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An event-related potential study on the early processing of crying faces

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Crying is an attachment behavior, which in course of evolution had survival value. This study examined the characteristics of the face-sensitive N170, and focused on whether crying expressions evoked different early event-related potential waveforms than other facial expressions. Twenty-five participants viewed photographs of six facial expressions, including crying, and performed an implicit processing task. All stimuli evoked the N170, but the facial expression modulated this component in terms of latency and

amplitude to some extent. The event-related potential correlates for crying faces differed mostly from those for neutral and fear faces. The results suggest that facial expressions are processed automatically and rapidly. The strong behavioral and emotional responses to crying appear not to be reflected in the early brain processes of face recognition. *NeuroReport* 18:631–634 © 2007 Lippincott Williams & Wilkins.

Keywords: crying, event-related potentials, emotional processing, face perception, N170

Introduction

Facial expressions are important communicative signals in everyday social interactions. The recognition of emotional expressions is one of the most relevant communication skills in humans. Information about emotional states should be processed rapidly and accurately to be available for the online regulation of social behavior [1]. It is thus reasonable to assume that specific brain processes have developed to facilitate the quick recognition of facial expressions.

Until present, the temporal aspects of the processing of facial expressions have been examined in several electrophysiological studies. In accordance with the notion that the facial configuration and emotional facial expression are processed independently and by different brain structures [2,3], most studies on event-related potentials (ERP) found that the type of facial expression did not influence the face-sensitive N170 or vertex positive potential (VPP) (e.g. [4–8]). ERP modulations sensitive to the nature of the expressed emotion on the face, however, have been found as early as 90 ms post-stimulus [9]. More importantly, three studies did find emotion-modulation effects on the N170 [9–11]. It, therefore, remains to be established whether the face-sensitive N170 and vertex positive potential (VPP) are completely unaffected by emotional expressions.

An important shortcoming of the previous studies is that they exclusively focused upon the processing of expressions of a limited number of so-called basic emotions. For one, crying expressions have almost never been included in ERP studies on face processing. This is remarkable as crying is a very important attachment behavior with clear evolutionary significance [12,13]. It is an inborn behavior that functions to call for and assure the protective and nurturing presence of

caregivers [12,14] and continues to be an attachment behavior throughout life [12]. Crying is hard to ignore and its main function may be to beckon others to help remove a given source of discomfort, to elicit attention, empathy and support, and to facilitate social bonding [15,16].

Previous research has revealed that crying elicits strong emotional reactions, such as empathy [18], and strong behavioral reactions, such as emotional support [17,18], in other people. In addition, crying promotes caregiving responses and strengthens social bonds. An interesting question is whether a forerunner for these behavioral responses can be found in the early processing of facial expressions by the human brain. So far, only one study has shown that the VPP did not vary in reaction to neutral adult faces, crying adult faces and neutral faces of babies [19]. Unfortunately, this study did not compare the ERP correlates evoked by crying faces with those evoked by other emotional expressions. By measuring ERPs in reaction to different facial expressions, we aimed to investigate whether facial expressions modulate the N170, and, more importantly, whether the N170 evoked by crying expressions differs from that evoked by other facial expressions.

Method

Participants

Twenty-six first-year psychology students, who received course credit for participation, took part in the study (18–24 years, mean 19.7 years). Data of one person had to be excluded due to malfunction of one of the electrooculograph (EOG) electrodes. All participants had normal or corrected-to-normal vision and one person was left-handed.

Stimuli and procedure

Color photographs were presented of four men and four women posing the following facial expressions: neutral, crying (tears were elicited with eye drops), anger, fear and laughing. The posers were simply instructed to look, for instance, as if they were crying. The so-called noncrying faces were produced by digitally removing the tears of the crying faces. The photographs were selected from a larger set of photographs on the basis of the high recognition rate in a previous study. This resulted in 48 photographs, which were displayed on a computer screen at 12.3 in. (31.3 cm) wide and 8.3 in. (21.0 cm) tall with a resolution of 72 pixels/inch (28.3 pixels/cm). Between stimuli, a white fixation point was presented on the center of the screen.

Participants were seated in a soundproof cabin with the computer screen at a viewing distance of 110 cm. The experiment consisted of a delayed-response task. Participants had to indicate with a left-hand or right-hand button press whether the person on the photograph was a man or a woman (sex discrimination). The hand participants used to indicate whether the person on the photograph was a man or a woman was counterbalanced across participants. We chose for an implicit processing task to ensure that possible differences in ERP correlates during the sex-discrimination task were not because of directed attention [20].

During both tasks, all photographs were repeated eight times, resulting in 384 trials. Trials were randomly presented with the restriction of immediate stimulus repetitions. On each trial, the stimulus was presented for 500 ms. A delayed response was given to lower the risk of the ERPs being contaminated by motor activity; 1000 ms after stimulus onset a response panel appeared on the screen for 1000 ms, indicating that the participant should give his/her response. The interval between two successive stimulus presentations varied randomly between 2000 and 3000 ms in steps of 200 ms. Before the

task, the participant was familiarized with the procedure in six training trials during which the participants rated photographs that were not included in the main task.

After completing the task, participants were asked to identify the emotion that the person on the photo expressed by choosing one of the following options: neutral, angry, astonished, happy, aversion, sad, bored, fearful or other.

Event-related potential recording and analysis

Electroencephalographic recordings (EEG) were made on 49 locations using active Ag–AgCl electrodes (Biosemi Active-Two, Amsterdam, Netherlands) mounted in an elastic cap. Horizontal EOGs were recorded from two electrodes placed at the outer canthi of both eyes. Vertical EOGs were recorded from electrodes on the infraorbital and supraorbital regions of the left eye placed in line with the pupil. The EEG and EOG signals were sampled at a rate of 256 Hz, and offline rereferenced to an averaged reference. The EEG recordings were band-pass-filtered (0.16–30 Hz, 24 dB/octave) and segmented into epochs of 1100 ms, including a 100 ms prestimulus baseline for each type of facial expression separately. After EOG correction, for each electrode, segments with an amplitude change exceeding 100 μ V were automatically rejected. Next, the EEG was averaged relative to the 100 ms baseline preceding stimulus onset. Separate averages were computed for each type of facial expression.

Results

All 25 participants performed the sex-discrimination task with a high level of accuracy. The average percentage of correctly classified stimuli varied between 99.3% for fear expressions and 99.8% for crying expressions. Afterwards, participants identified the emotion expressed. The recognition rate varied from 32.2% for fear faces to 99.5% for happy faces. A binomial

Fig. 1 Topographical distribution of the NI70.

test per facial expression revealed that participants selected the predicted emotion term at rates greater than chance (25%), all $P < 0.05$. The recognition rates determined were comparable with rates reported by Ekman [21].

As can be seen in Fig. 1, the N170 was most prominent at the electrode sites P7 and P8. We therefore decided only to analyze the results at these two electrode positions. Figure 2 shows the N170 at P7 and P8 elicited by the different facial expressions. The mean latencies and amplitudes of the N170 are given in Table 1.

The N170 latency varied with type of facial expression at P7 [$F(5,20) = 2.98$, $P < 0.05$]. The latency for fear expressions was shorter than the latency for crying expressions [$F(1,24) = 5.75$, $P < 0.05$] and the latency for anger expressions [$F(1,24) = 5.09$, $P < 0.05$]. At P8 site, type of facial expression did not significantly influence the N170 latency [$F(5,20) = 1.26$, $P = 0.32$]. Type of facial expression also did not modulate the N170 amplitude at P7 or P8 [$F(5,20) < 1.57$, $P > 0.20$]. In short, facial expression only modulated the N170 latency in the left occipitotemporal area, in which crying faces were processed more slowly than fear expressions. (We also looked into possible interactions between type of facial expression and electrode position. This interaction was never significant. $F(5,20) = 0.60$, $P = 0.70$, for N170 latency, $F(5,20) = 0.11$, $P = 0.99$, for N170 amplitude

and $F(5,20) = 0.93$, $P = 0.48$, for amplitude difference between P1 and N170).

To ensure that the effects observed are not a carryover effect from task differences observed at the earlier P1, we conducted a second set of analyses using the peak amplitude difference between P1 and N170 (e.g. [22]). The

Table 1 Mean amplitudes and latencies (SD) of N170 and N170–P1

	N170		N170–P1
	Latency	Amplitude	Amplitude
Electrode P7			
Neutral	164.38 (15.17)	–4.23 (3.01)	–6.86 (2.96)
Crying	165.94 (17.36)	–4.80 (2.81)	–7.75 (2.88)
Noncrying	164.38 (15.78)	–4.58 (2.81)	–7.72 (3.03)
Anger	168.13 (16.67)	–4.49 (2.71)	–7.25 (2.95)
Fear	161.88 (16.77)	–4.74 (2.76)	–6.94 (2.73)
Laughing	168.44 (17.04)	–4.82 (2.94)	–7.47 (2.90)
Electrode P8			
Neutral	163.44 (13.61)	–4.99 (3.77)	–10.25 (4.51)
Crying	164.84 (17.18)	–5.24 (4.05)	–11.17 (4.61)
Noncrying	166.72 (15.37)	–5.21 (3.96)	–10.92 (4.31)
Anger	167.19 (12.51)	–4.99 (4.30)	–10.62 (4.56)
Fear	162.50 (19.53)	–5.35 (4.01)	–10.76 (4.46)
Laughing	165.78 (11.50)	–5.53 (3.65)	–11.44 (4.75)

Fig. 2 Grand-averaged event related potential as function of type of facial expression (1, neutral; 2, crying; 3, noncrying; 4, angry; 5, fearful and 6, happy faces).

peak amplitude difference varied with type of facial expression at electrode positions P7 and P8 [$F(5,20) = 2.78$, $P < 0.05$ and $F(5,20) = 4.06$, $P < 0.05$]. At P7, the amplitude difference was greater for crying faces than for neutral faces [$F(1,24) = 7.42$, $P < 0.05$] and fear faces [$F(1,24) = 8.67$, $P < 0.01$]. Non-crying faces evoked a more negative N170 than neutral faces [$F(1,24) = 7.14$, $P < 0.05$] and fear faces [$F(1,24) = 9.02$, $P < 0.01$]. The amplitude difference was greater for laughing expressions than for fear expressions [$F(1,24) = 5.85$, $P < 0.05$]. At P8, neutral expressions evoked a less negative N170 than crying expressions [$F(1,24) = 8.52$, $P < 0.01$] and laughing expressions [$F(1,24) = 13.88$, $P < 0.01$]. In sum, facial expression influenced the peak amplitude difference in both occipitotemporal areas. Crying faces elicited a more negative N170 than neutral faces in both left and right occipitotemporal areas, and a more negative N170 than fearful faces in the left occipitotemporal area.

Discussion

In this study, we examined the face-sensitive N170 evoked during the implicit processing of different facial expressions. The major aim was to extend previous ERP findings by including crying faces. From an evolutionary point of view, crying appears to be an important and compelling communicative signal with survival value.

As expected, all face stimuli elicited the N170. In contrast to most previous studies (e.g. [4,5,7,8]), however, the latency and amplitude of the N170 were somewhat modulated by the emotional expression of the face. This suggests that the structural encoding of faces and the processing of emotional expression are not totally independent processes as assumed previously [2,3]. A possible explanation for the discrepancy between the various ERP studies is that the strength of habituation differed considerably. The repeated exposure to the same emotional expression may result in the gradual habituation of emotion-specific responses [5]. Most previous studies used the widely used and known set of facial expressions compiled by Ekman and Friesen [23] and most of them compared the ERP correlates evoked by neutral expressions only with those evoked by one or two basic emotions. This might have concealed possible differences in ERP correlates in response to different facial expressions. In contrast, the three studies that found emotional effects on the N170 [9–11] and this study all used a locally developed set of photographs and/or had participants view a broader range of facial expressions in one and the same task.

Although the N170 was modulated by the facial expression, the post-hoc comparisons failed to reveal any systematic differences between the ERP correlates evoked by the different facial expressions. The ERP correlates for crying faces mostly differed from those for neutral and fear faces, and more differences were found at the left occipitotemporal area (e.g. [11]). The processing of the facial expression seems to start as early as 170 ms after presentation, but crying expressions at this point do not elicit fundamentally different brain processes than expressions of basic emotions. This suggests that the strong emotional and behavioral responses to crying are not reflected in the early brain processes of face recognition.

Conclusion

This data support a model of automatic and rapid processing of emotional expressions. The N170 apparently

reflects not only the global processing of face stimuli but also the early processing of the facial expression. In contrast to behavioral results [17,18], however, crying expressions do not appear to elicit fundamentally different brain processes than other emotional expressions at this early stage.

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