Emotion
2011, Vol. 11, No. 3, 533–543

1528-3542/11/$12.00 DOI: 10.1037/a0023366

Assessing the Way People Look to Judge Their Intentions

J. Bruno Debruille and Mathieu B. Brodeur
McGill University

Ursula Hess
Université du Québec à Montréal

Faces of unknown persons are processed to infer the intentions of these persons not only when they depict full-blown emotions, but also at rest, or when these faces do not signal any strong feelings. We explored the brain processes involved in these inferences to test whether they are similar to those found when judging full-blown emotions. We recorded the event-related brain potentials (ERPs) elicited by faces of unknown persons who, when they were photographed, were not asked to adopt any particular expression. During the ERP recording, participants had to decide whether each face appeared to be that of a positively, negatively, ambiguously, or neutrally intentioned person. The early posterior negativity, the EPN, was found smaller for neutrally categorized faces than for the other faces, suggesting that the automatic processes it indexes are similar to those evoked by full-blown expressions and thus that these processes might be involved in the decoding of intentions. In contrast, in the same 200–400 ms time window, ERPs were not more negative at anterior sites for neutrally intentioned faces. Second, the peaks of the late positive potentials (LPPs) maximal at parietal sites around 700 ms postonset were not significantly smaller for neutrally intentioned faces. Third, the slow positive waves that followed the LPP were larger for faces that took more time to categorize, that is, for ambiguously intentioned faces. These three series of unexpected results may indicate processes similar to those triggered by full-blown emotions studies, but they question the characteristics of these processes.

Keywords: face, intention, expression, event-related brain potentials

The overwhelming majority of studies performed on the brain processes involved in the assessment of facial emotions so far have focused on the processes triggered by expressions of well-characterized emotions, such as those from the Pictures of Facial Affect (Ekman & Friesen, 1976; Ekman, 1999). To our knowledge, no study has yet investigated the brain processes by which we form an opinion about the valence of the intention of an unknown person by judging the way the person looks in social situations. Namely, when his or her face is either at rest or displays the social smile persons may have when they are looked at or photographed. Nevertheless, these processes are quite common. In fact, humans readily ascribe a number of important interpersonal orientations to others based on their mere appearance.

These processes are of great relevance because the question of whether a person is "nice" or trustworthy comes up numerous times in everyday interactions, both trivial ones, such as choosing whom to ask for directions when lost, or ones with potentially long-lasting consequences, such as selecting a person for a job.

We do not always have a large sample of actual behavior available, and emotions and their expressions are typically regulated to conform with the social demands of the situation. This may include not only up- and down-regulations but also suppression of emotions (Matsumoto, Yoo, Hirayama, & Petrova, 2005). Thus, the information that a "social face" provides has to be frequently used by observers.

Recent research suggests that this is based on perceived emotional traits in neutral faces (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007; Oosterhof & Todorov, 2009; Zebrowitz, Kikuchi, & Fellous, 2010; Hess, Adams, & Kleck, 2009; Hess, Hareli, Adams, Stevenson, & Lasalle, 2010). Specifically, people readily detect subtle emotions in faces used as neutral faces. Recent studies have shown that these "expressions" are used to infer another person's personality and behavioral intentions (Lasalle, Poirier, Simard, & Hess, 2010; Hess et al., 2010). In fact, theoretical accounts trying to explain why certain morphological features, such as square jaws, high foreheads, or eyebrow constellations, are perceived as signaling traits such as dominance, maturity, or trustworthiness, are based on the assumption that these facial features share a resemblance with a normally useful indicator of such traits, namely, emotional facial expressions (Hareli & Hess, 2010), and through this perceptual overlap are then used to infer personality from faces that do not in fact show emotional expres-

J. Bruno Debruille and Mathieu B. Brodeur, Departments of Psychiatry and of Neurology and Neurosurgery, McGill University, Montréal, Canada; Ursula Hess, Department of Psychology, Université du Québec à Montréal, Montréal, Canada.

Ursula Hess is now with the Department of Psychology at Humboldt University, Berlin, Germany.

We are very grateful to Nathalie Bouloute, Paul Dubuc, Nichol Pelchat, and Claire Lionnet for all the technical help they provided. We thank the volunteers of the Association Québécoise de la Schizophrénie, and the 600 persons who accepted to have their faces photographed. The first author was supported by scholarships from Le Fonds de la recherche en santé du Québec (FRSQ) and the Canadian Institutes for Health Research. The work was accomplished with the FRSQ grant # 97005 and with a grant from the Fondation Québécoise des Maladies Mentales. Results of this study have been presented in posters at the International Schizophrenia Meeting, at the meeting of the Society for Psychophysiological Research, and at the XIIth International Conference on ERPs (EPIC XII).

Correspondence concerning this article and requests for the MED bank should be addressed to J. Bruno Debruille, Human Cognitive Neuroscience Laboratory, Douglas Mental Health University Institute, 6875 Blvd LaSalle, Verdun, Québec H4H 1R3 Canada. E-mail: bruno.debruille@mcgill.ca

sions (Hess, Adams, & Kleck, 2008, 2009; Zebrowitz, Kikuchi, & Fellous, 2010; Oosterhof & Todorov, 2009). However, despite considerable behavioral evidence that the seemingly "emotional" content of faces used as neutral faces is processed in ways similar to the content of true emotion expressions, there is no evidence about the underlying neural processes. Collecting such evidence is the aim of the present study.

For this, models were photographed with what to them was a normal natural expression, which for some included a social smile. These smiles were accepted because they are the most usual bias one has to overcome when judging the real intention of a person and because this reaction might correspond to the character of the model when (s)he is looked at. Also, research has shown that such smiles are less likely to be perceived as expressing happiness but rather as expressing a social orientation, such as dominance (Hess, Beaupré, & Cheung, 2002; see also Niedenthal, Mermillod, Maringer, & Hess, 2010).

Instead of judging the emotion of these models, participants had to decide whether each face was that of a positively, negatively, ambiguously, or neutrally intentioned *person*. There was thus no request to take into account the facial expression of current emotions. Social smiles, or any other temporary expressions, had to be overcome to decide whether or not the person was a genuinely well-intentioned person. We recorded the event-related brain potentials (ERPs) elicited by the display of the faces of these models. Two reasons guided that choice: (a) the temporal resolution of ERPs, which allows following the development of the brain activity elicited by the onset of a face presentation with a precision of a few milliseconds; and (b) the extent of previous literature on the processing of emotional faces, which has identified at least four functionally different effects and thus at least four different processes.

First, even the very early processing of visual characteristics may depend on valence. The earliest ERP effects probably consist of those indexed by the greater positive deflections maximal around 100 ms post onset (the P1s), which were found to be elicited by negative facial expressions relative to faces used as neutral faces over the posterior cortex in a number of studies (Batty & Taylor, 2003; Eger, Jedynak, Iwaki, & Skrandies, 2003; Pizzagalli, Regard, & Lehmann, 1999; Pourtois, Dan, Grandjean, Sander, & Vuillemier, 2005; Streit et al., 1999). Although no larger P1s have been reliably obtained in response to positive relative to neutral facial expressions, Pizzagalli, Regard, and Lehmann (1999) found an enhanced P1 for liked relative to disliked faces. These effects have been attributed to a selective enhancement of visual processing in extrastriate visual areas, possibly by the amygdala (Amaral, Behniea, & Kelly, 2003; Morris et al., 1998; Pessoa, Kastner, & Ungerleider, 2002; Armony & Dolan, 2002; Vuilleumier, Richardson, Armony, Driver, & Dolan, 2004), a fast detector of threatening features, which may automatically modify the way extrastriate visual areas process stimuli. However, these very early processes are unlikely to be modulated by subtle expressions, and no P1 differences could be found in the present study. This prediction was based on the fact that these very early differences were not always found in previous works and that a "real" threat may be necessary to trigger this type of immediate activity of the amygdala.

A second ERP effect, also attributed to the effect of an output of the activity of the amygdala on the visual cortex, can be seen at occipital and temporal scalp sites a little later, roughly between 200 and 400 ms post onset. It consists of more negative ERPs for emotionally laden faces than for neutral faces. This effect, found by Vanderploeg, Brown, and Marsh (1987) and replicated by Marinkovic and Halgren (1998), is termed the Early Posterior Negativity (EPN, see also Schupp, Junghofer, Weike, & Hamm, 2004; Schupp et al., 2004; Balconi & Pozzoli, 2003; Eimer, Holmes, & McGlone, 2003; Sato, Kochiyama, Yoshikawa, & Matsumura, 2001). Like the P1 effect, this EPN effect is automatic, as it is found not only in emotion judgment tasks but also in implicit tasks, such as in a memory task that required subjects to decide whether each face stimulus had already been presented in the experiment or not (Marinkovic & Halgren, 1998). However, the EPN effect appears to be of greater amplitude in the emotion task than in the memory task, which is consistent with the idea that the automatic processing of facial expressions can be modulated,[1] as already suggested by Morris et al. (1998) and in agreement with a regulation of the amygdala activity itself by prefrontal structures (see below). Because of these modulations, and because of the explicit intention-categorization task planned to be used, our predictions for the present study were that the EPN effects would be found. In other terms, it was hypothesized that this part of the processing of the visual characteristics of subtle expressions would follow that of well-characterized emotions. This hypothesis contrasts with the predicted absence of P1 effects and goes with a functional differentiation of very early visual processing from visual processing that occur within 200 to 400 ms.

The third type of processes described in previous literature for typical expressions is indexed by the more positive ERPs elicited by faces with a negative expression than by neutral faces at anterior scalp sites. These modulations mainly affect the amplitude of two negative deflections, namely, that of the N2, which, for faces, peaks a little before 300 ms post onset, and that of an N450 (Ashley, Vuilleumier, & Swick, 2004; Eimer, Holmes, & McGlone, 2003; Holmes, Vuilleumier, & Eimer, 2003; Williams, Palmer, Liddell, Song, & Gordon, 2006a; Williams et al., 2006b). However, these anterior modulations can start as early as 130 ms (Eimer & Holmes, 2002). They may thus affect the amplitude of the positive deflection that precedes the N2, the P2, and sometimes even that of the negative deflection that precedes the P2. These effects have been found not only when comparing negative with neutral expression but also when comparing positive with neutral expressions (for a review, see Eimer & Holmes, 2007). Interestingly, they also seem to reflect automatic processes, as they can be found even when faces are presented subliminally (Kiss & Eimer, 2008; Liddell et al., 2005; Williams et al., 2006a). It has been proposed that the early part of these modulations triggered within 200 ms of stimulus onset could be generated by prefrontal or orbitofrontal mechanisms involved in the rapid detection of facial expression. Because it appears likely that this detection occurs mainly for well-characterized emotions, an absence of these very early anterior effects was hypothesized, just as we predicted an absence of P1 effect for our subtle expressions.

The later and more sustained part of the anterior positivity, the one that affects the N270 and the N450, is more broadly distributed on the scalp. It is likely to reflect subsequent processing of emo-

[1] Modulations of automatic processes are not exceptional; the knee reflex, for instance, can be reduced or enhanced.

tional faces at higher-order decision- and response-related stages (Eimer & Holmes, 2007). This is consistent with the results of Sabbagh, Moulson, and Harkness (2004) who reported that their anterior 'N270-450' elicited by facial stimuli (i.e., eyes regions) were larger in an emotion matching task than in a gender discrimination task and with earlier results showing attentional modulations (e.g., Eimer, Holmes, & McGlone, 2003; Holmes, Vuilleumier, & Eimer, 2003). For several authors (e.g., Bediou, Eimer, d'Amato, Hauk, & Calder, 2009; Sabbagh, Moulson, & Harkness, 2004), the brain generators involved in these modulations could to be the ventro-medial prefrontal cortex (vmPFC). According to Bediou et al. (2009), the activity of this structure that develops after 200 ms postonset is part of the activities that down-regulate the activity of the amygdala. It was hypothesized that this down-regulation may not be necessary for subtle expressions. In other terms, in the case of the present study, we predicted an absence of anterior differences in the ERPs of this time-window.

Finally, the emotional valence of faces affects the amplitude of a sustained positivity (or Late Positive Potential, LPP) that develops well after 250 ms poststimulus and has a broad fronto-parietal scalp distribution (Ashley, Vuilleumier, & Swick, 2004; Carretié & Iglesias, 1995; Eimer & Holmes, 2002; Krolak-Salmon, Fischer, Vighetto, & Mauguière, 2001; Meinhardt & Pekrun, 2003; Williams et al., 2006b; Vanderploeg, Brown, & Marsh, 1987; Marinkovic & Halgren, 1998; Laurian, Bader, Lanares, & Oros, 1991; Orozco & Ehlers, 1998). Larger LPPs are consistently found for negative- than for neutral-facial expressions, but only sometimes for happy-relative to neutral-facial expressions (e.g., in Eimer, Holmes, & McGlone, 2003; Marinkovic & Halgren, 1998). Interestingly, it seems that no effects of facial expression may be found in this time window when the task focused on a dimension other than expression, as in the memory task of Marinkovic and Halgren (1998). This suggests that these late ERPs could be related to the processing of the significance of the stimulus as a function of the task in accordance with the fact that they have been reported up to 1500 ms postonset by several teams, especially at prefrontal and frontal sites (Diedrich, Naumann, Maier, Beker, Bartussek, 1997; Naumann, Bartussek, Diedrich, & Laufer, 1992; Orozco & Ehlers, 1998; Marinkovic & Halgren, 1998), thus during the time period where participants provide their behavioral responses. Accordingly, in the present study, smaller LPPs were predicted for neutrally intentioned than for other faces. This hypothesis was based on the fact that these faces include less task-relevant information than other faces. The same line of reasoning leads to predict that faces including task relevant information that are ambiguous should elicit large LPPs.

As mentioned, an overwhelming majority of studies has focused on the processes triggered by full-blown facial expressions of well-characterized emotions, often compared with neutral expression. However, no study has investigated the brain processes by which we form an opinion about the behavioral intentions of an unknown person by judging the person's face in the absence of clearly defined expression of prototypical emotions. The present study thus aimed at testing whether the processes, and thus the ERP effects, found with full-blown expressions of emotions would be also found for faces in a task where participants would be asked to decide about the valence of the intentions of people who were not asked to adopt a particular expression when they were photographed. That is, to draw these inferences from the face could only focus on the physiognomic traits of the faces. We predicted that even in the absence of clearly defined prototypical expressions, the same processes evolved in processing emotion expressions would be recruited to achieve this task.

It has to be emphasized that in this context, the responses to each face was expected to vary across-subjects, as the trait inferences from faces that lack prototypical expressions of emotions have variable interrater reliability. One of the main hypotheses of the study was thus that the EPN and the LPP effects predicted would be present when ERPs are averaged according to these personal responses, whatever the judgment of the majority and the inter-participants agreement for each face.

Because of this prediction, faces for which there was only a low interrater agreement, that is, faces judged ambiguously intentioned by a notable proportion of people, were added. The aim of this addition of stimuli that are difficult to process was to assess the possibility that the smaller EPNs and LPPs obtained in previous studies for faces used as neutral faces were attributable to processing difficulty. This possibility derives from the fact that a notable part of these faces may be deprived from clear morphological features that resemble in appearance an emotion expression; they thus lack clear task-relevant information. Accordingly, other difficult to process stimuli, such as ambiguous faces, could thus also lead to smaller EPNs and smaller LPPs. In contrast, if the smaller EPNs and LPPs obtained for faces used as neutral faces in previous studies were not attributable to difficulty but to their "neutrality" then ambiguously intentioned faces should be found to elicit greater EPNs and LPPs than neutrally intentioned faces.

Method

Source of Stimuli

The photographs of the Multipurpose bank of European Descent faces (the MED bank; Debruille, Brodeur, & Stelcner 1999; Guillem, Bicu, & Debruille, 2001) were used. The MED bank is a freely available set of faces that was obtained by photographing 610 persons (324 females), mainly "white collars" of European descent between 18 and 65 years of age with a well-groomed physical appearance. View, size of stimuli, background, color, contrast, and luminance were standardized by photographing all faces frontally, from the same (2 m) distance, in the same studio, using the same camera, the same lens, lighting, and Kodak Ektachrome 64 ASA films digitized by the same Kodak procedure. The models photographed received no additional instructions unless they had a strained smile and were then told "to be natural" to collect a number of "looks" that differ from full-blown expressions of basic emotions (e.g., anger, fear, surprise, disgust, joy, and sadness). The majority of the facial expressions of the models used were neutral or subtle. When there was a nonsubtle facial expression, it was almost always a social smile. Nevertheless, these faces were kept, as smiles could be seen as the "natural reaction" that could happen in everyday life when this person is looked at and as smiles are not necessarily interpreted as signs of happiness or of positive intentions (e.g., Hess, Beaupré, & Cheung, 2002). In fact, observations of 15,824 children, adolescents, young adults, middle-aged adults, and older adults in public locations such as malls, stores, stadiums, restaurants, and so forth, found that across all age groups 35% of the men and 40% of the women smiled without any presumption that they experienced happiness at that time (Chapell, 1997).

Assessments and selection of stimuli. The faces of the MED bank were first assessed by presenting each face for approximately half a second to 50 judges, all attendants of summer university classes. They had to decide whether each photograph was that of a person looking positively, negatively, ambiguously, or neutrally intentioned. For each face, the number of people who judged it positive, negative, and so forth, was computed. A total of 240 photographs: the 60 faces judged positively, negatively, ambiguously, and neutrally intentioned (respectively) by the greatest percentages of people were then extracted for the present research. For the 60 positively intentioned faces, the average percentage of people who judged them positively intentioned was 78.4 (SD = 6.1). For the 60 negatively intentioned faces, the average percentage of people who judged them negatively intentioned was 55.3, (SD = 9.8); for the 60 neutrally intentioned faces, the percentage was 57.4 (SD = 5.7). For the 60 ambiguous faces, that is, the faces judged both positively and negatively intentioned, the average percentage was only 29.5, (SD = 8.4). These average percentages were significantly different for positively versus neutrally intentioned ($t = 19.5$, $p < .0001$) and for ambiguously versus neutrally intentioned ($t = 21.3$, $p < .0001$) but not for negatively versus neutrally intentioned. Sixty additional faces were selected among faces for which the percentage of people who judged them positive was approximately the same as the percentage of people who judged them negative, and by choosing the faces for which these percentages were the highest. The 60 + 60 + 60 + (60 + 60) = 300 resulting faces were arranged in a random order and placed into four carrousels of 75 slides each.

Participants

Twenty-one idividuals aged between 18 to 24 years were recruited. Inclusion criteria were a minimum of nine years of schooling and being right-handed with right-handed parents and siblings, having normal or corrected-to-normal vision, and reporting to be free of neurological and psychiatric diseases, without history of substance abuse. Participants were told about the experimental design and signed the informed consent form approved by the research ethics board of the Douglas Institute which follows the recommendations of the declaration of Helsinki (World Medical Association of Helsinki, 2001). They were paid 7 CAN$ per hour for their participation. Data from five participants were excluded after the experiment, because the number of faces that they categorized as negatively intentioned (four subjects) or ambiguously intentioned (one subject) during the experiment was smaller than 20, which is insufficient to compute ERPs. The remaining subjects were eight men and eight women.

Procedure

Participants were seated in a comfortable chair in a sound-attenuated room and asked to focus on a red dot marking the center of a screen 1.50 m away from their eyes. They were also asked to only blink while the slide carrousel was advanced. Photographs were presented one at the time for 400 ms, at a five-degree visual angle using the Instep stimulus presentation software, which triggered the advances of the slide carrousel. It also triggered the face displays by switching off and on, respectively, a silent Displaytech ferro-electric liquid crystal shutter placed into the lens of the slide projector. The time intervals between the carousel advances and the onset of the face varied randomly to prevent the development of contingent negative variations (Walter, Cooper, & Aldridge, 1964). Long intervals (6.5 to 7.5 s) between the display of two adjacent faces were used to prevent probability and sequence effects on P3b (LPP) amplitudes (Polich, 1990; Debruille, Pineda, & Renault, 1996; Miltner, Johnson, & Braun, 1991). The participants task was to decide whether a given face depicted a person who looks positively, negatively, ambiguously, or neutrally intentioned. They were asked to give their responses by pressing as fast and as accurately as possible one of the four arrow keys of an IBM-compatible computer keyboard with their right index finger. Each key corresponded to one of the categorization (positive, negative, ambiguous, and neutral). These correspondences were counterbalanced across subjects.

Data Acquisition and Processing

Reaction times (RTs) were recorded. The electroencephalogram (EEG) was captured by 16 tin electrodes placed on an elastic cap (Electrocap International) according to the 10–20 System (Jaspers, 1958) and referenced to the left earlobe. The electrode sites were grouped in a sagittal subset, a parasagittal subset next to the midline, and a temporal subset farther from midline. The sagittal subset included Fz, Cz, and Pz, the parasagittal, Fp1/2, P3/4, and O1/2, and the temporal, T3/4, and T5/6. One electrode was placed below the left eye for recording vertical EOG by comparing its signal to that from Fp1, and other electrodes were placed on the outer canthi for monitoring horizontal EOG. Signals were amplified 20,000 times by Contact Precision Amplifiers whose high- and low-pass half-amplitudes cut-off were set at 0.01 and 100 Hz using an electronic notch filter to remove 60 Hz. For each channel, the amplified EEG signals were digitized online at a 256-Hz frequency and stored along with the codes of the behavioral responses of the subject for off-line averaging using the Instep (version 4.3) software package.

Data Measures and Analyses

Mean RTs and ERPs were computed for each of the four types of responses (positive/negative/ambiguous/neutral) made by the participants. Grand average waveforms were explored in the regions of the P1, EPN, anterior 200–400 ms, and LPP effects. This visual inspection revealed possible effects in the last three time regions and in that of the slow wave that followed. The mean voltage relative to a 150 ms prestimulus baseline was thus computed within the 200–400 ms time window for the EPN and for the anterior 200–400 ms effect, and in the 500–700 ms time windows for the LPP. Additionally, measures were taken in the 700–1200 ms time window to study slow positive waves (SPWs) for which the amplitude, the scalp distribution and the direction of the differences appear to differ from those observed in the time window of the peak of the LPP. For the 200–400 ms and the 500–700 ms time windows, a priori contrasts analyses were conducted to test whether or not, as predicted, ERPs to neutral faces statistically differ from ERPs to positive and negative faces. The participants' response factor thus had initially only two levels (neutral/positive-negative). Then, we tested whether ambiguous faces differed from positive and negative faces and then from neutral faces. Finally, multiple comparisons were conducted between each of the four levels: positive, negative, neutral, and ambiguous. Each time, repeated-measure analyses of variance ANOVAs focused on the electrode sites defined by the a priori hypotheses were run. For the EPN, occipital (O1 and O2) and temporal (T5 and T6) sites were included. There was thus an electrode (occipital vs. temporal) and a hemiscalp (right vs. left) factor in addition to the response factor. For the 200–400 ms anterior effect, measures at Fp1, Fz, and Fp2 were used in an ANOVA that had a three-level electrode factor. For the LPP time window, the electrode factor included three levels, Fz, Cz, and Pz. For the SPW time window, three ANOVAs, one for each electrode subset, were conducted given that there was no a priori hypothesis pertaining to scalp distribution. The ANOVA for the sagittal subset included again Fz, Cz, and Pz. That for the parasagittal subset included two electrode factors: right/left and ant/post (three levels: Fp1/2 vs. P3/4 vs. O1/2). The ANOVAs for the temporal subset also included two electrode factors, except that the ant/post factor had only two levels (T3/4 vs. T5/6) The results of these ANOVAs are given with the original degrees of freedom, the Greenhouse and Geisser (1959) corrected probability levels and the epsilon correction factors.

Table 1
Assessing Response Idiosyncrasy

	‘Hits’	%	*SD*	‘False alarms’	%	*SD*
Positively intentioned	48/60	80	15	50.4/240	21	6
Negatively intentioned	32.4/60	54	16	26.4/240	11	5
Neutrally intentioned	28.8/60	48	10	45.6/240	19	6
Ambiguously intentioned	34.8/120	29	10	32.4/180	18	7

Note. Although presented as a hit and false alarm table because it uses the same principle of computation, Table 1 does not allow the measure of the accuracy of participants. Indeed, participants were not asked to give accurate responses but to provide a response for each expression according to their own impression. Thus, Table 1 allows the evaluation of the mean number of times the personal response of each participant differed from the response of the relative majority of the judges of the pretest (see Method). For positive faces for instance, ‘hits’ correspond to the number of faces judged positively intentioned during the pretest that were categorized positively intentioned by participants during the ERP experiment divided by the total number of faces judged positively intentioned. As to ‘false alarms’ for positively intentioned faces, they correspond to the number of faces judged negatively, neutrally, or ambiguously intentioned that were categorized positively intentioned by the participants during the ERP experiment divided by the total number of faces judged negatively, neutrally, and ambiguously intentioned. The same principle applies to negative, ambiguous, and neutral faces. However, as in any experiment, motor errors were possible, as participants may have sometimes used a key that did not correspond to the response they wanted to give.

Results

Behavioral Data

Reliability of previous categorizations. Overall, faces were assigned to the four categories in percentages that were similar to those of the pretests. The positively intentioned faces, which had been judged positively intentioned by 78.4% ($SD = 6.1$) of pretest participants, were categorized as positively intentioned by 79.7% ($SD = 13$) of the participants of the experiment. The negatively intentioned faces, which had been judged as negatively intentioned by 55.3% ($SD = 9.8$) of the pretest participants, were categorized as negatively intentioned by 54.3% ($SD = 20$) of the participants of the experiment. For the neutrally intentioned faces these numbers were respectively 57.4% ($SD = 5.7$) and 47.6% ($SD = 15.1$), and for ambiguous faces, they were 29.5%, ($SD = 8.4$) and 29.1% ($SD = 13.9$). Differences between positively and neutrally intentioned faces and between ambiguous and neutrally intentioned faces were thus also significant for the participants of the experiment ($t = 12.48$, $p < .0001$; $t = 8.18$, $p < .0001$, respectively) as was the difference between negatively and neutrally intentioned faces, $t = 2.07$, $p = .045$.

The idiosyncrasy of the personal responses of each participant during the experiment appears in the mean hits and false alarms given in Table 1 (assessing response idiosyncrasy). This table shows that among the 60 faces judged as positively intentioned during the pretest, 48, on average, were categorized as positively intentioned during the ERP experiment by each participant. Meanwhile, on average, 50.4 faces, among the 240 faces not judged as positively intentioned during the pretest, were categorized as such during the experiment. For the faces categorized as negatively intentioned during the ERP experiment, 32.4 had been judged as such in the pretest but 11 had been classified differently. For the neutrally intentioned faces, those numbers were 28.8 and 19, respectively. For the ambiguously intentioned faces, they were 34.8 and 18.

Reaction times (RTs). The pattern of RTs mirrored that of the emotion literature (Crawford, Harrisson, & Kapelis, 1995; Hugdahl, Iversen, & Johnsen, 1993; Kirouac & Doré, 1983; Marinkovic & Halgren, 1998). Mean RTs computed according to the categorizations made by the participants during the ERP experiment revealed that the shortest RTs were obtained for positive intention categorizations: 1236 ms. RTs were longer for negative (1468 ms), even longer for neutral (1772 ms), and maximum for ambiguous intention categorizations (1917 ms). A one-way ANOVA with response as factor (four levels) revealed that these differences were significant ($F(3, 45) = 57.07$, $p < .001$, $\varepsilon = .897$). Multiple comparisons were run to test whether adjacent mean RTs differed significantly. The difference between positively and negatively intentioned faces was found significant, $F(1, 15) = 19.02$, $p = .001$, as was that between negatively and neutrally intentioned faces, $F(1, 15) = 37.10$, $p < .001$ and that between neutrally and ambiguously intentioned faces, $F(1, 15) = 5.14$, $p = .039$.

Electrophysiological Data

General aspect. ERPs elicited by faces during the intention attribution task were similar to the ERPs elicited by faces in other studies in which a mastoid or an ear reference electrode was used, except for the N450, which appears small in the present study (see Figure 1). These ERPs included a positive wave peaking around 100 ms (P1) and maximum at posterior sites, a negative wave maximum at centrofrontal leads, which peaked around 115 ms, and the vertex positive potential (Jeffreys, 1989; Schendan, Ganis, & Kutas, 1998) peaking, as usual, around 150–180 ms. Like in other works (e.g., Vanderploeg, Brown, & Marsh, 1987; Marinkovic &

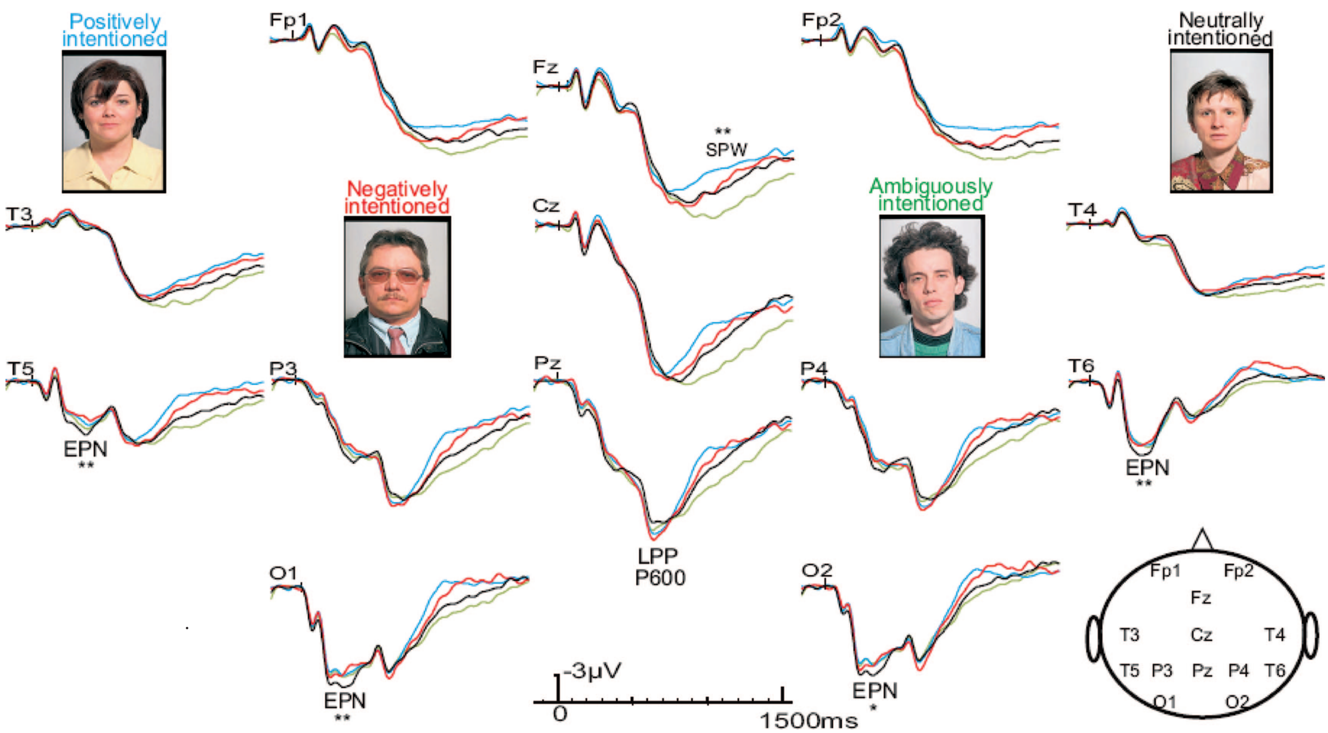

Figure 1. Grand average (n = 16) of the event-related brain potentials elicited by face photographs from the MED bank according to the personal responses of each subject for each face during the experiment. "EPN" indicate the early occipito-temporal effect (200–400 ms post stimulus onset) and "SPW", the slow positive wave effect (700–1200 ms). Stars indicate probabilities. $^{*}p \leq .05$. $^{**}p \leq .01$

Halgren, 1998), ERPs also included a positive deflection maximum at 330 ms at occipito-temporal sites. In contrast, at more anterior sites, two negative deflections could be seen. They were maximal at frontal sites and included the N270 and the N450, the latter taking the form of a little plateau on the downhill slope from the N270 to the peak of the P600, or LPP. This LPP, maximum at parietal sites around 630 ms, was prolonged by a slow positive wave maximum at anterior sites.

Results of statistical analyses. No larger P1s could be seen for negatively or positively intentioned faces. In fact, in this time window, ERPs for these faces were not significantly less positive than ERPs to other faces. Similarly, at anterior scalp sites, no early differences were seen. In contrast, in the 200–400 ms time window, at occipital and temporal sites (O1/2 & T5/6) as in Marinkovic and Halgren (1998) and in Vanderploeg, Brown, & Marsh (1987), ERPs to faces categorized as neutrally intentioned were more positive than ERPs to faces categorized otherwise. The ANOVA run to test the classical EPN differences between neutrally versus positively and negatively intentioned faces revealed that these differences were significant [$F(1, 15) = 9.4$, $p = .008$]. The differences were significant when tested between positively and neutrally intentioned faces [$F(1, 15) = 8.3$, $p = .011$] and between negatively and neutrally intentioned faces [$F(1, 15) = 6.9$, $p = .019$]. There was no EPN difference between negatively and positively intentioned faces [$F(1, 15) = .28$, $p = .60$] despite the large interrater agreement differences existing between these faces. There was no significant interaction with electrode (occipital vs. temporal) or with hemiscalp (right vs. left). A similar ANOVA was run to see whether there was a difference between ambiguous faces and positively and negatively intentioned faces. This was not the case [$F(2, 30) = .38$, $p = .67$], in accordance with visual inspection and still despite large interrater agreements differences. The last analysis revealed that the EPNs elicited by ambiguous faces were also greater than those elicited by neutral faces [$F(1, 15) = 7.53$, $p = .015$].

In this 200–400 ms time window, but at anterior scalp sites, ERPs appeared more positive for ambiguously categorized faces than for other faces (see Figure 1, at Fp2 and Fz). Analyses were performed at each scalp site. Differences were not significant at Fz [$F(3, 45) = 1.85$, $p = .15$] and Fp1 [$F(3, 45) = 1.59$, $p = .205$] but significant at Fp2 [$F(3, 45) = 3.4$, $p = .032$].

In the 500–700 ms time window, the ANOVAs run for the electrodes of the sagittal subset failed to reveal any significant effect of response [$F(3, 45) = 1.32$, $p = .28$] or any interaction between response and electrode [$F(6, 90) = .296$, $p = .86$].

In the slow-positive waves' (SPWs) time window (700–1200 ms), visual inspection revealed that the grand averages computed according to the responses were more positive for neutrally, negatively, and ambiguously intentioned faces than for positively intentioned faces. The ANOVA made for the midline subset revealed a significant effect of responses [$F(3, 45) = 6.3$, $p = .007$, $\varepsilon = .601$] and a trend toward an interaction between sites and responses [$F(6, 90) = 1.7$, $p = .17$, $\varepsilon = .525$], suggesting that the effect might be slightly larger at anterior than at posterior sites. The ANOVA performed with the parasagittal subset also revealed a significant effect of response [$F(3, 45) = 5.8$, $p = .009$, $\varepsilon =$

.630] and an interaction between response, hemisphere, and site [$F(6, 90) = 3.0$, $p = .026$, $\varepsilon = .664$]. Similarly, the ANOVA for the temporal subset revealed a significant effect of response [$F(3, 45) = 4.6$, $p = .015$, $\varepsilon = .741$] and a significant effect interaction between hemisphere and response [$F(3, 45) = 3.1$, $p = .05$, $\varepsilon = .782$], suggesting larger differences over the left than over the right hemiscalp. Post hoc analyses for sagittal and parasagittal subsets showed that the differences between positive and neutral response were significant at Cz [$F(1, 15) = 7.82$, $p = .014$], Fz [$F(1, 15) = 11.5$, $p = .004$], Fp1 [$F(1, 15) = 4.75$, $p = .046$], and Fp2 [$F(1, 15) = 6.84$, $p = .02$]. The differences between negative and neutral categorization only approached significance at Cz [$F(1, 15) = 4. = 23$, $p = .058$] and were not significant at the three other sites. The differences between ambiguous and neutral categorizations were significant at Cz [$F(1, 15) = 5.06$, $p = .04$]; at the three other sites, only tendencies were observed [Fz ($F(1, 15) = 3.96$, $p = .065$], Fp1 [$F(1, 15) = 2.28$, $p = .15$], and Fp2 [$F(1, 15) = 1.97$, $p = .18$].

Discussion

Results support the hypotheses that the automatic processes involved in judging facial expressions of well-characterized emotions are also used in the evaluation of intentions based on more subtle and less specific expressions. The early posterior negativities, the EPNs, were smaller for faces categorized as neutrally intentioned than for faces categorized as positively, negatively, or ambiguously intentioned. In the same 200–400 ms time window, but at anterior scalp sites, the negative deflections appeared smaller for ambiguously intentioned faces than for the other faces. Later, in the time window of the peak of the late positive potential (LPP), contrary to the predictions, there were no significant effects. Finally, large differences were found in the last time window, that of the slow positive wave, the SPW. There, ERPs were found to be more positive for faces that took more time to categorize. The longest reaction times (RTs) were associated with ambiguous categorizations, the shortest for positive intention categorizations. Negative and neutral intention categorizations fell in between.

Although they mirrored previously reported results (Crawford, Harrisson, & Kapelis, 1995; Hugdahl, Iversen, & Johnsen, 1993; Kirouac & Doré, 1983; Marinkovic & Halgren, 1998), the shortest RTs for faces categorized positively intentioned should be taken with caution. Given that these faces were those for which there was a greater interrater agreement, these shorter RTs could only index a lesser difficulty at judging these faces rather than be specific to positively intentioned faces.

The positive deflections peaking at posterior sites around 100 ms postonset, the P1s, were not of larger amplitudes for faces of people categorized as negatively or positively intentioned than for neutrally intentioned faces. These results contrast with those of Batty and Taylor (2003); Eger et al. (2003); Pizzagalli, Regard, & Lehmann (1999); Pourtois et al. (2005); and Streit et al. (1999), who found that negative faces elicited greater P1s than neutral faces. This discrepancy suggests that the expression impressions generated by the faces in this study were too subtle to trigger significant very early reactions. Accordingly, the amygdala did not enhance the very early visual processing of these faces by extrastriate areas in a detectable manner. On the other hand, this reaction of the amygdala could have occurred, but the P1 differences between neutrally intentioned faces and other faces could not be seen because of an early start of the EPN effect. Also, at very early latencies but at anterior electrode scalp sites, there was no early ERP effect before 200 ms, thus contrasting with the results of Eimer and Holmes (2002). This suggests that the prefrontal or orbitofrontal cortex structures that would be involved in the rapid detection of facial expressions may not have reacted to the subtle content of the faces used here.

Nevertheless, as in previous studies (Vanderploeg, Brown, & Marsh, 1987; Marinkovic & Halgren, 1998; Sato et al., 2001; Eimer, Holmes, & McGlone, 2003; Balconi & Pozzoli, 2003; Schupp et al., 2004), EPNs were larger for all the faces that were not categorized as neutrally intentioned, including ambiguous faces. Quite surprisingly, there seemed to be no impact of the large differences between the interrater agreements for the faces (i.e., 79.7% for positively, 54.3% for negatively, and 29.5% for ambiguously intentioned faces). The systematic difference between neutrally intentioned faces and all the faces that were not categorized as neutrally intentioned suggests in fact that the response of the participant for each face *depended* on the processes indexed by the EPN effect. Indeed, ERPs were computed according to these personal responses and not according to the response of the majority of participants. If the EPN is actually attributable to a modulation of visual processes by the amygdala, it means that these processes have a critical importance in determining how we finally respond to stimuli, even to those that are subtle and difficult to interpret. With such stimuli, the presence of larger EPNs for all the faces not categorized as neutrally intentioned suggests that the EPN effect may be a consequence of processes other than those evaluating the basic emotions, such as suppress the coma anger, fear, disgust, sadness, surprise, or joy. Specifically, it seems likely that these processes evaluate intentions or the value of the stimulus *for* the subject, in accordance with fact that similar EPN effects were found for words (Kissler, Herbert, Peyk, & Junghofer, 2007; Herbert, Junghofer & Kissler, 2008) and scenes (Junghofer, Bradley, Elbert, & Lang, 2001; Schupp, Junghofer, Weike, & Hamm, 2003a, 2003b, 2004).

The present study is the first that focuses on the neurocognitive processing of physiognomic traits and subtle expressions of emotions. The results strongly suggest that the processes indexed by the EPN are modulated in the same way as when judging emotional valence of faces, words, or scenes, despite the fact that, for these latter judgments, full-blown facial expressions of emotions, heavily loaded words, and moving scenes were used. This suggests the intention categorization may indeed be based on EPN indexed processes. As mentioned, these processes are automatic, as EPN effects are seen in tasks that do not focus on valence, but they are enhanced by tasks that focus on valence (Marinkovic & Halgren, 1998). The present results suggest that they could be further boosted by focusing on intentions, which would make sense as it is even more important to code for survival than emotions. The present results could also suggest that part of the same processes that have been attributed so far to the decoding of emotions might be implicated in the coding of intentions, or, more generally, in the coding of the valence of the stimulus for the subject.

Finally, another point can be made using the fact that the EPN for faces categorized ambiguously intentioned were larger than those for faces categorized neutral. The smaller EPN to neutral faces found in previous studies are *un*likely to be related to a difficulty at processing these faces, which are deprived from clear valence information.

In any case, the neural pathways responsible for the early activity of the amygdala may include those going from the pulvinar to the amygdala suggested by deGelder, Vroomen, Pourtois, & Weiskrantz (1999) and by Morris, Öhman, & Dolan (1999) for fear and anger expressions. They could also include pathways going from occipito-temporal areas to the amygdala via the fusiform gyri. Feedbackward processes reentrant the visual cortex could then occur (Martinez et al., 2001). Accordingly, the EPN effects would reflect additional allocations of attentional resources (Mangun & Hillyard, 1995) to the visual processing of faces, the valence of which has not been found neutral. Feedback fibers going from the amygdala to the occipito-temporal visual associative areas would trigger the allocation of these resources that enhance, for instance, the precision of visual processing. The greater negativities obtained for intention laden faces that were obtained between 200 and 400 ms could reflect this enhanced visual processing. Given the importance it seems to have in determining the actual response of the subject to subtle expressions, this enhancement could pertain to particular traits, such as those that signal a threat or its absence.

Still in the 200–400 ms time window, but at anterior electrode sites, the ERPs were not found more negative for neutral faces than for expressive faces in contrast with what has been previously reported (see Eimer & Holmes, 2007, for a review). As a matter of fact, the ERPs to faces categorized neutrally intentioned were (not significantly) more positive than those elicited by positive faces and almost superimposable to ERPs to negative faces. It appears worth noting that in the previous works mentioned, the negative deflections peaking around 270 ms postonset at Fz reached 3.5 or even 4 μV for neutral faces. Here, these deflections were smaller, reaching only 1.5 μV for neutral faces, and less than 1 μV for ambiguous faces. The absence of replication of previous findings and the small amplitudes of the N270s suggest that the down-regulation of the amygdala by prefrontal structures mentioned in the introduction section would be less important in the absence of clear cut emotion expressions. In fact, to be able to perform the categorization requested in the absence of clear facial signals, the best strategy might be to boost, rather than to inhibit, expression processing. Ambiguous categorizations may be a by-product of this boost (or of a total absence of down-regulation), as it is accompanied by the smallest N270s. In contrast, when expressions are more prototypical (as in Eimer & Holmes, 2007), the best strategy may be to inhibit further search for expression in neutral faces, as no subtle emotion has to be detected in these experiments. This would account for the largest N270s found in these protocols for neutral faces. However, this reasoning implies that the amplitude of the N270s is an index whose (negative) amplitude is positively correlated with the strength of this inhibition. This contrasts with the view developed by Eimer and Holmes (2007) and, more recently, by Bediou et al. (2009) that the cause of these variations is in fact a positive wave, superimposed on the negative deflection, and whose amplitude would be greater for faces with emotional valence than for neutral faces. Further studies may be necessary to elucidate this point.

The amplitudes of the peaks of the LPPs elicited by the face stimuli were large (equal or greater than 15 μv) and maximal at Pz. To the extent that these LPP peaks can be considered to belong to the P3b family of components, their large amplitude is not surprising. The amplitude of the P3b to a given target is known to increase with the difficulty of the task (e.g., Golstein, Spencer, & Donchin, 2002). The stimuli used in the present study were indeed difficult to categorize, as suggested by the long reaction times (1230 ms at least). On the other hand, in contrast with the large and robust effects found in previous studies (e.g., Marinkovic & Halgren, 1998; Laurian et al., 1991; and Orozco & Ehlers, 1998), the LPP peaks were only slightly and not significantly greater for faces categorized to have emotional (negative, positive or ambiguous) valence than for neutral faces. The comparison with the P3b could be of further help to understand this absence of significant effects. The amplitude of the P3b is known to increase with the amount of task relevant information delivered by the stimulus (e.g., Ruchkin, Johnson, Canoune, Ritter, & Hammer, 1990). In previous studies, neutral faces could be stimuli that do not bring clear emotional information. This could be an alternative way of accounting for the smaller LPPs they elicited. In the present study, the similarity of the LPP amplitudes obtained across conditions could then be related to the absence of clarity of valence information in most faces.

As to effects on the slow positive waves (SPWs), they were found to follow reaction times, with greater SPWs for faces that took longer to classify. The relation between SPWs and the response selection process is consistent with the fronto-central location of the maxima of SPWs, with the fact that it is for the expressions that were the most difficult to characterize, that is, for ambiguous faces, that the SPWs were the largest (Figure 1, at Fp1, Fp2, Fz, Cz sites), which goes with views on the functional significance of the SPWs (Garcia-Larrea & Cézanne-Bert, 1998) or 'P4s' (Christensen, Ivkovich, & Drake, 2001). Nevertheless, these results contrasted with the less positive ERPs that were obtained in that time window for neutral than for emotionally laden faces when using well-characterized expression of emotion (e.g., Eimer & Holmes, 2007). Rather than suggesting that the cognitive processes indexed by these late ERP effects only depend on emotional valence, the present results advocate again the importance of difficulty and thus of the clarity of the task-relevant information conveyed by the stimulus. This importance appears, at first, in contradiction with the smaller SPWs elicited by neutral faces reviewed in the literature (e.g., in Eimer & Holmes, 2007) whereas they are, in this perspective, more difficult to process than faces with a clear emotion. According to the difficulty account, it thus seems that they should have elicited larger SPWs.

However, there may be a way to reconcile these results based on the strategy differences that may exist between the two kinds of experiments. In experiments contrasting neutral faces to well-characterized expressions of emotions, neutral faces may simply appear as faces lacking task-relevant information because of the anchoring effects of the intense expressions. Late processes focusing on this type of information could then stop earlier than for emotionally laden faces. In contrast, in experiments where subtle expressions and physiognomic traits have to be taken into account, neutral faces could be further processed as stimulus material including potentially task relevant information. This perspective provides an account for the larger SPWs found for neutral faces than for emotionally laden faces when participants have to *rate the degree* to which faces are emotional. In this task, even subtle information has to be taken into account. In these particular conditions, faces used as neutral could be further processed despite the fact that they were contrasted with well-characterized expressions of emotions (Marinkovic & Halgren, 1998). This way of thinking also provides an account for the absence of such SPW differences found by González-Garrido, Ramos-Loyo, López-Franco and Gómez-Velázquez (2009) and by Marinkovic and Halgren (1998) when the attention of the participant was diverted from facial expressions (by focusing on the size of the ears and by doing a recognition memory task, respectively). There, emotions were not task-relevant.

Conclusion

In sum, for face stimuli with nonprototypical expressions, that is, with expressions generated essentially by the morphology of the face, the classical EPN effect was found suggesting that at least some of the early automatic processing of these faces is similar to the processing of full-blown expressions. The fact that these results were found in an intention categorization task suggests the possibility that part of the processes thought to be devoted to the analysis of emotions might in fact focus on the decoding of intentions. In contrast, none of the other effects typically associated with facial expressions categorizations were replicated as such. The discussion of the results of the present study led to suggest that these other effects could index processes modulated by the amount and the clarity of task-relevant information included in the face stimuli rather than by the particular nature or the emotional valence of this information.

References

Amaral, D. G., Behniea, H., & Kelly, J. L. (2003). Topographic organization of projections from the amygdala to the visual cortex in the macaque monkey. *Neuroscience, 118,* 1099–1120.

Armony, J. L., & Dolan, R. J. (2002). Modulation of spatial attention by fear conditioned stimuli: An event-related fMRI study. *Neuropsychologia, 40,* 817–826.

Ashley, V., Vuilleumier, P., & Swick, D. (2004). Time course and specificity of event-related potentials to emotional expressions. *Neuroreport, 15,* 211–216.

Balconi, M., & Pozzoli, U. (2003). Face-selective processing and the effect of pleasant and unpleasant emotional expressions on ERP correlates. *International Journal of Psychophysiology, 49,* 67–74.

Batty, M., & Taylor, M. J. (2003). Early processing of the six basic facial emotional expressions. *Cognitive Brain Research, 17,* 613–620.

Becker, D. V., Kenrick, D. T., Neuberg, S. L., Blackwell, K. C., & Smith, D. M. (2007). The confounded nature of angry men and happy women. *Journal of Personality and Social Psychology, 92,* 179–190.

Bediou, B., Eimer, M., d'Amato, T., Hauk, O., & Calder, A. J. (2009). In the eye of the beholder: Individual differences in reward-drive modulate early frontocentral ERPs to angry faces. *Neuropsychologia, 47*(3), 825–834.

Carretié, L., & Iglesias, J. (1995). An ERP study on the specificity of facial expression processing. *International Journal of Psychophysiology, 19,* 183–192.

Chapell, M. S. (1997). Frequency of public smiling across the life span. *Perceptual and Motor Skills, 85*(3), 1326.

Christensen, C. A., Ivkovich, D., & Drake, K. J. (2001). Late positive ERP peaks observed in stimulus-response compatibility tasks tested under speed-accuracy instructions. *Psychophysiology, 38,* 401–416.

Crawford, H. J., Harrisson, D. W., & Kapelis, L. (1995). Visual field asymetry in facial affect perception: Moderating effects of hypnosis, hypnotic susceptibility level, absorption, and sustained attentional abilities. *International Journal of Neuroscience, 82,* 11–23.

Debruille, J. B., Brodeur, M., & Stelcner, S. (1999). Mechanisms of attribution of intent to unknown persons: First ERP recordings using the med bank of face. *International Journal of Psychophysiology, 33,* 76.

Debruille, J. B., Pineda, J., & Renault, B. (1996). N400-like potentials elicited by faces and knowledge inhibition. *Cognitive Brain Research, 4,* 133–144.

deGelder, B., Vroomen, J., Pourtois, G., & Weiskrantz, L. (1999). Non-conscious recognition of affect in the absence of striate cortex. *NeuroReport, 10,* 3759–3763.

Diedrich, O., Naumann, E., Maier, S., Beker, G., & Bartussek, D. (1997). A frontal positive slow wave in the ERP associated with emotional slides. *Journal of Psychophysiology, 11,* 71–84.

Eger, E., Jedynak, A., Iwaki, T., & Skrandies, W. (2003). Rapid extraction of emotional expression: Evidence from evoked potential fields during brief presentation of face stimuli. *Neuropsychologia, 41,* 808–817.

Eimer, M., & Holmes, A. (2002). An ERP study on the time course of emotional face processing. *Neuroreport, 13,* 427–431.

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia, 45,* 15–31.

Eimer, M., Holmes, A., & McGlone, F. P. (2003). The role of spatial attention in the processing of facial expression: An ERP study of rapid brain responses to six basic emotions. *Cognitive, Affective and Behavioural Neurocience, 3*(2), 97–110.

Ekman, P. (1999). Facial expression. In: T. Dalgleish, & M. Power (Eds.), *Handbook of cognition and emotion* (pp. 310–320). Chichester, England: Wiley & Son Ltd.

Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect.* Palo Alto: Consulting Psychologists Press.

Garcia-Larrea, L., & Cézanne-Bert, G. (1998). P3, positive slow wave and working memory load: A study on the functional correlates of slow wave activity. *Electroencephalogarphy and Clinical Neurophysiology, 108,* 260–273.

Golstein, A., Spencer, K. M., & Donchin, E. (2002). The influence of stimulus deviance and novelty on the P300 and Novelty P3. *Psychophysiology, 39,* 781–790.

González-Garrido, A. A., Ramos-Loyo, J., López-Franco, A., & Gómez-Velázquez, F. R. (2009). Visual processing in a facial emotional context: An ERP study. *International Journal of Psychophysiology, 71,* 25–30.

Greenhouse, G. W., & Geisser, S. (1959). On methods of analysis of profile data. *Psychometrika, 24,* 1582–1589.

Guillem, F., Bicu, M., & Debruille, J. B. (2001). Dissociating memory processes involved in direct and indirect tests with ERPs to unfamiliar faces. *Cognitive Brain Research, 11,* 113–125.

Herbert, C., Junghofer, M., & Kissler, J. (2008). Event-related potentials to emotional adjectives during reading. *Psychophysiology, 45*(3), 487–498.

Hareli, S. & Hess, U. (2010). What emotional reactions can tell us about the nature of others: An appraisal perspective on person perception. *Cognition and Emotion, 24,* 128–140.

Hess, U., Adams, R. B., Jr., & Kleck, R. E. (2009). The face is not an empty canvas: How facial expressions interact with facial appearance. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364,* 3497–3504.

Hess, U., Adams, R. B. J., & Kleck, R. E. (2008). The role of perceived emotion in first impressions. In N. Ambady & J. J. Skowronski (Eds.), *First impressions* (pp. 234–254). Guilford Press.

Hess, U., Beaupré, M. G., & Cheung, N. (2002). Who to whom and why – cultural differences and similarities in the function of smiles. In M. Abel

& C. H. Ceia (Eds.), *An empirical reflection on the smile* (pp. 187–216). New York: The Edwin Mellen Press.

Hess, U., Hareli, S., Adams, R. B. J., Stevenson, M. T., & Lasalle, M. (2010). *On the face of it: The perception of traits from emotions in the neutral face.* Manuscript submitted for publication.

Holmes, A., Vuilleumier, P., & Eimer, M. (2003). The processing of emotional facial expression is gated by spatial attention: Evidence from event-related brain potentials. *Brain Research: Cognitive Brain Research, 16,* 174–184.

Hugdahl, H., Iversen, P. M., & Johnsen, B. H. (1993). Laterality for the facial expressions: Does the sex of the subject interact with the sex of the stimulus face? *Cortex, 29,* 325–331.

Jaspers, H. H. (1958). The ten-twenty system of the International Federation. *Electroencephalography and Clinical Neurophysiology, 10,* 371–375.

Jeffreys, D. A. (1989). A face-responsive potential recorded from the human scalp. *Experimental Brain Research, 78,* 193–202.

Junghofer, M., Bradley, M. M., Elbert, T. R., & Lang, P. J. (2001). Fleeting images: A new look at early emotion discrimination. *Psychophysiology, 38,* 175–178.

Kirouac, G., & Doré, F. Y. (1983). Accuracy and latency of judgment of facial expression of emotions. *Perceptual & Motor Skills, 57,* 683–686.

Kiss, M., & Eimer, M. (2008). ERPs reveal subliminal processing of fearful faces. *Psychophysiology, 45*(2), 318–326.

Kissler, J., Herbert, C., Peyk, P., & Junghofer, M. (2007). Buzzwords″ -Early cortical responses to emotional words. *Psychological Science, 18,* 475–480.

Krolak-Salmon, P., Fischer, C., Vighetto, A., & Mauguière, F. (2001). Processing of facial emotional expression: Spatio-temporal data as assessed by scalp event-related potentials. *European Journal of Neuroscience, 13,* 987–994.

Lasalle, M., Poirier, S., Simard, A., & Hess, U. (2010). Emotions in the neutral face = perceived personality: The impact of perceived emotions on personality attributions. Paper presented at the 11th annual SPSP conference, Las Vegas, NV.

Laurian, S., Bader, M., Lanares, J., & Oros, L. (1991). Topography of event-related potentials elicited by visual emotional stimuli. *International Journal of Psychophysiology, 10,* 231–238.

Liddell, B. J., Brown, K. J., Kemp, A. H., Barton, M. J., Das, P., Peduto, A. . . . & Williams, L. M. (2005). A direct brainstem-amygdala-cortical ‘alarm’ system for subliminal signals of fear. *Neuroimage, 24*(1), 235–243.

Mangun, G. R., & Hillyard, S. A. (1995). Mechanisms and models of selective attention. In: M. D. E. Rugg, M. G. H. Coles (Eds.), *Electrophysiology of mind: Event-related brain potentials and cognition* (pp. 40–85). Oxford, UK: Oxford University Press.

Marinkovic, K., & Halgren, E. (1998). Human brain potentials related to the emotional expression, repetition, and gender of faces. *Psychobiology, 26*(4), 348–356.

Martinez, A., DiRusso, F., Anllo-Vento, L., Sereno, M. I., Buxton, R. B., & Hillyard, S. A. (2001). Putting spatial attention on the map: Timing and localization of stimulus selection processes in striate and extrastriate visual areas. *Vision Research, 41*(10–11), 1437–1457.

Matsumoto, D., Yoo, S. H., Hirayama, S., & Petrova, G. (2005). Development and validation of a measure of display rule knowledge: The display rule assessment inventory. *Emotion, 5,* 23–40.

Meinhardt, J., & Pekrun, R. (2003). Attentional resource allocation to emotional events: An ERP study. *Cognition and Emotion, 17,* 477–500.

Miltner, W., Johnson, R. J., & Braun, C. (1991). Auditory and somatosensory event-related potentials: Il. Effects of the inter-stimulus interval. *Journal of Psychophysiology, 5,* 27–42.

Morris, J. S., Öhman, A., & Dolan, R. J. (1999). A subcortical pathway to the right amygdala mediating “unseen” fear. *Proceedings of the National Academy of Sciences USA, 96,* 1680–1685.

Morris, J. S., Friston, K. J., Büchel, C., Frith, C. D., Young, A. W., Calder, A. J., & Dolan, R. J. (1998). A neuromadulatory role for the human amygdala in processing emotional facial expressions. *Brain, 121,* 47–57.

Naumann, E., Bartussek, D., Diedrich, O., & Laufer, M. E. (1992). Assessing cognitive and affective information processing functions of the brain by means of the late positive complex of the event-related potential. *Journal of Psychophysiology, 6,* 285–298.

Niedenthal, P. M., Mermillod, M., Maringer, M., & Hess, U. (2010). The Simulation of Smiles (SIMS) Model: Embodied simulation and the meaning of facial expression. *Behavioral and Brain Sciences, 33,* 417–433.

Oosterhof, N., & Todorov, A. (2009). Shared perceptual basis of emotional expressions and trustworthiness impressions from faces. *Emotion, 9,* 128–133.

Orozco, S., & Ehlers, C. L. (1998). Gender differences in electrophysiological responses to facial stimuli. - *Biological Psychiatry, 44*(4), 281–289.

Pessoa, L., Kastner, S., & Ungerleider, L. G. (2002). Attentional control of the processing of neural and emotional stimuli. *Cognitive Brain Research, 15,* 31–45.

Pizzagalli, D., Regard, M., & Lehmann, D. (1999). Rapid emotional face processing in the human right and left brain hemispheres: And ERP study. *Neuroreport, 10,* 2691–2698.

Polich, J. (1990). Probability and inter-stimulus interval effects on the P300 from auditory stimuli. *International Journal of Psychophysiology, 10,* 163–170.

Pourtois, G., Dan, E. S., Grandjean, D., Sander, D., & Vuilleumier, P. (2005). Enhanced extrastriate visual response to bandpass spatial frequency filtered fearful faces: Time course and topographic evoked-potentials mapping. *Human Brain Mapping, 26,* 65–79.

Ruchkin, D. S., Johnson, R., Jr., Canoune, H. L., Ritter, W., & Hammer, M. (1990). Multiple sources of P3b associated with different types of information. *Psychophysiology, 27*(2), 157–176.

Sabbagh, M. A., Moulson, M. C., & Harkness, K. L. (2004). Neural correlates of mental state decoding in human adults: An event-related potential study. *Journal of Cognitive Neuroscience, 163,* 415–426.

Sato, W., Kochiyama, T., Yoshikawa, S., & Matsumura, M. (2001). Emotional expression boosts early visual processing of the face: ERP recording and its decomposition by independent component analysis. *Neuroreport, 26,* 709–714.

Schendan, H. E., Ganis, G., & Kutas, M. (1998). Neurophysiological evidence for visual perceptual categorization of words and faces within 150 ms. *Psychophysiology, 35*(3), 240–251.

Schupp, H. T., Junghofer, M., Weike, A. I., & Hamm, A. O. (2003a). Attention and emotion: An ERP analysis of facilitated emotional stimulus processing. *NeuroReport, 14,* 1107–1110.

Schupp, H. T., Junghofer, M., Weike, A. I., & Hamm, A. O. (2003b). Emotional facilitation of sensory processing in the visual cortex. *Psychological Science, 14,* 7–13.

Schupp, H. T., Junghofer, M., Weike, A. I., & Hamm, A. O. (2004). The selective processing of briefly presented affective pictures: An ERP analysis. *Psychophysiology, 41,* 441–449.

Schupp, H. T., Ohman, A., Junghofer, M., Weike, A. I., Stockburger, J., & Hamm, A. O. (2004). The facilitated processing of threatening faces: An ERP analysis. *Emotion, 4,* 189–200.

Streit, M., Ioannides, A. A., Liu, L., Wölwer, W., Dammers, J., Gross, J., . . . & Muller-Gartner, H. W. (1999). Neurophysiological correlates of the recognition of facial expressions of emotion as revealed by magnetoencephalography. *Cognitive Brain Research, 7,* 481–491.

Vanderploeg, R. D., Brown, W. S., & Marsh, J. T. (1987). Judgments of emotion in words and faces: ERP correlates. *International Journal of Psychophysiology, 5*(3), 193–205.

Vuilleumier, P., Richardson, M. P., Armony, J. L., Driver, J., & Dolan, R. J. (2004). Distant influences of amygdala lesion on visual cortical activation during emotional face processing. *Nature Neuroscience, 7,* 1271–1280.

Walter, W. G., Cooper, R., & Aldridge, V. G. (1964). Contingent negative variation: An electric sign of sensorimotor association and expectancy in the human brain. *Nature, 203,* 380.

Williams, L. M., Liddell, B. J., Kemp, A. H., Bryant, R. A., Meares, R. A., Peduto, A. S., & Gordon, E. (2006a). Amygdala-prefrontal dissociation of subliminal and supraliminal fear. *Human Brain Mapping, 27*(8), 652–661.

Williams, L. M., Palmer, D., Liddell, B. J., Song, L., & Gordon, E. (2006b). The "when" and "where" of perceiving signals of threat versus non-threat. *NeuroImage, 31,* 458–467.

World Medical Association Declaration of Helsinki. (2001). Ethical principles for medical research involving human subjects. *Bulletin of the World Health Organization, 79*(4), 373–4.

Zebrowitz, L. A., Kikuchi, M., & Fellous, J. M. (2010). Facial resemblance to emotions: Group differences, impression effects, and race stereotypes. *Journal of Personality and Social Psychology, 98,* 175–189.

Received December 9, 2009
Revision received February 22, 2011
Accepted February 23, 2011 ■

Correction to Debruille, Brodeur, and Hess (2011)

In the article, “Assessing the Way People Look to Judge their Intentions,” by J. Bruno Debruille, Mathieu B. Brodeur, and Ursula Hess (*Emotion*, Vol. 11, No. 3, pp. 533–543), Figure 1, which should have been printed in color, was inadvertently printed in black and white. The online version has been corrected.

DOI: 10.1037/a0024807