, 2008). According to this hypothesis, it was predicted that high and low HIV risk categories are already differentiated in the brain within the first 300 ms of processing time (cf. Thorpe *et al.*, 1996). A further characteristic of intuition is its reliance on immediate affective reactions (Lieberman, 2000; Slovic and Peters, 2006). Previous research consistently revealed that affective stimulus processing is associated with enlarged late positive potentials (LPP) between 300 and 700 ms after stimulus onset (Schupp *et al.*, 2006). Thus, based on the notion that HIV risk is a potential threat for health, larger LPP amplitudes were expected for high HIV risk persons compared to low. Finally, more refined single trial analyses were conducted in order to test the hypothesis that the relationship of risk and ERP components becomes more refined across the processing stream.

METHODS

Participants

Totally, 42 participants (of which, 27 were women) in the age group of 20–32 years (mean = 24.1, s.d. = 2.6) were recruited on the campus of the University of Konstanz. Four participants were excluded from analysis because of excessive electroencephalogram (EEG) artifacts or insufficient numbers of trials to compute ERP averages. About 91% of the participants indicated heterosexual orientation and the remaining participants reported bisexual orientation. In addition, 88% of the sample was sexually experienced and 60% reported being in a steady relationship. Participants received either €15 or course credits as compensation for participation. The participants provided written consent to the study protocol, which was approved by the local ethical review board.

Stimulus material

Facial portraits were selected from the AR Face Database (Martinez and Benavente, 1998), the CVL Face Database (Peer, 2005) and the CAL/PAL Faces Database (Minear and Park, 2004). To minimize perceptual confounds, the following criteria were used to select the stimulus materials: (i) Frontal head portrait; (ii) neutral emotional expression; (iii) gaze directed to the perceiver; (iv) Caucasian face; and (v) young adult. In addition, picture brightness, area covered by face and picture size (768 × 576 pixel) were equated across stimuli. Two stimulus sets were obtained, consisting of 120 female and 120 male faces.

Experimental task

The experiment consisted of 120 trials during which each of the pictures was presented for 2 s, preceded by the presentation of a fixation cross (1 s). After a delay period of 1 s, risk perceptions were assessed by asking participants 'How likely do you think is it that this person is HIV-positive?' (translated from the German 'Für wie wahrscheinlich halten Sie es, dass diese Person HIV-positiv ist?'). Participants evaluated HIV risk on a 7-point likelihood rating scale ranging from 'very unlikely' [1] to 'very likely' [7] (cf. Dijkstra *et al.*, 2000).[1] The next trial was initiated after an ITI of 6.5 s. Stimuli were presented on a 21-inch CRT monitor located ∼100 cm in front of the participant (visual angle: 13.9° horizontal, 10.4° vertical) using Presentation software (Neurobehavioral Systems, Inc., Albany, CA, USA). To increase ecological validity, each participant viewed 120 opposite sex faces. The order of the 120 pictures was randomized.

After a break (∼10 min), additional characteristics of the impressions were assessed. Specifically, participants rated each person regarding attractiveness, healthiness, responsibility, trustworthiness, valence, arousal and willingness to interact. All ratings were given on a 7-point scale, with high numbers indicating the respective characteristic to be more pronounced. Each trial started with the presentation of the facial stimuli for 1 s, followed by the self-paced presentation of the rating scales. The order of ratings varied randomly from trial to trial for each participant. Due to a technical failure, ratings from nine participants could not be assessed.

ERP recordings

Electrophysiological data were collected from the scalp using a 257-lead HydroCel Geodesic Sensor Net (Electrical Geodesics, Inc., Eugene, OR, USA). The EEG was recorded continuously with a sampling rate of 250 Hz, with the vertex sensor as reference electrode and on-line filtered from 0.1 to 100 Hz using Netstation acquisition software and EGI amplifiers. Impedances were kept below 50 kΩ, as recommended for this type of amplifier by EGI guidelines. Off-line analyses were performed using EMEGS (Junghöfer and Peyk, 2004) and EEGLAB (Delorme and Makeig, 2004) software packages. Processing steps included low-pass filtering at 40 Hz, artifact detection, sensor interpolation, baseline-correction

[1]Analysis of reaction times revealed that, on average, responses to high risk stimulus persons were delivered faster (mean = 2470 ms) compared to low risk stimulus persons (mean = 2605 ms), $t(40) = 2.79$, $P < 0.01$. However, interpretation of these data is ambiguous as participants always had to wait for 1 s before they were allowed to deliver their HIV ratings.

for pre-stimulus (100 ms) ERP activity and conversion to an average reference (Junghöfer *et al.*, 2000).

ERP analysis

In the main analyses, stimulus persons were categorized according to idiosyncratic risk ratings, whereby stimulus persons receiving risk ratings between 1 and 3 were coded as 'safe' and stimulus persons receiving ratings between 5 and 7 as 'risky'. Control analyses were undertaken to secure that the observed results are reliable across alternative ways of calculating ERP averages to risky and safe persons.[2] To capture the effects of HIV risk on ERP components, waveform analysis and area score assessment were used in concert.

Waveform analyses

In the first stream of analyses, each time point and sensor was tested separately using a one-factorial (risky *vs* safe) ANOVA. Significant effects were thresholded at $P < 0.05$, and at least eight continuous data points (32 ms) and four neighboring sensors guarded against chance findings (Sabbagh and Taylor, 2000; Schupp *et al.*, 2003). The resulting pattern of significant ERP modulation served to determine critical time periods as well as regions-of-interest for subsequent detailed statistical evaluation utilizing area score assessments.

Area score assessment

In a time interval between 180 and 240 ms poststimulus, a frontal ERP component was scored including EGI sensors 47, 48, 49, 50, 54, 55, 56, 57, 58, 62, 63, 64 (left) and 1, 2, 194, 195, 203, 204, 205, 211, 212, 213, 221, 222 (right). Between 350 and 450 ms, a fronto-central component was indexed as mean activity comprising left (16, 17, 22, 23, 24, 27, 28, 29, 30, 34, 35, 36) and right (4, 5, 6, 7, 12, 13, 14, 20, 198, 207, 215, 224) EGI sensors. The centro-parietal LPP component was indexed as mean activity from 450 to 600 ms comprising left (9, 17, 43, 44, 45, 51, 52, 53, 58, 59, 60, 64, 65, 66, 78, 79, 80) and right (131,132, 143,144, 154, 155, 164, 182, 183, 184, 185, 186, 194, 195, 196, 197, 198) EGI sensors. ERP components were subjected to ANOVAs including the factors 'Risk' (risky *vs* safe), 'Gender' (male *vs* female), and 'Laterality' (left *vs* right). Where appropriate, degrees of freedom were adjusted using the Greenhouse–Geisser method to correct for violations of sphericity.

RESULTS

Explicit risk ratings: risky and safe persons

In order to contrast ERP waveforms elicited by risky and safe stimulus persons, it is necessary to demonstrate that the stimulus persons actually varied in their ascribed HIV risk.

[2]To rule out that the reported findings reflect unequal numbers of trials in low and high risk categories, HIV risk ratings were *z*-standardized within each participant. ERPs corresponding to low and high *z*-standardized risk ratings (safe: $z < -0.2$; risky: $z > 0.2$) were calculated. The results fully replicated the results based on the dichotomized raw scores: risky as compared to safe stimulus persons were associated with a significantly enlarged right frontal positivity, $F_{1,36} = 7.7$, $P < 0.01$, an enlarged fronto–central component, $F_{1,36} = 5.4$, $P < 0.05$, and a larger centro–parietal LPP, $F_{1,36} = 5.7$, $P < 0.05$.

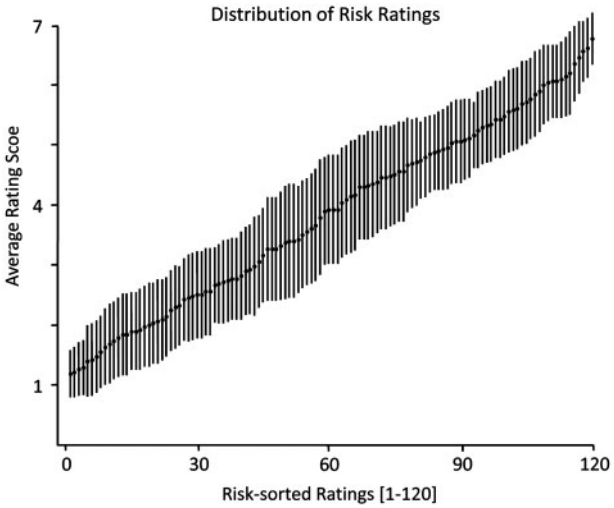

Fig. 1 Average ratings of HIV risk (1—low risk; 7—high risk) and standard errors, rank-ordered by increasing risk.

In one analysis, risk ratings were rank ordered for each participant and mean responses at each rank were calculated across participants. As shown in Figure 1, mean risk ratings increased linearly from very low risk (minimum = 1.2) to very high risk (maximum = 6.7). In a further analysis, variance and range of risk ratings were calculated for each subject. On average, risk ratings showed substantial variance ($\overline{S^2} = 2.5$) and participants used the full range of the risk scale (mean range = 5.6). These analyses demonstrate that our naturalistic stimuli produced broad variations in perceived HIV risk and provided the grounds for contrasting ERPs towards safe and risky persons.

ERPs

Waveform analyses

Single sensor waveform analyses revealed three effects of risk on ERP components (Figure 2a). A first effect of risk emerged over right-frontal sensor sites in a time window lasting from 180 to 240 ms. Specifically, while the overall ERP waveform showed a negative polarity, the difference in processing risky as compared to safe persons is seen as a relative positive potential shift (Figure 3). A second effect was observed between 350 and 450 ms over fronto-central sensor sites. While the overall ERP waveform displayed a negative polarity, the processing of risky as compared to safe stimuli persons is observed as a relative positive ERP shift (Figure 3). Subsequently, a centro-parietal LPP component was observed between 450 and 600 ms with increased amplitudes for risky as compared to safe stimulus persons (Figure 3). To examine these effects in more detail, ANOVAs were calculated for the three ERP components.

Frontal component (180–240 ms)

Over frontal regions, the main effect of 'Risk' ($F_{1,36} = 6.3$, $P < 0.05$) was qualified by a significant 'Risk × Laterality'

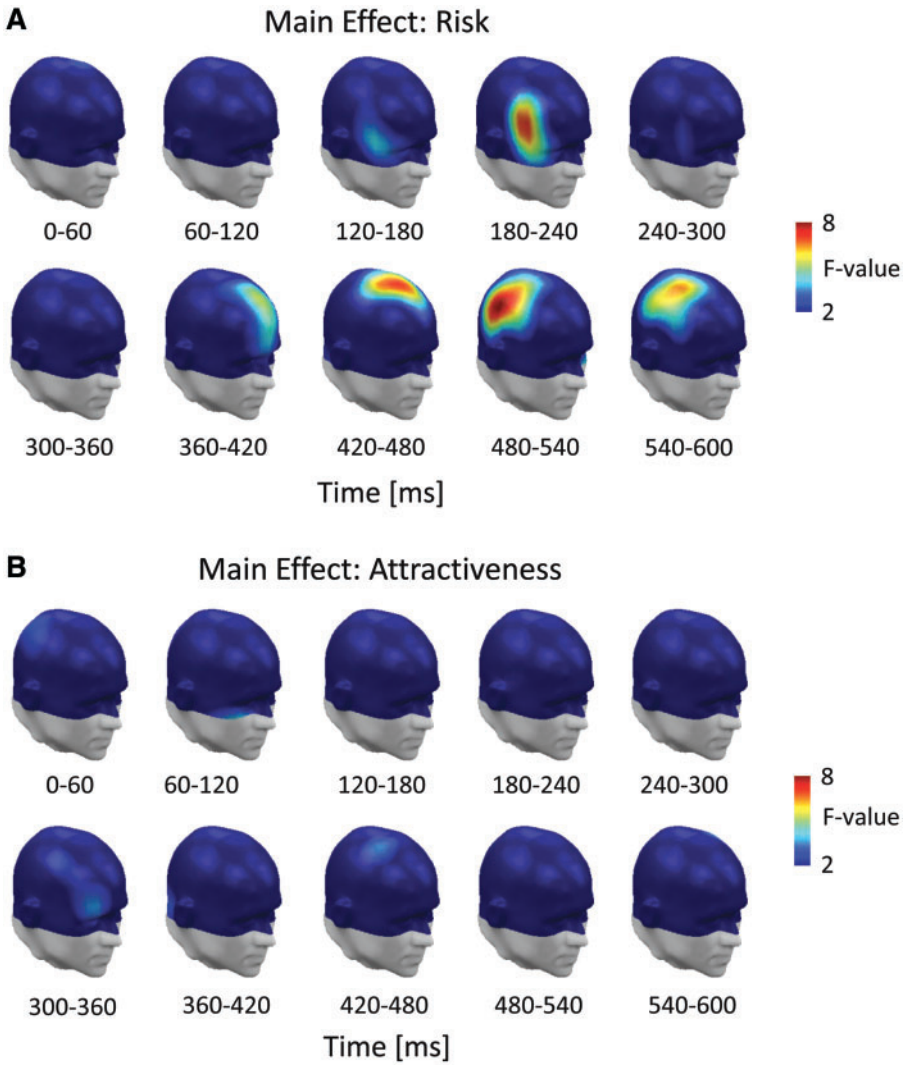

Fig. 2 Main effects of risk (**A**) and attractiveness (**B**). The outcome of the point-by-point waveform ANOVA is illustrated in terms of *F*-values collapsed across meaningful time bins. *F*-values of 4.1 correspond to $P = 0.05$.

interaction, ($F_{1,36} = 5.3$, $P < 0.05$). Post-hoc tests indicated that risky stimulus persons (mean = −0.66 μV, s.d. = 1.8 μV) elicited a relative positive potential as compared to safe stimulus persons over right frontal sensors (mean = −1.0 μV, s.d. = 1.8 μV), $t_{37} = 3.6$, $P < 0.001$. In contrast, corresponding left hemispheric regions revealed no significant modulation for risky (mean = −0.77 μV, s.d. = 1.7 μV) and safe stimulus persons (mean = −0.8 μV, s.d. = 1.8 μV). A significant main effect of 'Gender' ($F_{1,36} = 8.36$, $P < 0.01$) indicated a relative increased positivity for male compared with female participants. No further main effects or higher order interactions reached statistical significance.

Fronto-central component (350–450 ms)

Risky stimulus persons elicited a relative positive potential over fronto-central regions as compared to safe stimulus persons (risky: mean = −0.55 μV, s.d. = 3.7 μV; safe: mean = −0.98 μV, s.d. = 3.8 μV), $F_{1,36} = 5.5$, $P < 0.05$. No further main effects or higher order interactions reached statistical significance.

Centro-parietal LPP component (450–600 ms)

A main effect of 'Risk' ($F_{1,36} = 6.43$, $P < 0.05$) was observed over centro-parietal regions. Risky stimulus persons (mean = 1.53 μV, s.d. = 2.0 μV) elicited a significantly increased positivity in comparison to safe stimulus persons (mean = 1.22 μV, s.d. = 1.8 μV). While the interaction 'Risk × Laterality' did not reach statistical significance, $F_{1,36} = 4.1$, $P = 0.05$, exploratory analysis revealed that the effect was most accentuated over right hemispheric regions, $t_{37} = 2.8$, $P < 0.01$. No other main effect or higher order interaction was statistically significant.

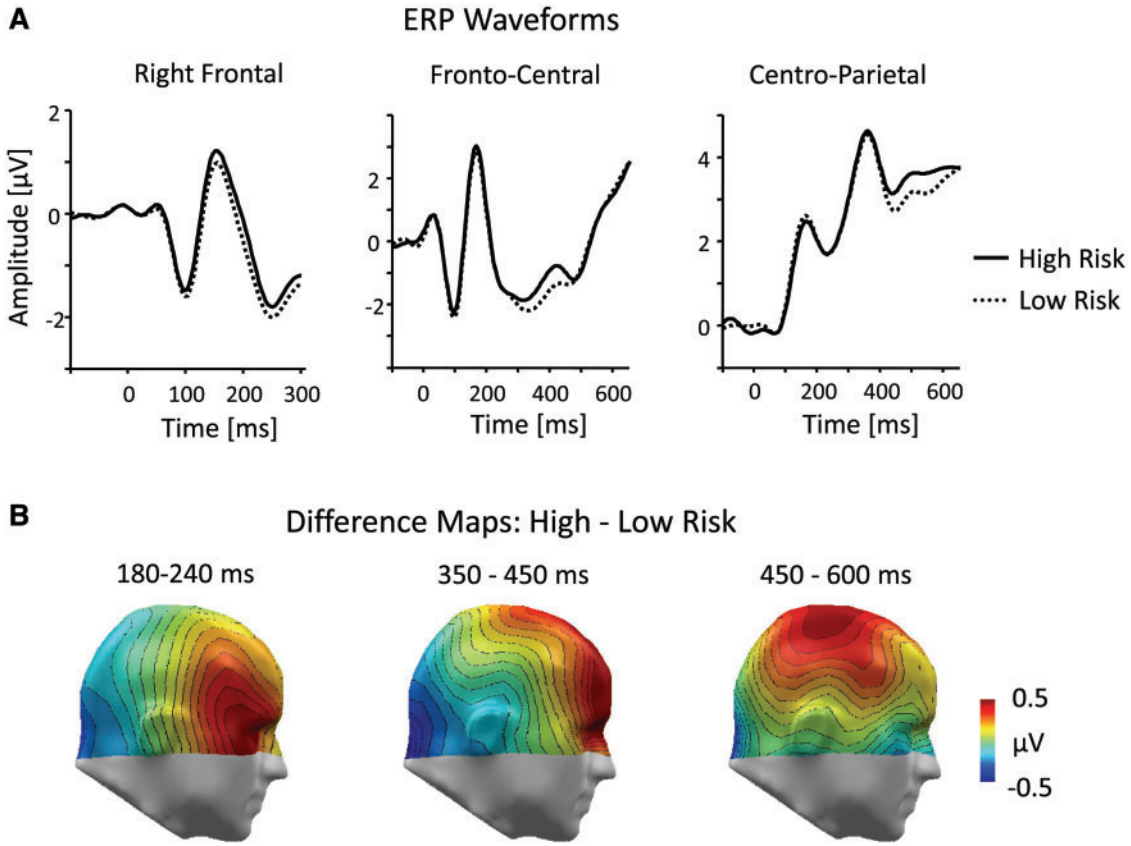

Fig. 3 (**A**) ERP waveforms associated with risky and safe stimulus persons are shown for EGI sensors no. 205, 20 and 81 which are in the vicinity of FC4/FT8, AFz and CPz according to the 10/10 system, respectively. (**B**) Scalp potential maps of the difference waves (risky–safe persons). The difference maps display a right view.

The covariation of ERP components and HIV risk

To ensure a good signal-to-noise ratio, our main ERP analysis was based on a dichotomous categorization of HIV risk. However, since the HIV risk ratings were given on a 7-point scale, a single trial analysis explored the risk/ERP relationship at a more refined level (cf. Lang *et al.*, 1993; Delorme *et al.*, 2007). To this end, separately for each participant, single trial EEG data were extracted for each of the three ERP components. The resulting EEG values were then sorted in ascending order by the subsequent rating of perceived HIV risk. To adjust for differences in artifact-free trial number across participants, the data were normalized to 60 pseudo-trials, smoothed, averaged across participants and one-tailed Pearson correlation coefficients and Fisher's *z*-transformation computed to assess the covariation of perceived HIV risk and ERP components. The outcome of this single trial EEG analysis is illustrated in Figure 4 using the ERP Image tool (Delorme and Makeig, 2004). The right frontal ERP between 180 and 240 ms and the fronto-central ERP effect between 350 and 450 ms showed a significant correlation with perceived HIV risk, both $r(59) = 0.22$, P's < 0.05. A strong correlation emerged between perceived HIV risk and the centro-parietal ERP component, $r(59) = 0.52$, $P < 0.0001$, which was significantly larger than for earlier ERP components, Fisher's $z = 1.88$, $P = 0.03$. These findings show that the relationship with perceived HIV risk became stronger across the processing stream, being most prominent for the centro-parietal LPP component.

The relationship of HIV risk ratings and other personality characteristics

There is strong evidence that physical attractiveness drives sexual interest and influences partner selection (Blanton and Gerrard, 1997; Agocha and Cooper, 1999; Dijkstra *et al.*, 2000). Furthermore, physical attractiveness has been shown to modulate risk perceptions raising the question whether the observed risk/ERP relationship is secondary to physical attractiveness. Perceived risk and physical attractiveness showed a low negative correlation with $r(119) = -0.21$, $P < 0.05$. Furthermore, while previous research suggests that physical attractiveness may modulate ERP components (Oliver-Rodriguez *et al.*, 1999; Werheid *et al.*, 2007), analysis of the attractiveness/ERP relationship analogous to the risk/ERP relationship showed no significant effects when contrasting ERP to attractive or unattractive people (Figure 2B). These findings suggest that risk perceptions

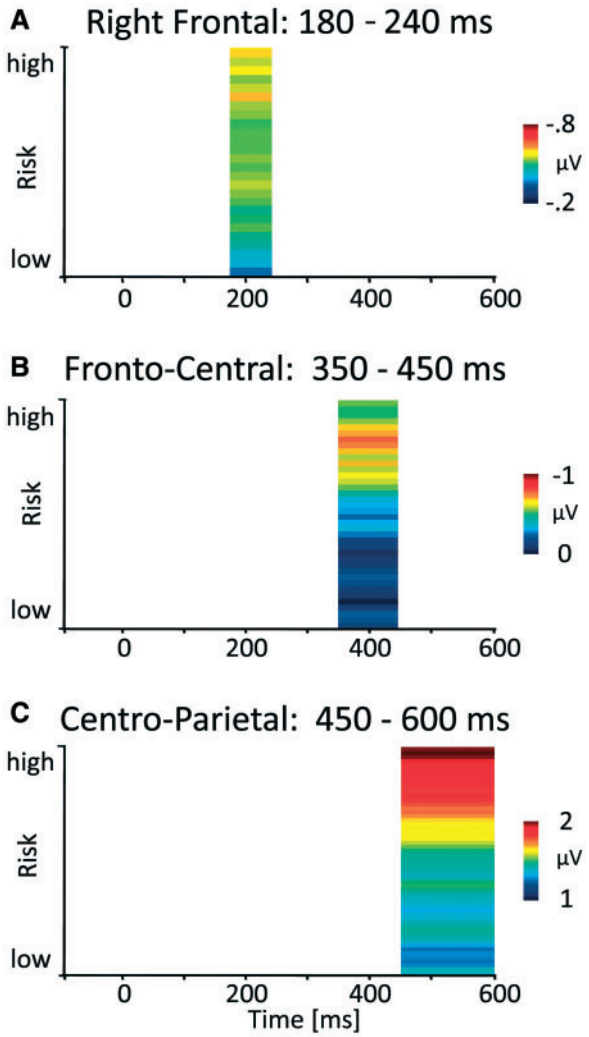

Fig. 4 ERP Images sorted by increasing risk ratings for the three time windows and sensor clusters of interest. These plots show the image obtained by group-averaging across the individual subject plots. Horizontal lines represent the color-coded voltage per pseudo-trial and trials are sorted in the ascending by risk ratings. (**A**) Group ERP Image for the early right frontal effect (180–240 ms). (**B**) Group ERP Image for the centro-frontal effect (350–450 ms). (**C**) Group ERP Image for the right centro-parietal LPP effect (450–600 ms).

and the ERP effects associated with high risk stimulus processing are not strongly related to physical attractiveness.

Previous research revealed that trustworthiness and lack of responsibility are important characteristics of the high risk HIV stereotype (Renner and Schwarzer, 2003). Consistent with this notion, HIV risk ratings showed a large negative correlation with ratings of trustworthiness, $r(119) = -0.68$, $P < 0.001$, and responsibility, $r(119) = -0.67$, $P < 0.001$. Furthermore, while HIV risk was negatively associated with valence, $r(119) = -0.43$, $P < 0.001$, and health, $r(119) = -0.44$, $P < 0.001$ and positively associated with arousal, $r(119) = 0.49$, $P < 0.001$, the correlation of risk with trustworthiness and responsibility was significantly larger compared to all other personality characteristics, Fisher's $z = 2.09$, $P < 0.05$.

DISCUSSION

The present study investigated the perception of HIV risk based on facial appearance. The study was designed to mimic the alleged screening of others for HIV risk, which behavioral research has found to be a common illusory risk control strategy (Williams *et al.*, 1992). The substantial variance in ratings of HIV risk confirmed the hypothesis that facial appearance provided information for categorizing the HIV risk of unacquainted persons. With regard to the neural correlates of HIV risk perception, results revealed the rapid discrimination between low and high risk stimulus persons. Brain waves over right-frontal regions revealed differences associated with HIV risk already at ~180 ms. Furthermore, we observed enlarged LPP amplitudes towards risky persons suggesting an increased stimulus significance response to high HIV risk persons. These findings demonstrate features of affect and speed in intuitive risk perception.

ERP correlates of intuitive risk perception

Intuitions are assumed to reflect a fast processing mode that utilizes unconsciously generated information (Lieberman, 2000). In the present study, differences between high and low HIV risk categories emerged around 180 ms, thereby providing an upper bound for the time needed to extract risk-related information from facial appearances. As conscious stimulus representation is presumed to depend on several 100 ms of processing time (Chun and Potter, 1995), the differential brain responses to high and low risk stimuli occur too early to be based on deliberate (conscious) reasoning (Neely, 1977). Thus, the stimulus-driven engagement of neural networks by facial stimuli revealed implicit differentiations systematically related to the subsequent rating of HIV risk. Overall, the differentiation of risky and safe persons within split seconds provides compelling evidence for a rather fast process: a defining feature of intuition.

A characteristic of intuitions is the contribution of affective processes (Lieberman, 2000). Accordingly, risk perception may be based on an immediate affective reaction rather than being the result of deliberative reasoning. It is proposed that the observed LPP component between 450 and 600 ms indicates the generation of an affective reaction discriminating between high and low HIV risk stimuli. Specifically, the finding of larger LPPs to high risk stimuli relates to a large array of studies which consistently reveal that emotional stimuli such as natural scenes, facial expressions, words and symbolic gestures elicit larger LPPs as compared to neutral control stimuli. Several of these studies also suggest a greater potency of negative stimuli (Schupp *et al.*, 2004, 2007; Kissler *et al.*, 2007; Wieser *et al.*, 2010; Flaisch *et al.*, 2011). Similarly, perceiving a high HIV risk person is presumably associated with a need for an immediate response to prevent personal harm and may represent one instance of the general phenomenon that bad is stronger than good (Taylor, 1991; Ito *et al.*, 1998; Baumeister *et al.*, 2001). Furthermore, our findings also concur with reports of right-lateralized

LPPs in studies on evaluative categorization (e.g. Cacioppo *et al.*, 1996). Taken together, the LPP findings support the notion of an intuitive mode of risk perception with regard to the involvement of affective processes.

An alternative explanation of the observed LPP findings may invoke differences in stimulus probability. Previous ERP studies varying the probability of target stimuli revealed that rare target stimuli elicit larger LPP amplitudes (Johnson, 1988). Given that ratings at the low and high end of the risk rating scale were both infrequent, a stimulus probability account would predict a quadratic relationship of the degree of risk and LPP amplitudes. In contrast, ERP Image analysis revealed a linear increase of the LPP amplitude with increasing risk ratings. Thus, the current findings are not secondary to differences in stimulus probability. Furthermore, the LPP is not modulated by intrinsic stimulus significance alone but also by explicit stimulus significance. Explicitly defined target stimuli based on simple physical stimulus features or membership in semantic categories elicit larger LPPs compared to non-target stimuli (Johnson, 1988; Thorpe *et al.*, 1996; Codispoti *et al.*, 2006). On the one hand, as the current paradigm differs in many ways from these studies, it is unclear whether these findings relate to the present study. Specifically, there were no explicit target stimuli and HIV risk had to be evaluated on a 7-point rating scale of HIV risk rather than categorized into dichotomous stimulus categories. On the other hand, one may argue that participants could have reframed the task in specific ways, i.e. 'identifying risky individuals'. According to this hypothesis, the LPP findings depend on an explicit processing goal of the participants. Previous ERP studies revealed that paying explicit attention to emotional target stimuli increased the LPP component (Schupp *et al.*, 2007; Ferrari *et al.*, 2008). Thus, the present findings may either reflect a main effect of risk or the interaction of an explicit processing goal (i.e. high risk stimulus detection) and intrinsic stimulus significance (i.e. the occurrence of a high risk stimulus). More relevantly, however, both explanations are consistent with an intuitive mode of processing. Specifically, risk-relevant information had to be extracted early in the processing stream, i.e. a fast process, in order to elicit increased LPP amplitudes, i.e. presumed to indicate an affective reaction. It will be interesting to determine in future research whether increased LPP amplitudes to risky stimuli occur implicitly when participants perform a distractor task unrelated to risk perception.

The relationship of HIV risk and ERP components was tracked across the processing stream using single trial analysis. Both, the early right frontal (180–240 ms) and later centro-frontal (350–450 ms) effect showed a significant but rather low correlation with HIV risk ratings. The early right-frontal ERP effect concurs with studies investigating the processing of emotional and neutral faces (Eimer *et al.*, 2003) and may partially reflect the engagement of the right orbito–frontal cortex. Being part of a larger interconnected network, the orbito-frontal cortex possibly provides top-down input regulating later stages of visual processing (Bechara *et al.*, 2000; Kringelbach and Rolls, 2004; Vuilleumier, 2005; Adolphs and Spezio, 2006). The subsequent effect of relatively larger positive potentials to risky faces over fronto-central sites between 350 and 450 ms is reminiscent of the novelty P3, i.e. an automatic orienting response to novel stimuli (Friedman *et al.*, 2001). However, the current design differs in many ways from the experimental approach used in this line of research. In the current study, every stimulus was novel and only shown once. Furthermore, both processes—stimulus significance and stimulus novelty—may simultaneously contribute to surface recorded scalp potentials (Debener *et al.*, 2005). While the interpretation of this component awaits future research, the fronto-central effect may indicate that attentional orientation to novel stimuli is amplified towards faces perceived as risky. A significantly stronger relationship between ERP amplitude and HIV risk ratings was observed for the LPP component between 450 and 600 ms. Thus, the relationship of ERP amplitude to explicit ratings of HIV became increasingly refined across the processing stream. With regard to neural generators, the LPP has been linked to widespread activation broadcasting stimulus information to many associative cortical regions rather than reflecting local or modular processing, (Nieuwenhuis *et al.*, 2005; Sergent *et al.*, 2005; DelCul *et al.*, 2007; Schupp *et al.*, 2007). From a functional perspective, the LPP component has been related to processes of stimulus recognition, working memory representation and focused attention (Vogel *et al.*, 1998; Nieuwenhuis *et al.*, 2005; Sergent *et al.*, 2005; DelCul *et al.*, 2007). One may accordingly speculate that the LPP component is an indirect electrocortical reflection of the gradual representation of HIV risk, which may serve as basis for the explicitly provided risk rating.

Snap judgments of HIV risk

The present findings suggest that a brief glimpse of an unacquainted person can be sufficient to form an impression of HIV risk. When probed at the end of the experiment, participants could not explain how they arrived at their risk judgments and reported either severe difficulties verbalizing 'hunches' or a complete lack of insight. Feelings of knowing despite a lack of introspection are typical of intuition and presumed to be based on implicit learning processes (e.g. Lewicki, 1986; Lieberman, 2000; Seligman and Kahana, 2009). Furthermore, the perspective of an associative network structure raises the issue of how HIV risk ratings are systematically related to other person characteristics. Given the important role of attractiveness in partner selection, it might be hypothesized that HIV risk judgments relate to the attractiveness of the person. However, neither the hypothesis that attractiveness increases HIV risk (i.e. higher likelihood of many partners), nor the 'what is beautiful is good'—heuristic received strong support (cf. Blanton and Gerrard, 1997;

Agocha and Cooper, 1999; Dijkstra *et al.*, 2000). A different line of research revealed that distrust and lack of responsibility are key features of the high HIV risk stereotype (Renner and Schwarzer, 2003). Consistent with these findings, a pronounced correlation of HIV risk with ratings of trust and responsibility was observed in the present study. Furthermore, ample evidence supports the notion that inferences regarding trustworthiness are based on immediate person perception. For instance, exposure times as little as 33 ms are sufficient to infer trust or threat (Bar *et al.*, 2006; Willis and Todorov, 2006). In addition, distrust has been shown to engage the neural structures implicated in emotion processing (amygdala and insular cortex; Winston *et al.*, 2002; Engell *et al.*, 2007; Todorov *et al.*, 2008). Our findings may be related to these studies because HIV risk, trustworthiness and responsibility shared a substantial part of their variance, which may indicate that they tap into common meaning structures (Edelman, 1998). Overall, judging HIV risk may reflect the correspondence of implicitly perceived facial cues and the high-risk stereotype.

Strength and limitations

The case of HIV was selected as model system to investigate the intuitive nature of risk perception. While the findings support this notion, limitations need to be acknowledged and important issues remain to be examined in future research. For instance, field research indicated that knowledge of sexual history and familiarity with the person are further sources of information in HIV risk perception (Williams *et al.*, 1992), which need to be considered in future research. Furthermore, it needs to be determined whether the observed findings are disease-specific or relate more generally to serious diseases. Based on the important role of contagiousness in lay disease representations (Bishop, 1991), one may speculate that the current findings relate specifically to contagious, sexually-transmitted diseases. Finally, the finding that intuitive processing may lead to a false sense of safety and thereby facilitate unprotected sexual behavior in the 'hot' context of dating (Norton *et al.*, 2005), does not imply that our participants would actually rely on the illusory control strategy to screen their partners for HIV risk.

CONCLUSION

Traditionally, risk perception has been conceptualized as beliefs about the probability and the severity of health hazards (Weinstein, 2000; Renner and Schupp, 2011). This 'risk as analysis' view has recently been complemented by the proposal of a more experiential mode of risk perception which emphasizes the role affect and feelings (Loewenstein *et al.*, 2001; Slovic and Peters, 2006). The present findings are consistent with this 'risk as feeling' notion: (i) Risky stimuli were rapidly discriminated;(ii) were accompanied by the neural signature of increased stimulus significance; and (iii) participants were unable to explicate the basis of their risk judgments. Taken together, the present findings indicate that the strategy to screen partners for their HIV risk may result from an experiential mode of risk perception.

Conflict of Interest

None declared.

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