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Interaction of facial expressions and familiarity: ERP evidence

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Abstract

There is mounting evidence that under some conditions the processing of facial identity and facial emotional expressions may not be independent; however, the nature of this interaction remains to be established. By using event-related brain potentials (ERP) we attempted to localize these interactions within the information processing system. During an expression discrimination task (Experiment 1) categorization was faster for portraits of personally familiar vs. unfamiliar persons displaying happiness. The peak latency of the P300 (trend) and the onset of the stimulus-locked LRP were shorter for familiar than unfamiliar faces. This implies a late perceptual but pre-motoric locus of the facilitating effect of familiarity on expression categorization. In Experiment 2 participants performed familiarity decisions about portraits expressing different emotions. Results revealed an advantage of happiness over disgust specifically for familiar faces. The facilitation was localized in the response selection stage as suggested by a shorter onset of the LRP. Both experiments indicate that familiarity and facial expression may not be independent processes. However, depending on the kind of decision different processing stages may be facilitated for happy familiar faces.

Keywords: Face recognition; Emotional expressions

1. Introduction

The recognition of facial expressions appears to be independent of a person's identity or familiarity. Thus, we can recognize facial expressions of both familiar and unfamiliar people and, conversely, we do not need to analyse the expression of a face in order to recognize the person. However, there is some evidence for an interaction between the processing of facial expressions and identity. For example, we sometimes have to look twice to recognize someone familiar if she displays a facial expression never seen before or we may get confused when a seemingly strange person smiles at us. The present study seeks to corroborate the evidence for such interactions between facial expression and facial familiarity and attempts to determine the underlying mechanisms as well as the functional loci of possible interactions in the information processing chain.

1.1. Independence of facial familiarity and facial expression

In their functional model of face recognition Bruce and Young (1986) assume the independence of the recognition of facial expressions and facial identity. According to their model familiarity is assessed by face recognition units (FRUs) which are independent of expression analysis. Both processes are assumed to occur in separate, parallel pathways. For example, Ellis et al. (1990) showed that the initial classification of familiar faces according to occupation primed the decision for familiarity in a subsequent familiarity decision task but not in an expression decision task. Bobes et al. (2000) showed different topographical distributions of event-related potentials (ERPs) for a familiarity and an expression matching tasks. This suggests distinct neural subsystems subserving both processes. In addition, a double dissociation of face and expression recognition has been reported by Tranel et al. (1988) who studied three patients with prosopagnosia, the inability to identify faces, who could nevertheless recognize facial expressions. Conversely, Young et al. (1993) reported upon a patient with a selective deficit in processing facial expressions vis a vis intact recognition of facial familiarity. These results suggest independent functions of recognizing facial familiarity and facial expression. However, there is some recent evidence

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that at some level(s) the processes of expression and identity recognition may in fact interact.

1.2. Interaction of facial familiarity and facial expression

In their model of a distributed human neural system for face perception Haxby et al. (2000) identified a core system, subserving the visual analysis of identity as well as changeable aspects of faces, such as facial expression, being located in the occipitotemporal cortex with projections to the fusiform gyrus and superior temporal sulcus. This core system is supplemented by an extended system responsible for related aspects of face perception like directing attention or semantic information processing. According to this model functional interactions of different processes might be possible although they are based on separate brain systems (see Posamentier and Abdi, 2003 for a review). The processing of facial expressions starts as early as 80 ms after stimulus onset (Eger et al., 2003), which is even earlier than the N170 component in the ERP, thought to reflect structural face encoding (Eimer, 2000b). Therefore, it stands to reason that the information extracted from expressive faces may modulate early structural face encoding processes (Bruce and Young, 1986). Indeed, Caharel et al. (2005) and Batty and Taylor (2003) found increased N170 amplitudes for negative when compared to positive or neutral facial expressions. Sprengelmeyer and Jentzsch (2006) reported a modulation of the N170 by the intensity of emotional facial expressions. It is possible that expressive faces may boost attention and arousal via interconnections with the amygdala (Sato et al., 2001) and may also modulate later processing stages. For example, in an fMRI study, Vuilleumier et al. (2002) found increased activation in the amygdala for emotionally expressive faces shown at task-irrelevant locations and independent of spatial attention. In addition, in a gender discrimination task Krolak-Salmon et al. (2001) reported differential ERP activity between 250 and 750 ms in occipital and occipito-temporal areas related to emotional expression. They took this as support for top-down modulations from limbic (including amygdala) and frontal areas influencing extra-striate visual areas. Ganel et al. (2005) found increased activation for expressive faces in the fusiform face area (FFA) even when identity was attended. The FFA is commonly thought to mediate only the processing of identity. The results of Ganel et al. (2005), however, suggest an overlap of the neural networks subserving the processing of both identity and emotional expression. Thus, emotional stimuli may guide focussed attention to the relevant location because the amygdala is part of the attentional system (Eastwood et al., 2001). This in return may speed up the classification of a face as being familiar or not.

Schweinberger and Soukup (1998) addressed the interaction of facial expression and identity with the selective attention paradigm of Garner (1976). With a stimulus set of two individual faces (person A versus B) and two expressions (happy versus sad) the authors were able to show an asymmetric influence of facial identity on the discrimination of facial expressions. Facial expressions were easier to discriminate when they were correlated with the task-irrelevant identity of a face, for example when person A was displayed only with a happy expression and person B only with a sad expression, than when there was no such correlation. No effect of irrelevant correlation with facial expression was seen in the identity discrimination task.

In a study by Baudouin et al. (2000b) participants had to discriminate neutral from happy facial expressions. It was argued that because expression discrimination is a relatively fast process, an interaction between facial familiarity and the discrimination task would emerge only if this process is made relatively difficult and slow. To this aim, faces were displayed with short rather than long presentation times (15 ms versus 400 ms) or with the mouth concealed rather than visible. Specifically in the hard conditions expression discrimination was facilitated for famous faces when compared to unfamiliar faces. The authors concluded that facial familiarity increases ‘‘perceptual fluency’’, facilitating recognition of facial expressions under difficult conditions.

There is also evidence that facial expressions influence the perception and recognition of familiarity. A smile as compared to a neutral expression may increase the subjective familiarity for both unfamiliar and familiar faces (Baudouin et al., 2000a). Endo et al. (1992) found that the recognition of personally familiar faces was facilitated when they displayed a neutral as compared to happy and angry expressions. In contrast, famous faces were recognized faster with happy expressions. The authors argued that a neutral expression is more frequently seen in personally familiar faces whereas famous faces are more often seen with a happy expression. With faces morphed with respect to familiarity and expression Kaufmann and Schweinberger (2004) showed that famous faces are recognized faster when displaying moderately positive expressions whereas the recognition of unfamiliar faces was unaffected by expression.

Together, the studies outlined above suggest an interaction of the perception of facial expressions and facial familiarity in one or the other direction. However, some studies suffer from methodological shortcomings. Schweinberger and Soukup (1998) used a very small stimulus set involving only two different individuals. In the study of Baudouin et al. (2000b) the concealed mouth probably altered the recognition of facial expression and disrupted normal holistic processing. The perceptual variation of a concealed mouth may have affected the two expressions differently. The mouth region may be more important for recognizing happiness than neutral expressions (Calder et al., 2001). In addition, the recognition of familiar people relies more on internal facial features as compared to unfamiliar faces (Ellis et al., 1979). Hence, the interaction of the hard/easy condition and familiarity in the expression discrimination task may have been due to differential effects of the perceptual manipulation on the familiarity and the expression dimension.

1.3. Objectives

The first aim of the present study was to provide further evidence for the presence of interactions between facial familiarity and facial expressions. Our second aim was to elucidate the mechanisms underlying such interactions. Here we reexamined these questions within a standard paradigm with improved stimulus material and by means of recording event-related brain potentials. A two-choice RT task was used where participants either discriminated facial expressions or facial familiarity. In the expression discrimination task, facial familiarity was varied independently of expression—that is, half of the presented portraits belonged either to personally familiar or unfamiliar faces. In the familiarity discrimination task the other dimension – facial expression – was varied independently.

The stimulus set used in this study consisted of portraits of personally familiar and age- and gender-matched unfamiliar persons, displaying neutral expressions, happiness, or disgust. We used personally familiar faces rather than celebrities from the public domain because their representations in memory should be more consistent and more robust (Caharel et al., 2006; Tong and Nakayama, 1999). Thus, we expected an enhancement of the hypothesized interaction between facial expression and facial familiarity. Most studies searching for an interaction have used either unfamiliar (Schweinberger and Soukup, 1998), or famous faces (Baudouin et al., 2000b). Different degrees of familiarity could be a reason for inconsistent results. Only Endo et al. (1992) and Caharel et al. (2005) used personally familiar faces. However, the number of stimuli had been small (e.g. only the mother's and the own face in the Caharel study) making an interpretation difficult. With a larger set of personally familiar faces we expected to optimize the chances of finding any interactions in processing facial familiarity and facial expression.

Event-related potentials were recorded in order to draw conclusions about the temporal characteristics of the functional processing stage which might be affected by the hypothesized interaction. Several distinct components were used in order to pinpoint the functional locus of these putative interactions. The face-sensitive N170 component of the ERP is associated with the formation of a visual representation of a face-like stimulus. It may reflect the functional process of structural face encoding (Bentin et al., 1996; Eimer, 2000b; Rossion et al., 2000) as conceptualized by Bruce and Young (1986). The P300 component may be related to the perceptual evaluation or classification of task relevant stimuli (Johnson, 1986; McCarthy and Donchin, 1983). The Lateralized Readiness Potential (LRP; Coles, 1989) reflects the activation of a specific response following more abstract response selection (de Jong et al., 1988). Osman et al. (1995) proposed to separate the information processing from stimulus to overt response into two intervals with the LRP. The first interval from stimulus presentation until the beginning of response activation (LRP) is best calculated in the stimulus-synchronized LRP (S-LRP). It is informative about the time demand of processes taking place until the completion of response selection (Leuthold et al., 1996). The second interval from the onset of the LRP until the overt response is measured in LRPs averaged synchronized to the response (LRP-R) and indicates the time demands of motor processes beyond central response selection (Masaki et al., 2004).

In contrast to the assumptions of the functional model of face recognition by Bruce and Young (1986) the main objective of the present study was to find interactions between the recognition of facial expressions and of facial familiarity. The first experiment aimed at effects of task-irrelevant facial familiarity in an expression discrimination task for personally familiar and unfamiliar faces. In the second experiment we investigated effects of task-irrelevant facial expression in a familiarity discrimination task on the same stimulus set. These experiments went beyond previous studies, addressing the question of an interaction between facial identity and expression by using more faces with a clearly defined and high degree of familiarity and by using several functionally distinct ERP components in order to localize any effects.

2. Experiment 1

In Experiment 1 participants discriminated the expressions of happiness and disgust displayed by personally familiar and unfamiliar faces. Because normally the discrimination of expression is a relatively fast process, an effect of familiarity on this task might only emerge when the recognition of facial expressions is slow (Baudouin et al., 2000b). Therefore, in the present experiment the intensity of the emotional expressions was varied in strength with the aim of manipulating the speed of expression discrimination. Apart from replicating the facilitating effect of facial identity on expression discrimination we aimed at pinpointing its functional locus by means of recording ERPs. Increased RTs should emerge for faces with weak expressiveness. Most importantly, as personal familiarity should facilitate the discrimination of facial expressions we expected faster RTs for familiar as compared to unfamiliar faces especially when expressions were of low intensity.

Different hypotheses arise concerning the processing stage that is facilitated by familiarity. If the response selection stage is facilitated, the S-LRP onset should be shorter for familiar than unfamiliar faces. The facilitation of late perceptual processes and, accordingly, the perception and classification of facial expressions should be indicated by a shorter peak latency of the P300 component for personally familiar faces. Because evidence of familiarity effects on the N170 is largely negative (Caharel et al., 2005; but see Caharel et al., 2006; Eimer, 2000a) we do not expect the interaction to take place during structural encoding as indexed by the N170 (Caharel et al., 2005). If familiarity shortens the temporal demands for motor preparation following response selection, a reduced LRP-R interval for personally familiar faces should be present in the data.

2.1. Method

2.1.1. Participants

The sixteen participants (five men; mean age = 24.6 years; range: 20–32) were personally familiar with half of the persons whose portraits were shown in the experiment as pre-experimentally verified. Participants fulfilled either course requirement or received a payment of 15 €. The mean handedness score (Oldfield, 1971) was 78 (range: −82 to +100).

2.1.2. Stimuli and apparatus

Color portraits were taken from 16 staff members of the psychology department serving as personally familiar faces. To these persons 16 unfamiliar persons were matched in age and gender. Each person was photographed in three slightly different head positions (frontal view and 10 degrees to the left and right)[1] with three different expressions (happiness, disgust, neutral) in two

[1] The variation of head position was small and only served to preclude that responses are based on pictorial information after some stimulus repetitions. Because preliminary tests had suggested no effect of head position on performance data, this factor is not further taken into consideration.

expressive intensities (weak, strong). Eye gaze was always towards the camera and lips were closed. All pictures were edited in Adobe Photoshop® to 8-bit pictures (256 colors; horizontal and vertical dimension of 125 × 166 pixels). They were presented on a 17-in. screen at a size of 5.0 cm × 6.6 cm, corresponding to visual angles of 2.9° by 3.8° at a viewing distance of 1 m. ERTS® served as software for stimulus presentation and response recording.

A *pre-experiment* was conducted to ensure that the expressiveness of the portraits was comparable for familiar and unfamiliar faces. Two groups of 12 participants each performed the expression discrimination task. The experimental group consisted of psychology students that were familiar with half of the portrayed people whereas the control group – students of other subjects – was not. Repeated measures ANOVAs including the between-factor group and the within-factors familiarity and intensity were conducted for response times (RT) and error rates. Both RTs ($M = 936$ ms versus 832 ms), $F(1,22) = 220.4$, $p < .01$, and error rates ($M = 21.2\%$ versus 9.4%), $F(1,22) = 139.0$, $p < .01$, were increased for portraits with weak expressive intensity. Most importantly, for RTs a main effect of familiarity, $F(1,22) = 17.9$, $p < .01$, interacted with the factor group, $F(1,22) = 4.7$, $p < .05$. RTs were faster for familiar as compared to unfamiliar persons only for the experimental group ($M = 828$ ms versus 866 ms), $t(11) = -4.3$, $p = .001$, but not for the control group ($M = 907$ ms versus 918 ms), $p > .05$. This was less clear for error rates where the interaction just failed significance, $F(1,22) = 3.9$, $p < .06$. It can be concluded that facial familiarity facilitated the discrimination of facial expression mainly in the experimental group. As this effect was not observed in the control group it is likely that the expressiveness of the portraits is comparable for familiar and unfamiliar faces. Thus, we take the stimulus set to be basically sound to be used in the experiments proper.

2.1.3. Design and procedure

In a two-choice reaction time task participants had to discriminate the facial expressions happiness and disgust. From a list of the names of the 16 potentially familiar persons the 14 most familiar persons and their unfamiliar matches were selected for each participant. Hence, portraits of 28 persons were presented. Each person was presented on different pictures displaying happiness or disgust with weak or strong expressive intensity and taken from three slightly different views. This sequence of portraits was shown three times at different random orders, totaling 1008 trials. Each trial started with a blank screen followed by a fixation cross for 500 ms. The portrait appeared for a maximum of 2000 ms; presentation was terminated by the participants response. Feedback was provided immediately after the response in case of early (below 100 ms; ‘‘Zu früh’’) or late responses (above 2000 ms; ‘‘Zu langsam’’); no feedback was provided after correct responses. After each quarter of trials, a break was allowed and the assignment of facial expression to response hand was changed. At the beginning of the experiment and at each assignment change participants practiced the new assignment for 40 trials by pressing the corresponding button in response to the words ‘‘Freude’’ (happiness) or ‘‘Ekel’’ (disgust) presented on the screen. After each block of trials, written feedback about mean RT, error count and error rate was provided on the screen.

2.1.4. Electrophysiological recordings

The EEG was recorded from 31 electrode sites including IO1, IO2 (below the eyes), LO1, LO2 (next to the outer canthus of each eye), Fp1, Fp2, Fz, F3, F4, F7, F8, FT9, FT10, Cz, C3′ and C4′ (4 cm to the left and right of Cz, respectively), T7, T8, Pz, P3, P4, P7, P8, P9, P10, PO9, PO10, O1, O2, Iz and the right mastoid (M2) according to the modified 10-20 International System (Pivik et al., 1993). Tin electrodes placed within an electrode cap (Electro-Cap International Inc.) were used with ECI Electro-Gel™ electrolyte paste. Electrode impedances were kept below 5 kΩ. The electrodes Fp1, IO1, LO1, and LO2 served for controlling EOG artifacts. All electrodes were referenced to the left mastoid (M1). At recording low pass filters were set at 30 Hz; TC was 0.001 Hz. The electrophysiological signals were digitized at 250 Hz and recorded continuously together with triggers that marked stimulus onset and response.

Offline the continuous record was segmented into stimulus- and response-synchronized epochs of 1200 and 2300 ms duration, starting 200 and 1800 ms before the stimulus or response, respectively. The baseline was set between −200 and 0 ms for stimulus-synchronized epochs. The same baseline was used for response-synchronized epochs. The EEG-data were digitally band-pass filtered with low and high cutoff frequencies set to 0.01 and 8 Hz, respectively. Blink-contaminated trials were corrected by the method described by Elbert et al. (1985). All trials were discarded that contained incorrect responses, signal drifts of more than 120 μV within the recording epoch, or other EEG artifacts if blink correction was not possible. On average, 111 trials (SD = 28) per participant were discarded during artefact correction. In order to calculate ERPs, epochs were averaged according to the experimental conditions. ERPs were converted to an average reference montage disregarding the electrodes IO1, IO2, LO1 and, LO2.

The LRP was derived by calculating the difference between the ERPs contra- and ipsilateral to the responding hand at electrode sites C3′ and C4′ and averaged across hands (Coles, 1989). To assess possible influences of horizontal eye movements on the LRP, the lateralized horizontal EOG (LhEOG) was calculated at electrode sites LO1 and LO2 in the same way as the LRP. The calculation was applied to both stimulus- and response-synchronized epochs.

2.1.5. Data analysis

Statistical analyses of correct RTs and error rates were performed by means of repeated measures ANOVAs including the within-subject variables familiarity (familiar vs. unfamiliar faces), expressive intensity (weak versus strong), and facial expression (happiness versus disgust). All ANOVAs used Huyhn–Feldt corrected degrees of freedom. Bonferroni-corrected significance levels were applied to the multiple *t*-tests used for post hoc comparisons. As it was hypothesized that familiarity facilitates discrimination of facial expressions mainly when this process is slow, an additional analysis of the RTs was based upon a median split for each participant and condition. A repeated measures ANOVA was calculated including the factors RT-bin (fast versus slow trials), familiarity, intensity, and facial expression.

Experimental effects in LRP onsets were analyzed with a jackknifing-based method (Miller et al., 1998). Averages were calculated from n times n-1 participants. The LRP onset (derived at a fixed onset threshold of 0.6 μV) was derived from each new jackknifing-subsample. The data were submitted to a one-tailed *t*-test, corrected according to Miller et al. (1998), with the hypothesis to find an earlier onset of the LRP for familiar when compared to unfamiliar faces. In order to assess possible influences of lateralized eye movements on the LRP, mean amplitudes over an interval of 100 ms around the S-LRP and LRP-R onsets were derived for the LhEOG. Mean amplitudes were analyzed by means of ANOVAs including the experimental factors familiarity and expression. Peak amplitudes and latencies were derived from individual ERPs at the electrode sites P9 and P10 for the N170 component (maximum between 100 and 250 ms) and at Pz for the P300 component (maximum between 300 and 800 ms) where the respective components showed their maximum. Previous studies showed pronounced effects of facial expression (Schupp et al., 2004) and of familiarity (Schweinberger et al., 1995) on ERPs between 200 and 400 ms. Therefore, we also analyzed mean ERP amplitudes for consecutive intervals of 50 ms starting from 200 ms until 400 ms. We chose to measure mean amplitudes because peaks of the N250 in individual waveforms were hard to determine. Repeated measures ANOVAs were performed with factors familiarity, expression, and electrode (including a subset of 28 electrodes by omitting electrodes LO1, LO2, IO1, and IO2).

2.2. Results

2.2.1. Reaction times and error rates

Performance data are presented in Table 1. Responses were faster to portraits with strong ($M = 662$ ms) as compared to weak expressive intensity ($M = 72$ ms), $F(1,15) = 159.8$, $p < .01$. The factor intensity did not interact with other factors. Participants showed faster RTs on faces displaying disgust when compared to happiness ($M = 684$ ms versus 704 ms), $F(1,15) = 4.7$, $p < .05$. Most importantly, RTs were faster to familiar than to unfamiliar faces ($M = 687$ ms versus 698 ms), $F(1,15) = 9.9$, $p < .01$. This effect of familiarity interacted with facial expression, $F(1,15) = 5.2$, $p < .05$, being present only for portraits displaying happiness ($M = 694$ ms versus 714 ms), $t(15) = -3.77$, $p < .01$, but not for disgust (683 ms versus 685 ms).

For the additional analysis including the median-split RTs (factor RT-bin) the main effects of the other factors and their interactions are not reiterated because they did not differ from the previous analysis (see above). Interestingly,

Table 1
Reaction times and error rates for Experiment 1 (standard deviations in parentheses)

	RT (SD)		Error rate (SD)	
	Happiness	Disgust	Happiness	Disgust
Familiar	694 ms (103)	683 ms (83)	7.4% (3.9)	11.4% (4.9)
Unfamiliar	714 ms (111)	685 ms (94)	14.0% (5.3)	9.2% (4.6)

the factor RT-bin significantly modulated the effect of familiarity in the expression discrimination task, $F(1,15) = 12.5$, $p < .01$. A facilitation for familiar over unfamiliar faces was only present for trials with slow RT ($M = 801$ ms versus 817 ms), $F(1,15) = 11.8$, $p < .01$, but not for trials with fast RT ($M = 773$ ms versus 777 ms), $F(1,15) = 2.2$, $p > .10$. The advantage of disgust over happy expressions was also modulated by RT-bin, $F(1,15) = 5.2$, $p < .05$, as it was only present for slow RTs ($M = 797$ ms versus 821 ms), $F(1,15) = 5.8$, $p < .05$, but not for fast ones, $p > .10$.

Participants made fewer errors on portraits with familiar than unfamiliar faces ($M = 9.4\%$ versus 11.6%), $F(1,15) = 16.1$, $p < .01$, and for faces with strong as compared to weak expressive intensity ($M = 5.8\%$ versus 15.3%), $F(1,15) = 210.0$, $p < .01$. The effect of familiarity depended strongly on facial expression, $F(1,15) = 19.7$, $p < .01$, and on intensity, reflected in a three way interaction of familiarity, expression, and intensity: $F(1,15) = 15.5$, $p < .01$. For happy faces there were more correct responses for familiar than unfamiliar portraits ($M = 7.4\%$ versus 13.9%), $t(15) = -4.1$, $p < .01$, an effect that was independent of intensity. In contrast, for faces showing disgust participants made slightly fewer errors for unfamiliar than familiar faces, but only when expressive intensity was weak ($M = 13.2\%$ versus 17.5%), $t(15) = 3.4$, $p < .05$.

2.2.2. Event-related potentials

Fig. 1A shows the N170 at electrodes P9 and P10 being visible as a negative deviation after 170 ms. It is obvious that there were no differences either in peak latency or amplitude between the different conditions, $F\text{s} < 1$.

Analysis of the mean amplitude distribution between 200 and 400 ms (Fig. 1A and B) revealed significant interactions for electrode and expression, $F\text{s}(27,405) > 4.0$, $ps < .005$, as well as for electrode and familiarity, $F\text{s}(27,405) > 5.2$, $ps < .001$, in all time intervals. As can be seen in Fig. 1B there is increased negativity at posterior electrode sites for faces displaying disgust when compared to happy faces, as well as for familiar relative to unfamiliar faces.

The analysis of the P300 latency at the Pz electrode (Fig. 2) revealed a significant interaction of the factors familiarity and expression, $F(1,15) = 5.2$; $p < .05$. Post hoc comparisons revealed a trend for a shorter P300 latency for happy familiar than happy unfamiliar faces ($M = 557$ ms versus 584 ms), $t(15) = -1.9$, $p < .10$.

The P300 peak amplitude was increased for strong ($M = 10.8$ μV) relative to weak ($M = 9.6$ μV) expressiveness, $F(1,15) = 22.4$, $p < .01$. In addition, the amplitude was increased for familiar when compared to unfamiliar faces ($M = 10.4$ μV versus 9.8 μV), $F(1,15) = 5.9$, $p < .05$, as well as for portraits displaying disgust when compared to a smile ($M = 10.7$ μV versus 9.6 μV), $F(1,15) = 25.9$, $p < .01$. There was no interaction.

The onset of the S-LRP (Fig. 3, left panel) within the expression discrimination task started earlier for personally familiar portraits when compared to

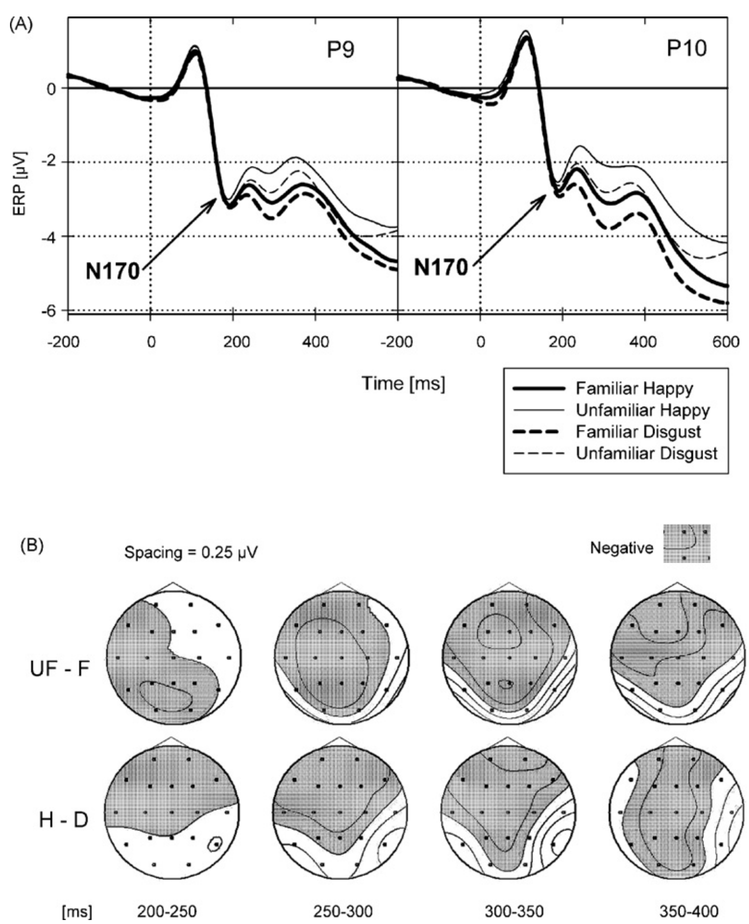

Fig. 1. The N170 component (panel A) at electrode sites P9 and P10 is presented for the expression discrimination task of Experiment 1, separated for familiarity and facial expression. Panel B shows scalp distributions of mean amplitude differences between conditions in four consecutive time intervals (UF = unfamiliar, F = familiar; H = happy, D = disgust). Note that at posterior sites there is increased negativity for familiar vs. unfamiliar faces (UF-F) as well as for faces displaying disgust vs. happiness (H–D).

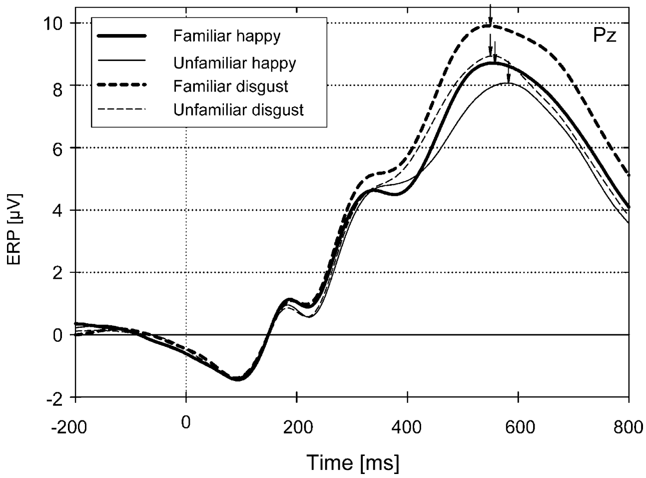

Fig. 2. The P300 component is presented at electrode site Pz for the expression discrimination task of Experiment 1, separated for familiarity and facial expression. The peak latencies of the P300 of the respective conditions are marked with small arrows. Note that the peak latency is slightly shorter for familiar faces displaying happiness when compared to unfamiliar happy faces.

unfamiliar ones (M = 412 ms versus 423 ms), $t_J(15) = 1.98$, $p < .05$; one-tailed. This difference was most prominent for portraits with happy expressions (M = 412 ms versus 431 ms), $t_J(15) = 1.78$, $p < .05$, one-tailed, whereas it was absent for faces showing disgust (M = 411 ms versus 415 ms), $t_J < 1$. No difference between conditions was present for the response-locked LRP (Fig. 3, right panel). An influence of the LhEOG on the S-LRP, and the LRP-R could be denied, $ps > .10$.

2.3. Discussion

In Experiment 1 the discrimination of facial expressions was faster for disgust than happiness. Importantly, the happiness recognition was facilitated by personal familiarity of the face. This facilitation was not specific for faces with weak expressive intensity as was initially hypothesized. However, a median split of RT indicated that it was more pronounced in trials with slow RT. The facilitation due to familiarity was reflected in ERPs as well. The interval between stimulus and LRP-onset – indicating the time until response selection – was shorter for personally familiar as compared to unfamiliar happy

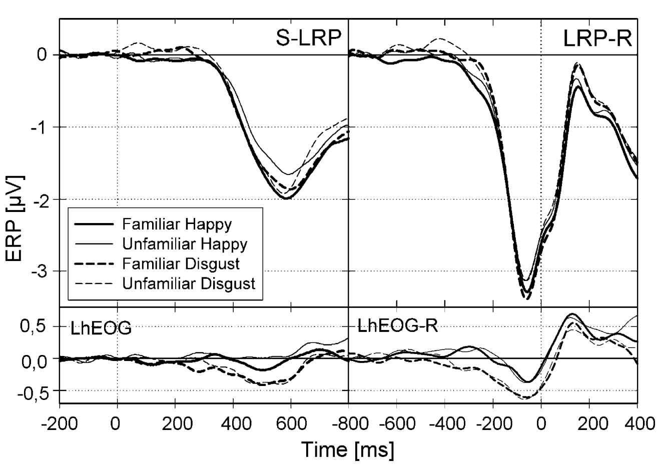

Fig. 3. Stimulus- (left side) and response-locked averages (right side) of the Lateralized Readiness Potential (LRP) are presented for the expression discrimination task of Experiment 1, separated for familiarity and facial expression. Note the earlier onset of the S-LRP for happy familiar when compared to happy unfamiliar faces. The corresponding lateralized horizontal EOGs (LhEOG) are presented below.

faces. The same facilitation was numerically even larger in the P300 peak latency. Statistically, however, it was only a trend. This may be due to the small overall effect in RT. In addition, the late peak of the P300 due to relatively high variability may have led to an increased variability of the elicitation point of the component, thus decreasing reliability of peak detection. In contrast, there was no indication of facilitation for perceptual processes – as indicated by the N170 component – and motoric processes – as indicated by the response locked LRP.

Together, the results of Experiment 1 suggest a moderate facilitative effect of personal familiarity on post-perceptual but premotoric stages of expression discrimination. In contrast, Baudouin et al. (2000b) claimed that the familiarity of a face increases fluency of perceptual processing and therefore improves the recognition of expressions. Also Schweinberger and Soukup (1998) proposed their observed interaction to act on a perceptual level. However, our results indicate that such a perceptual facilitation does not occur in early perceptual processing stages, as indexed by the N170 component (Caharel et al., 2005), because its latency was unaffected by facial familiarity (but see Caharel et al., 2006) and facial expressions. Instead, the present results point towards late perceptual stages – as indicated by the trend in P300 latency – or to response selection – indicated by the effect on the S-LRP onset – as possible loci of facilitation of the expression discrimination task for personally familiar faces.

A facilitation of expression categorization by facial familiarity was only observed for happy faces. It is possible that personally familiar faces with happy expressions possess a greater emotional valence and personal importance than unfamiliar faces (Herzmann et al., 2004). Emotionally valenced pictures enjoy faster processing than their neutral counterparts (Adolphs, 2002; Eimer and Holmes, 2002; Sato et al., 2001). During a passive viewing task, Cuthbert et al. (2000) found an earlier positive slow wave in the ERP starting at 200 ms after stimulus onset and an increased skin conductance response for pleasant pictures when compared to unpleasant or neutral pictures. It was suggested that these pictures show earlier and increased affective arousal. In addition, if the expression is displayed by a familiar rather than unfamiliar person, it may evoke an even increased affective arousal. Indeed, in Experiment 1 familiar faces showed an enhanced P300 (at the Pz electrode) which may reflect increased affective arousal to these faces.

An effect of arousal may be mediated by the amygdala which is important for connecting faces to an emotional response (Rolls, 1999) and for directing attention to emotionally valenced pictures (Vuilleumier et al., 2001). The amygdala seems to be activated by facial expressions not only of fear (Morris et al., 1998) but also of happiness (Whalen et al., 1998). Highly salient facial stimuli, such as personally familiar faces, may activate limbic structures and the amygdala (Breen et al., 2000). As regards the present results, increased arousal, and hence, amygdala activation is very likely for personally familiar faces displaying happiness. However, it is unlikely that the increased arousal to these faces modulated earlier perceptual stages because an effect of the N170 or the early posterior negativity is lacking. Especially happy familiar faces may be associated with more positive response options, hence, facilitating later stages, possibly the response selection stage. Nevertheless, with the present results we cannot clearly decide whether the locus of facilitation emerges already for expression discrimination (indexed by the P300) or for the response selection stage (indexed by the S-LRP).

Whereas expression classifications were faster for disgust than for happiness it was not modulated by facial familiarity. In the ERP data of Experiment 1 two main effects of emotional expression were visible. There was an increased posterior temporal negative deflection from 200 to 400 ms and an increased parietal P300 for faces displaying disgust when compared to happiness. These effects parallel results of Schupp et al. (2004) who found an increased early negativity at posterior electrodes as well as an increased parietal positivity for negative versus positive facial expressions. The authors suggested that this may reflect increased attention to potentially threatening stimuli; this may also hold for expressions of disgust as compared to happiness in our experiment. Indeed, independent of familiarity shorter RTs were found for faces displaying disgust. The reduced RTs may be related to the increased attention to these faces especially in an expression discrimination task.

Alternatively, disgust may be easier to recognize in general particularly in our stimulus set, hence, leading to faster responses. This is possibly due to the noticeable wrinkled nose region. In contrast, as all expressions were displayed with a closed mouth, the recognition of happiness was disproportionately harder and hence more benefiting from familiarity.

3. Experiment 2

In Experiment 2 the question was addressed whether an interaction between facial familiarity and facial expression would also hold true when familiarity is the task-relevant dimension. Based on the results of Experiment 1 which suggests an interaction between familiarity and facial expression in an expression discrimination task we hypothesized an interaction between both processes in a familiarity discrimination task. Participants performed a speeded familiarity discrimination task on portraits that displayed strong happiness, strong disgust, or a neutral expression. It was expected that the happy and neutral expressions that have been seen frequently in familiar faces would facilitate the familiarity decision. If, on the other hand, expressiveness or emotional arousal of a face is the crucial factor, facilitation should only be evident for familiar faces with both happiness and disgust but not for neutral familiar faces.

3.1. Method

3.1.1. Participants

The twenty participants (all women; mean age = 25.0 years; range: 20–34) of Experiment 2 were personally familiar with half of the presented persons displayed in the experiment. Participants received either course credits or a payment of 12 €. Their mean handedness score was 75 (ranging from −83 to +100; Oldfield, 1971).

3.1.2. Design and procedure

The same stimulus set was used as in the previous experiment with the exception that portraits with weak expressive intensity were omitted and portraits with neutral expression were added. This yielded a two by three factorial design: familiar and unfamiliar faces displaying neutral expressions, happiness, or disgust. In a two-choice reaction time task participants discriminated whether the presented face was familiar or not. Trials were presented in randomized order with the same trial scheme as in Experiment 1. Again, the 14 most familiar out of 16 potentially familiar persons and their unfamiliar matches were selected for each participant. The stimulus set (28 faces with three emotional expressions taken from three slightly different perspectives) was shown twice, totaling 504 trials. After half of all trials, the hand-to-key assignment was changed in order to calculate the LRPs. The order was counterbalanced across participants. Before the experimental blocks participants viewed all 28 persons, to be included in the stimulus set, with a neutral expression and made a verbal response about their familiarity. This was done to avoid errors, because persons in the stimulus set were displayed repeatedly. If a potentially familiar person was not recognized according to the picture it was replaced by another familiar person out of the pool of 16 familiar persons.

3.1.3. Electrophysiological recordings

The same electrode setup was used as in Experiment 1. Furthermore, electrophysiological data were treated in the same way as in the previous experiment and averaged according to the six experimental conditions (neutral expression, happiness, and disgust for familiar and unfamiliar faces, respectively). On average 22 trials (SD = 18) per participant were discarded during artefact correction.

3.1.4. Data analysis

For statistical analyses the same tests and procedures were used as in the previous experiments, with the exception that the within-subject factor expressive intensity was dropped and that the factor expression now involved three levels (happiness, disgust, neutral). All ERP analyses proceeded in the same way as in Experiment 1 (see above).

3.2. Results

3.2.1. Reaction time and error percentage

Performance data are presented in Table 2. Familiar portraits were classified faster than unfamiliar portraits (M = 559 ms versus 609 ms), $F(1,19) = 72.2$, $p < .01$. In addition, the expression of a portrait also affected RT, $F(2,38) = 4.8$, $p < .05$. Post hoc comparisons revealed a trend for RTs on portraits with neutral expressions being slightly faster when compared to the expression of disgust (M = 580 ms versus 590 ms), $t(19) = 2.4$, $p < .07$. Most importantly, there was an interaction of familiarity and expression, $F(2,38) = 5.1$, $p < .05$. The classification of a portrait as familiar was facilitated when the face displayed either a happy (M = 552 ms), $t(19) = -4.5$, $p < .01$, or a neutral expression (M = 556 ms), $t(19) = -3.1$, $p < .05$, when compared to disgust (M = 568 ms). No effect of expression was found for unfamiliar faces.

The mean error percentage of 3.9 was fairly low. There were no significant effects concerning factors familiarity or expression.

3.2.2. Event-related potentials

Fig. 4 (top) displays the N170 component of Experiment 2. There was no difference in peak latency between conditions, $F < 1$. The amplitude was larger at electrode P10 ($M = -6.1$ μV) than at P9 ($M = -4.2$ μV), $F(1,19) = 6.9$, $p < .05$. The mean amplitude for familiar faces was larger by 0.3 μV than to unfamiliar faces, $F(1,19) = 16.6$, $p < .01$. Furthermore, there were significant differences between expressions, $F(2,38) = 15.9$, $p < .01$; a smaller amplitude arose from faces with a neutral expression ($M = -4.8$ μV) when compared to faces expressing happiness ($M = -5.3$ μV), $t(19) = 4.8$, $p < .01$, or disgust ($M = -5.4$ μV), $t(19) = -4.3$, $p < .01$.

Analysis of the mean amplitudes between 200 and 400 ms revealed significant interactions for electrode and expression, Fs$(54,1026) > 5.5$, ps $< .001$, as well as for electrode and familiarity, Fs$(27,405) > 8.5$, ps $< .001$) in all four time intervals. As can be seen in Fig. 4 (bottom) there is increased negativity at posterior electrode sites for faces displaying disgust when compared to happy or neutral faces as well as for familiar when compared to unfamiliar faces.

For the P300 component (Fig. 5) there was a large difference in peak latency between familiar and unfamiliar faces (M = 535 ms versus 583 ms), $F(1,19) = 38.4$, $p < .01$. In addition, an increased P300 peak amplitude was found for familiar (M = 11.6 μV) when compared to unfamiliar faces (M = 8.7 μV), $F(1,19) = 50.6$, $p < .01$. Facial expression neither affected P300 latency as main effect, F = 1.8, or interaction, $F < 1$, nor P300 amplitude.

Fig. 6 displays the S-LRP and LRP-R averaged for familiar and unfamiliar faces and for the different expressions. The onset of the S-LRP to familiar faces was earlier for happy expressions (M = 329 ms) than for disgust (M = 362 ms), $t_J(19) = 1.75$, $p < .05$. No difference was found between expressions of unfamiliar faces, $t_J < 1$. There were no effects of facial expression in the interval between LRP-onset and response for familiar or unfamiliar faces. Neither for stimulus-, nor for response-locked averages did experimental conditions affect the LhEOG, ps $> .10$. Hence, an influence of horizontal eye movements on the LRP can be excluded.

3.3. Discussion

Experiment 2 addressed the question, whether emotional facial expressions modulate the recognition of personally familiar faces. Results revealed that in contrast to unfamiliar faces the recognition of familiar faces was modulated by facial expression; specifically, they were recognized faster with neutral and happy expressions than when displaying disgust. S-LRP onsets clearly point towards premotoric stages as functional loci of the processing facilitation for happy and neutral familiar faces relative to disgust. Considering that there was not even a trend for an influence of expression on the P300 latency here, one might even more specifically suggest the response selection stage as a major locus for the interaction between familiarity and emotional expression.

Results of Experiment 2 revealed differences in RTs between happy or neutral when compared to disgust-expressing familiar faces. Hence, an emotional expression per se does not induce facilitation. Unfortunately, an interpretation

Table 2
Reaction times and error rates for Experiment 2 (standard deviations in parentheses)

	RT (SD)		Error rate (SD)	
	Familiar	Unfamiliar	Familiar	Unfamiliar
Happiness	552 ms (61)	612 ms (62)	3.5% (2.5)	3.8% (3.3)
Disgust	568 ms (68)	611 ms (64)	4.6% (3.0)	4.2% (3.7)
Neutral	557 ms (68)	603 ms (63)	3.8% (2.4)	3.8% (3.2)

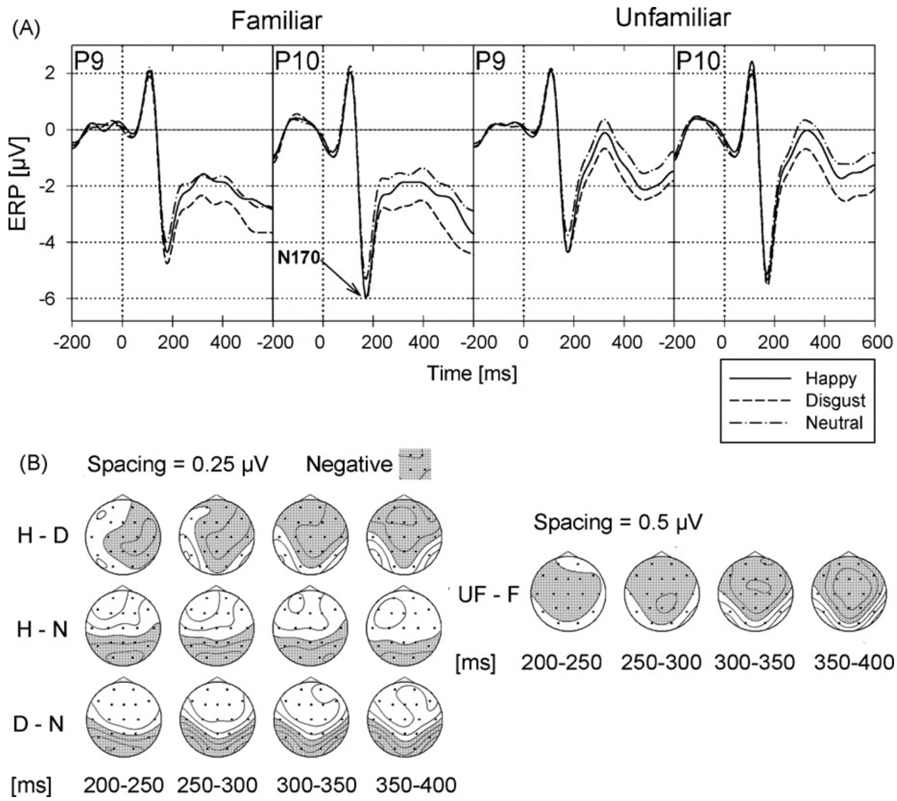

Fig. 4. The N170 component (top panel A) at electrode sites P9 and P10 is presented for the familiarity discrimination task of Experiment 2, separated for facial expression and familiarity. Mean amplitude differences between expressions (left panel B) and between familiarity conditions (right panel B) in four consecutive time intervals are plotted in the bottom panel B (H = happy, D = disgust, N = neutral, UF = unfamiliar, F = familiar). Note that at posterior sites there is increased negativity for faces displaying disgust vs. happy or neutral expressions (H–D, D–N) as well as for familiar vs. unfamiliar faces (UF-F).

based on the trials with neutral expressions has to be taken with some caution because these faces had been pre-exposed prior to the experiment which might have induced a priming effect (Begleiter et al., 1995). Although unfamiliar faces had also been pre-exposed and facilitation for the neutral expression should have emerged for these faces, too, priming effects have been reported to be smaller for unfamiliar than for familiar faces (Jemel et al., 2003; Schweinberger et al., 1995). Hence, the pre-exposure of the neutral faces might have primed the neutral familiar faces more than the neutral unfamiliar faces. Therefore, in the following we will only refer to the expressions of happiness and disgust.

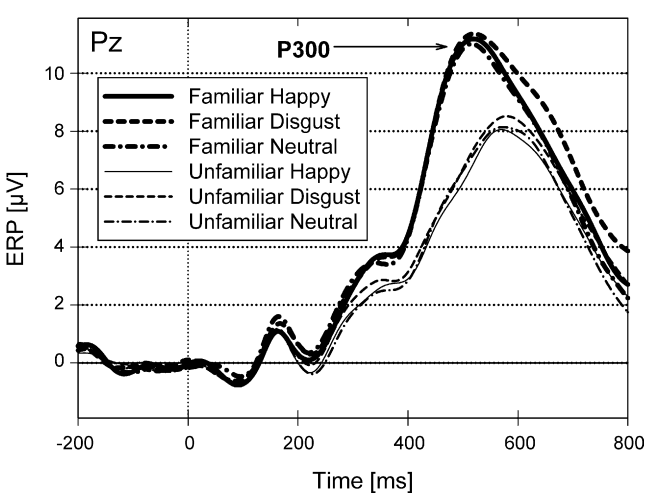

Fig. 5. The P300 component at the electrode site Pz is presented for the familiarity discrimination task of Experiment 2, separated for facial expressions and familiarity.

A smile is the most common facial expression when someone familiar approaches us. Hence, it may not be surprising to find facilitated responses especially for familiar faces displaying happiness. This effect may not represent a ‘‘smiling bias’’, that is, increased familiarity ratings for happy faces. Such an effect has been found by Baudouin et al. (2000b) for smiling familiar and unfamiliar faces. These authors suggested the decision (i.e. response selection) stage as the level of interaction between familiarity and emotional (smiling) expression. Although the response selection stage seems to be facilitated for our happy familiar faces, no such effect was present for unfamiliar faces. A possible explanation for this discrepancy might relate to the current use of highly familiar faces that were easy to recognize. In Baudouins experiments the easy conditions also did not yield a smiling bias. In addition, in the present experiment we used a familiarity discrimination rather than a rating task. This may have resulted in the reliance primarily on internal facial features for familiar faces, and on external features for unfamiliar faces (Young et al., 1985). Hence, a smiling bias may not be expected for unfamiliar faces especially when participants are to respond quickly.

The specific effect of happiness relative to disgust for familiar faces may relate to the action program related to these particular expressions. A smile on a face encountered very often calls for some kind of action on the viewers part, because it signals that the person is familiar, holds a friendly attitude towards the viewer, is about to say hello etc. In all these cases it is of social importance to be ready for action. In contrast, the display of disgust rarely calls for immediate action. Disgust is usually displayed when a person is confronted with or has consumed something unpleasant; however, disgust alone does not signal any immediately imminent danger for the viewer unless combined with expressions of threat of fear. Therefore, it is plausible that the perception of disgust does not intrude task-related processes of the observer especially in the context of a familiarity discrimination task. In contrast, the perception of happiness on a familiar face may boost the action system especially when familiarity is the task relevant dimension. This does not necessarily contradict the faster RTs for

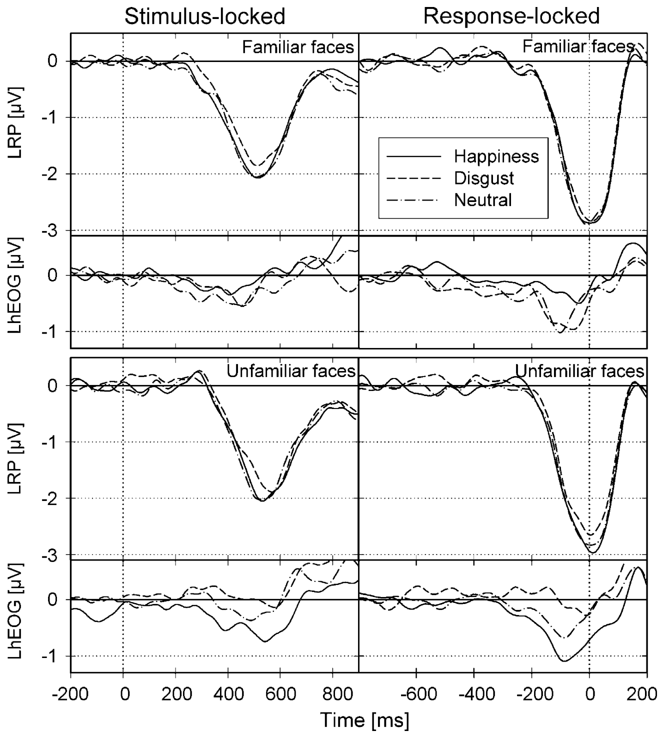

Fig. 6. Stimulus- (left side) and response-locked averages (right side) of the Lateralized Readiness Potential (LRP) are presented for the familiarity discrimination task of Experiment 2, separated for facial expressions, and familiarity (top vs. bottom panel). The corresponding lateralized horizontal EOGs (LhEOG) are presented below.

disgust relative to happiness in the first experiment because task instructions, and the relevant dimension were different.

Somewhat unexpectedly we found increased N170 amplitudes for familiar when compared to unfamiliar faces. Increased N170 amplitudes for familiar faces have been shown previously in at least one study and were interpreted as being due to top-down influences of memory representations on structural encoding (Caharel et al., 2006). In contrast, several reports did not find a sensitivity of the N170 amplitude to familiarity (Eimer, 2000b; Schweinberger et al., 2002a,b). However, in contrast to Caharel et al. and the present study these studies used famous faces but not personally familiar ones. Personal familiarity might influence the subjective importance of the faces (Herzmann et al., 2004) as well as the strength of representations in memory, thus possibly affecting the N170.

Alternatively, our increased N170 for familiar faces may be due to an overlap with the subsequent posterior negativity (see Fig. 6, bottom), which may represent an N250r-like component as observed by Schweinberger et al. (1995) in the context of repetition priming. This component is larger for familiar than unfamiliar faces and is suggested to reflect the stimulus-triggered access to stored facial representations. Because all faces had been repeatedly shown in the present experiment it is conceivable that priming effects have built up that were more pronounced for the familiar than for the unfamiliar faces (Schweinberger et al., 1995) and which overlapped with the N170 component.

The additional increase of the N170 amplitude for expressive relative to neutral familiar faces may relate to a more intense structural encoding process due to the emotional expression or because of emotional responses of the viewers. Early effects of expression on N170 have been reported before (Caharel et al., 2005; Pizzagalli et al., 2000). In addition, it has been shown that the fusiform face area is sensitive to variations in expression, even if attention is directed towards identity (Ganel et al., 2005). However, the increased N170 for expressive relative to neutral faces may be also explained by an overlap of the subsequent posterior negativity, which was also increased for expressive when compared to neutral faces in the time intervals from 200 to 400 ms (see also discussion of Experiment 1 and Schupp et al., 2004).

4. General discussion

Following up on recent evidence that questions the traditional view of independence between the recognition of facial expression and facial familiarity (Bruce and Young, 1986), the present article investigated the interaction of these processes (Baudouin et al., 2000b; Endo et al., 1992; Schweinberger and Soukup, 1998). By means of performance data and ERPs we tried to elucidate the functional processing stage which might be responsible for such an interaction. Participants performed two-choice reaction time tasks, discriminating either facial expressions (Experiment 1) or facial familiarity (Experiment 2), while variations of the other dimension (familiarity or expression, respectively) were irrelevant for the task.

At variance with the functional model of face recognition by Bruce and Young (1986) and several other reports (Bobes et al., 2000; Young et al., 1986) we found interactions between the recognition of facial expressions and facial familiarity in both directions. The discrimination of facial expression or of familiarity was facilitated especially for personally familiar faces displaying happiness but not for unfamiliar faces or for disgust. These findings extend previous studies, which had found only asymmetrical interactions between facial identity/familiarity and the discrimination of facial expressions (Baudouin et al., 2002; Endo et al., 1992; Schweinberger and Soukup, 1998) in two important ways. First, it demonstrates that it is possible to find symmetrical interactions at least under some circumstances (see also Ganel and Goshen-Gottstein, 2004). Second, by employing ERP measures we pinpointed the functional locus of this interaction within the information processing stream.

In the present study faces had been familiar through long-standing personal encounter. Being the academic teachers of the participants the portrayed persons likely bore high personal importance. Therefore, they might have induced higher arousal than the unfamiliar persons. This is supported by results of Herzmann et al. (2004), showing increased SCR amplitudes to portraits of personally familiar teaching staff members relative to publicly famous and unfamiliar faces. Brain regions which are involved in face recognition can be modulated by affective and socially relevant information (Hariri et al., 2001; Morris et al., 1998; Pizzagalli et al., 2002). Although in the present study, all faces were displayed with the same facial expressions, our findings suggest that the impact of the emotional expression on the observer depends on the person displaying the emotion. This may already be true for famous versus unfamiliar faces. For example, Gallegos and Tranel (2005) found faster naming times for familiar famous faces with a happy as compared to neutral expressions. The authors concluded that the facilitation may be modulated via an influence of the amygdala on extrastriate cortex. It is plausible to assume that happiness expressions in personally familiar persons may further increase the level of arousal. Hence it is not surprising that an interaction between facial familiarity and facial expressions was specifically observed for personally familiar faces displaying happiness. In addition, the suggestion by Gallegos and Tranel

(2005) that expression-dependent facilitation may be mediated by the amygdala, could also explain the absence of a facilitation for familiar faces displaying disgust. Processing disgust expressions appears to be mediated by a different neuronal network not involving the amygdala (Sprengelmeyer et al., 2003).

As mentioned above, for the recognition of unfamiliar faces external facial features are more important than internal features while internal facial features gain importance with increasing familiarity (Young et al., 1985). Results of Goshen-Gottstein and Ganel (2000) from a priming task suggest that the reliance on internal features is important for an interaction to emerge between facial identity and the discrimination of gender. Priming was only observed for faces with external features removed but not for whole faces including hair and hairline. Accordingly, the symmetrical interaction for personally familiar faces observed in the present experiments might have emerged because for these faces it may be more difficult to maintain selective attention to facial familiarity or to facial expression. This does not necessarily hold true for unfamiliar faces because here, internal facial features are less important.

The differential importance of internal and external features for unfamiliar and familiar faces may also explain why the data suggest different loci for the facilitative interaction between facial familiarity and facial expression. In the expression discrimination task (Experiment 1) a slightly earlier peak for the P300 in combination with earlier stimulus-locked LRP onsets suggests that expression classification processes are facilitated for familiar faces displaying happiness. In Experiment 2 the onsets of the stimulus-locked LRPs were modulated by happy facial expressions in the absence of P300-latency effects; this clearly points towards the response selection stage as being facilitated by happy expressions in familiar faces. Possibly the importance of a few specific internal facial features in the expression discrimination task (presumably mouth and eyes) may strongly and more or less permanently direct attention onto those features that are also of particular relevance for face identification. Therefore, in this task face identity may kick in earlier in the information processing chain and interact with facial expression. In contrast, in the familiarity discrimination task attention may be more distributed across facial features and may focus towards internal features only when the face encountered is indeed familiar (Young et al., 1985). Hence, processing of those features which may subserve an interaction between identity and emotional expression may take longer and the facilitation might affect a later stage, that is, response selection.

We conclude that, contrary to the influential functional model of face recognition by Bruce and Young (1986), results of the present article showed that an interaction between facial familiarity and facial expression is observable for personally familiar faces. Event-related potentials pointed to late perceptual processing and response selection to be facilitated by familiarity for expression discrimination and by facial expression for familiarity discrimination tasks, respectively. It was argued that the affective response to personally familiar faces could be the basis of an interaction for both processes. In addition, the kind of facial expression and the heightened importance of internal features for familiar faces might also be relevant for an interaction to emerge. Future research and models of face recognition should take into account the degree of familiarity as well as processing differences between different facial expressions.

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