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Shaping internal working models : parental love withdrawal, oxytocin, and asymmetric frontal brain activity affect socio-emotional information processing

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2 | Love withdrawal is related to heightened processing of faces with emotional expressions and incongruent emotional feedback: Evidence from ERPs

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Abstract

Parental use of love withdrawal is thought to affect children's later psychological functioning because it creates a link between children's performance and relational consequences. To investigate whether love withdrawal is also associated with the underlying level of basic information processing in the brain, we studied event-related potentials to feedback stimuli that combined performance feedback with emotional facial expressions. We focused on the VPP (face processing) and N400 (incongruence processing). More maternal use of love withdrawal was related to more positive VPP amplitudes, larger effects of the emotional facial expression on VPP amplitude, and more negative N400 responses to incongruent combinations of feedback and facial expressions. Our findings suggest a heightened processing of faces with emotional expressions and greater sensitivity to incongruence between feedback and facial expression in individuals who experienced more love withdrawal.

Introduction

Love withdrawal is a disciplinary strategy that involves withholding love and affection when a child misbehaves or fails at a task. When used excessively, it is considered psychological maltreatment (Euser, Van IJzendoorn, Prinzie, & Bakermans-Kranenburg, 2010). By using love withdrawal the parent communicates to the child that his or her love and affection for the child are conditional upon the child's compliance and success. The formation of this link between compliance or performance on the one hand and relational consequences on the other is thought to underlie both the effectiveness and emotional costs of love withdrawal (Assor, Roth, & Deci, 2004; Elliot & Thrash, 2004). Parental, and in particular maternal, use of love withdrawal has been associated with low self-esteem, low emotional well-being, feelings of resentment toward the parents, and fear of failure in adolescence and young adulthood (Assor et al., 2004; Elliot & Thrash, 2004; Goldstein & Heaven, 2000; Renk, McKinney, Klein, & Oliveros,

2006; Soenens, Vansteenkiste, Luyten, Duriez, & Goossens, 2005b). It remains unclear, however, whether the use of love withdrawal also affects the deeper level of information processing in the brain. It remains to be studied whether the association of compliance and performance with relational consequences, formed through the experience of parental love withdrawal, affects the perception and processing of information relevant to this association. As a first step toward filling this gap we present a study on event-related potentials to one type of information that is especially relevant to this association, emotional facial expressions accompanying feedback.

Because parental use of love withdrawal is thought to affect psychological functioning through the establishment of a link between performance and compliance on the one hand and relational consequences, including intense emotional expressions, on the other, emotional information and expressions within the context of performance situations may be more relevant for, more attended by, and processed to a larger extent by persons who have experienced high levels of maternal love withdrawal compared to those who have experienced less love withdrawal. This would increase the amplitude of a component of the event-related potential (ERP) called the Vertex Positive Potential (VPP).

The VPP is a positive deflection in the ERP that peaks at frontocentral electrode sites, roughly between 140 and 180 ms after stimulus onset. Evidence suggests that the VPP and N170, a negative going occipito-temporal right hemisphere dominant component, represent two sides of the same generator dipoles in occipito-temporal cortex (Joyce & Rossion, 2005). Both components have been associated with the configural processing of faces, with larger amplitudes indicating more extensive processing, and show larger amplitudes in response to emotional compared to neutral expressions (Luo, Feng, He, Wang, & Luo, 2010). VPP and N170 are often found to be sensitive to intensity, but not valence of emotional expressions (Luo et al., 2010; Sprengelmeyer & Jentzsch, 2006), although larger amplitudes in response to negative (often fearful) compared to positive (often happy) expressions have been observed in some studies (Ashley, Vuilleumier, & Swick, 2004; Krombholz, Schaefer, & Boucsein, 2007; Williams, Palmer, Liddell, Song, & Gordon, 2006).

In addition to heightening the processing of facial expressions in performance situations, parental use of love withdrawal may also affect the processing of incongruence between performance feedback and emotional expressions. Because a link between performance and relational consequences is established through the experience of love withdrawal, the violation of this link may become an especially salient and unexpected event. Such a violation occurs when performance feedback is presented with an emotional expression that does not match the feedback (e.g., presenting positive feedback with a disgusted facial expression). One component of the event-related potential (ERP) that is particularly sensitive to incongruence (mismatch) is the N400. The N400 is a negative-going ERP component that peaks at parietal electrode sites, around 400 ms after the presentation of a stimulus that is incongruent with its context (e.g., the word 'knife' at the end of the sentence 'soup is eaten with a ...'). The N400 is sensitive to the amount or salience of this discrepancy (Caldera, Jermann, Lopez Arango, & Van der Linden, 2004).

Neural generators of the N400 effect may vary according to the demands of the task at hand, and include a network of areas involved in the processing of learned associations, including the anterior temporal lobes, superior temporal sulcus, parahippocampal gyri, superior parietal regions, inferior frontal gyrus, and insular regions (Frühholz, Fehr, & Herrmann, 2009; Silva-Pereyra et al., 2003). The N400 is typically studied in the context of language processing, but has also been observed following facial stimuli, often lateralized toward the right when emotional expressions are involved (Bobes, Martín, Olivares, & Valdés-Sosa, 2000; Caldera et al., 2004; Frühholz et al., 2009; Münte et al., 1998). Because incongruence between feedback and emotional expression violates the performance-relational consequence link, we expect this incongruence to be more salient and therefore N400 responses to be larger for persons who have experienced high maternal love withdrawal than for those who have experienced less maternal love withdrawal.

Some support for the idea that love withdrawal may be related to the processing of facial expressions and performance feedback comes from a recent study in which one characteristic associated with love withdrawal, fear of failure, has been associated with the amplitudes of the N400 and VPP (Tops & Wijers, 2011). The participants in this study performed a flanker task, in which a picture of a happy or disgusted face was presented after every response. The pictures were presented in green after a correct response and in red after an error. Tops and Wijers (2011) found that the amplitude of the N400 to incongruent feedback stimuli (disgusted faces in green and happy faces in red) increased when participants reported higher levels of fear of failure. Also, when higher levels of fear of failure were reported the amplitude of the VPP in response to disgusted facial expressions was larger compared to VPP amplitude in response to happy expressions.

In the present study, we investigate the relations between maternal use of love withdrawal and the VPP and N400 using a similar design. Because it is particularly the use of love withdrawal by mothers with their daughters that has been linked to unfavorable outcomes in adolescence and young adulthood (e.g., Elliot & Thrash, 2004; Renk et al., 2006), we focus on maternal use of love withdrawal in females. We expect higher maternal use of love withdrawal to be related to larger N400 and VPP amplitudes. To evaluate the unique contribution of love withdrawal, we controlled for fear of failure in our analyses. In this manner, we aim to add to previous findings by investigating how parenting practices contribute to information processing biases.

Method

Participants

Data were acquired from 27 participants who participated in a larger study that additionally focused on the role of oxytocin. Data for the current study were derived from the placebo condition. All participants were female undergraduate students, aged 18-30 years ($M = 20.59$, $SD = 3.08$), and were paid 50 Euros for participation. Exclusion criteria included colorblindness, smoking, alcohol and drug abuse, neurological and psychiatric disorders, pregnancy, breastfeeding, and use of medication (except oral contraceptives). The study was approved by the ethics committee of the Leiden University Medical Center.

Procedure

Participants completed questionnaires on maternal use of love withdrawal and fear of failure during an introductory course in child and family studies. The questionnaires were administered to 391 18-30 year old women who were willing to participate in an EEG experiment. Within this sample of 391 students, the distribution of scores on the love withdrawal questionnaire was skewed toward the right, indicating that in this pool of students high maternal love withdrawal is (relatively) underrepresented. To ensure an acceptable coverage of the full range of scores on the love withdrawal questionnaire within the sample of students taking part in the EEG experiment, participants for this experiment were selected stratified from the pool of 391 students: Half of the participants were selected randomly from the group scoring in the upper quartile of the questionnaire ($n = 13$ for the current sample), and half of the participants were selected randomly from the group scoring in the other three quartiles ($n = 14$ for the current sample). They were asked to come to our laboratory for two experimental sessions, separated by approximately four weeks.

Informed consent was obtained at the beginning of the first session. Concerning the administration of oxytocin, participants were told that they would receive oxytocin during one session and a placebo during the other, but that the order was not known even to the experimenter. This message was repeated at the beginning of the second session. When participants were asked, at the end of the second session, which substance they thought they had taken during that session their guesses were not significantly better than chance ($p > .05$). Participants were not informed about the effects of oxytocin under investigation, only about the possible side effects they might experience (which was required by the ethics committee). We therefore believe that influences of the procedure of nasal spray administration on overall performance, if any, have been negligible.

At the start of each session, a saliva sample was collected and participants completed a number of questionnaires. The participants then received nasal spray containing either 24 IU of oxytocin or a placebo (saline solution). All participants received both substances once, either the placebo during the first session and oxytocin during the second, or oxytocin during the first session and the placebo during the second. The order of administration was counterbalanced across participants and unknown to both the participant and the experimenter.

Participants were then fitted with an electrode net after which they completed a flanker task (with a short break after the fourth block). Halfway through and after completion of the task saliva samples were collected and participants completed several questionnaires. Data regarding oxytocin, saliva samples, and questionnaires will be presented elsewhere.

Questionnaires

To assess the level of fear of failure, participants filled out the 9-item Concern over Mistakes-subscale of the Multidimensional Perfectionism Scale (Frost, Marten, Lahart, & Rosenblate, 1990). Participants rated their agreement with nine statements (e.g., "People will probably think less of me when I make a mistake") on a 5-point scale ranging from 1 (completely disagree) to 5 (completely agree). The average score on the fear of failure questionnaire was 23.00 ($SD = 6.73$). Both skewness (-0.04) and kurtosis (-0.35) were acceptable and a Shapiro-Wilks test indicated that the distribution within the current sample was not significantly different from the normal distribution ($W = .97, p > .50$). Cronbach's alpha was .88 for the current sample.

To measure maternal use of love withdrawal, a questionnaire containing 11 items was completed by the participants. This questionnaire contained all five items of the Withdrawal of Relations subscale of the Children's Report of Parental Behavior Inventory (CRPBI; Beyers & Goossens, 2003; Schludermann & Schludermann, 1988), two items that were adapted from this same questionnaire, and four items adapted from the Parental Discipline Questionnaire (PDQ; Hoffman & Saltzstein, 1967; Patrick & Gibbs, 2007). Participants rated how well each of the 11 statements described their mother (e.g., "My mother is a person who, when I disappoint her, tells me how sad I make her") on a 5-point scale ranging from 1 (not at all) to 5 (very well). The average score on the love withdrawal questionnaire was 25.67 ($SD = 6.83$). Both skewness (-0.05) and kurtosis (-0.58) were acceptable and a Shapiro-Wilks test indicated that the distribution within the current sample was not significantly different from the normal distribution ($W = .98, p > .50$). Internal consistency of this questionnaire was adequate, Cronbach's alpha was .79 for the current sample. Reliability and validity of the CRPBI and its subscales have been well established (for information see Locke & Prinz, 2002; Schludermann & Schludermann, 1983, 1988) and various subscales, including the Withdrawal of Relations scale, are frequently used to study both the antecedents and consequences of parental use of psychologically controlling strategies like love withdrawal (e.g., Elliot & Thrash, 2004; Soenens et al., 2005a, 2005b).

Experimental task

Participants completed eight 72-trial blocks of a modified Eriksen flanker task (Eriksen & Eriksen, 1974), preceded by a 72-trial practice block. Target stimuli consisted of a row of five arrows ($7.4^\circ \times 1.4^\circ$ visual angle), presented for 50 ms, all pointing in the same direction (congruent targets), or with the middle arrow pointing in the opposite direction (incongruent targets). Target stimuli were preceded by a fixation cross, presented in black for 1000 ms and then in red for 800-1200 ms. The participants had to indicate, as fast as possible, whether the

middle arrow pointed left or right by pressing the corresponding button on a response pad. To ensure participants would indeed react as fast they could and consequently would commit a substantial number of errors, response deadlines were employed. Because reaction times are generally faster to congruent than to incongruent targets, separate deadlines were used for both target types. New response deadlines were calculated after every block based on the participants' mean reaction times in the previous block.

Following each response (600-1000 ms after target stimulus offset) a feedback stimulus was presented for 1500 ms. A photograph of a happy or a disgusted face ($18.8^\circ \times 21.2^\circ$) was presented in green if the participant's response was correct or in red if the participant made an error, resulting in four categories of feedback stimuli: green-happy, red-disgust (congruent), green-disgust and red-happy (incongruent). We chose to present disgusted facial expressions, rather than e.g., angry ones, because we anticipated that responses to these expressions would be most relevant for our understanding of the consequences of parental love withdrawal. Parental use of love withdrawal as a punishment triggers feelings of shame and rejection in the child (e.g., Elliot & Thrash, 2004). These same emotions are most likely to be activated by photographs of disgusted faces (Elison, 2005). Photographs were selected from Ekman's (Ekman & Friesen, 1976) standard set of prototypical facial expressions. If the participant's reaction time exceeded the response deadline the text 'too late' ($6.8^\circ \times 0.9^\circ$) appeared on screen. Only ERPs time-locked to the four categories of feedback stimuli (faces) were analyzed, because ERPs time-locked to 'too late' contained excessive artifacts (due to blinks, and eye and head movements). To make sure the participants would stay involved in the task, they could earn points during the last four blocks.

ERPs

Participants' EEG was acquired during performance of the flanker task using 129-channel hydrocel geodesic sensor nets, amplified using a NetAmps300 amplifier, low-pass filtered at half (i.e., 125 Hz) the digitization rate of 250 Hz and recorded using NetStation software (Electrical Geodesics, Inc.). Impedances were kept below 50 k Ω . Further processing of the raw EEG was conducted offline using Brain Vision Analyzer 2.0 software (Brain Products). The EEG was filtered with a passband range of 0.5-30 Hz (-3 dB, 12 dB/octave [high-pass filter], -3 dB, 48 dB/octave [low-pass filter]) and rereferenced to the average of activity in all channels. Segments extending from 200 ms before to 800 ms after the onset of each feedback stimulus were extracted, corrected for ocular artifacts using ICA, and averaged per condition (green-happy, green-disgust, red-happy, red-disgust) after removal of segments containing residual artifacts (whole segments were removed if the difference between the maximum and minimum activity exceeded 60 μ V in the vertical EOG channel (channel 8-channel 126) or 40 μ V in the horizontal EOG channel (channel 128-channel 125), and individual channels were removed from a segment if the difference between the maximum and minimum activity in that channel during that segment exceeded 150 μ V). For each of the four resulting ERPs a 200 ms pre-stimulus baseline was subtracted from all data points. On average, participants provided 486 trials ($SD = 21$), excluding late

trials, that were free of artifacts after ocular artifact correction (198 green-happy [96%], 201 green-disgust [97%], 43 red-happy [91%], 44 red-disgust [92%]).

The VPP was measured directly from the ERPs time-locked to the onset of the feedback stimuli. A clear positive peak was observed in the ERPs at approximately 155 ms after feedback onset at frontocentral electrode sites (maximal slightly frontal to Cz). This peak appeared to be more positive following disgusted compared to happy faces, and this difference peaked at approximately 165 ms after feedback onset, close to Cz. The VPP was therefore defined as the average amplitude in the 140-180 ms post-stimulus interval at electrode Cz.

Because the N400 is a relative rather than an absolute negativity, it is best measured from a difference wave. Difference waves were therefore created by subtracting the ERP time-locked to the onset of incongruent feedback stimuli from the ERP time-locked to the onset of congruent feedback stimuli. Separate difference waves were calculated for green and red feedback stimuli. A clear minimum was observed in the difference waves at approximately 375 ms after feedback onset, at right-parietal electrode sites (around CP2 and CP4). The N400 was then defined as the average amplitude of the difference wave in the 300-450 ms post-stimulus interval, averaged over the group of electrodes surrounding CP2 and CP4: 80, 86, 87 (CP2), 93 (CP4) and 105. The N400 is thus more negative when the ERP time-locked to incongruent stimuli has a more negative amplitude relative to the ERP time-locked to congruent stimuli (i.e. when the incongruence effect is stronger).

Analyses

Statistical analyses were performed using SPSS 17 software. In a preliminary phase repeated measures ANOVAs were performed to evaluate the effects of color and facial expression on VPP amplitude and to confirm the occurrence of N400 responses to incongruent combinations of feedback and facial expressions. Next, repeated measures ANCOVAs were performed to evaluate the effects of facial expression (VPP only), color, maternal use of love withdrawal and fear of failure on the amplitudes of the VPP and N400.

Results

Behavioral data

The average error rate for our participants was 16% ($SD = 7$). Participants responded significantly faster to congruent ($M = 263$ ms, $SD = 31$) than to incongruent targets ($M = 307$ ms, $SD = 41$), $t(26) = -13.37$, $p < .01$. Maternal use of love withdrawal (LWm) and fear of failure (FoF) were significantly correlated ($r = .47$, $p < .05$). LWm and FoF were not significantly correlated with participants' error percentages and reaction times to congruent and incongruent targets (all $rs < |.25|$, all $ps > .10$).

ERPs: preliminary analyses

Because, as mentioned above, VPP amplitude appeared to be more positive in response to disgusted compared to happy faces, we performed an ANOVA with color (red vs. green) and facial expression (happy vs. disgusted) as the independent variables. We found a significant main effect of facial expression, $F(1,26) = 9.97, p < .05$, confirming our observation. There was a significant main effect of color as well (more positive VPP in response to green compared to red photographs), $F(1,26) = 14.52, p < .05$, but no significant interaction of color and facial expression, $F(1,26) = 1.77, p > .10$.

To confirm the occurrence of N400 responses to incongruent facial expressions, an ANOVA was performed with color (red vs. green) and congruence (congruent vs. incongruent) as independent variables and the average amplitude across the time range (i.e., 300-450 ms) and electrodes (i.e., 80, 86, 87 [CP2], 93 [CP4] and 105) chosen for analysis of the N400 as the dependent variable. We found a significant

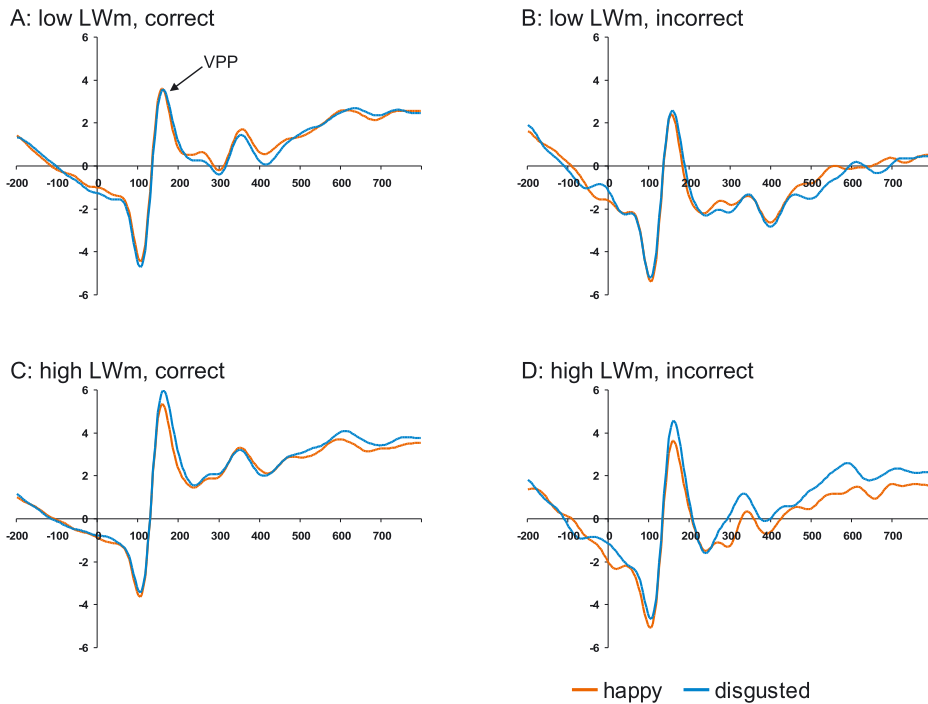


Figure 1. Grandaverage ERPs at Cz, illustrating the VPP. A and B: ERPs to green (A) and red (B) feedback stimuli (i.e., feedback following correct and incorrect responses) for participants reporting low maternal use of love withdrawal. C and D: ERPs to green (C) and red (D) feedback stimuli for participants reporting high maternal use of love withdrawal. Participants were divided into groups for displaying purposes only. Participants reporting higher maternal use of love withdrawal showed a more positive response to the feedback stimuli between 140 and 180 ms after stimulus onset (VPP) and a larger difference in VPP amplitude to happy and disgusted facial expressions (more positive VPP to disgusted than to happy expressions). ERPs were low-pass filtered at 15 Hz for displaying purposes.

main effect of congruence, $F(1,26) = 8.98, p < .05$, confirming the presence of the N400. The main effect of color was significant as well, $F(1,26) = 35.70, p < .05$ (more positive amplitude in response to green compared to red photographs), but there was no significant interaction of color and congruence, $F(1,26) = 0.03, p > .10$.

ERPs: analyses with LWm and FoF

Grandaverage ERPs at Cz and CP4 time-locked to the onset of the feedback stimuli are presented in Figures 1 and 2, illustrating the VPP and N400. Figure 3 presents scalp voltage-distributions for these two components.

All analyses described below were first conducted with order of administration (placebo first vs. oxytocin first) and use of oral contraceptives (used vs. not used) as additional independent variables. Because no significant effects for order of administration (all $F_s < 2.53$, all $p_s > .10$) and use of oral contraceptives (all $F_s < 2.03$, all $p_s > .10$) were found, we excluded these variables from the final analyses.

We performed a repeated measures ANCOVA with VPP amplitude as the dependent variable, color (red vs. green) and facial expression (happy vs. disgusted) as within subjects factors, and LWm and FoF as covariates. We obtained a significant main effect of LWm, $F(1,24) = 7.05, p < .05$, and a significant

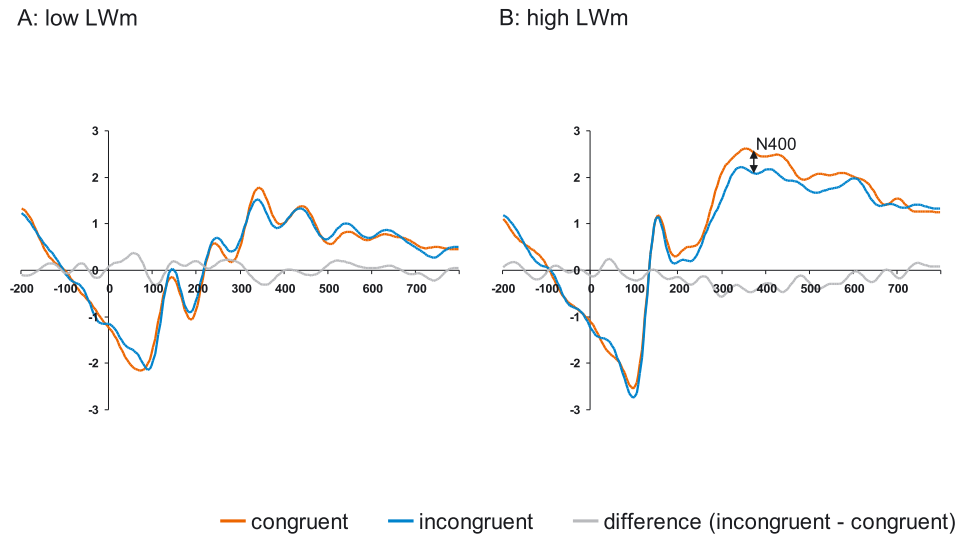


Figure 2. Grandaverage ERPs at CP4, illustrating the N400. A: ERPs to congruent and incongruent feedback stimuli for participants reporting low maternal use of love withdrawal. B: ERPs to congruent and incongruent feedback stimuli for participants reporting high maternal use of love withdrawal. Participants were divided into groups for displaying purposes only. Participants reporting higher maternal use of love withdrawal showed a more negative response to incongruent compared to congruent feedback stimuli between 300 and 450 ms after stimulus onset at right parietal electrode sites (N400). ERPs were low-pass filtered at 15 Hz for displaying purposes.

interaction effect between facial expression and LWm, $F(1,24) = 12.61$, $p < .01$. Higher maternal use of love withdrawal was associated with more positive VPP amplitudes in response to the feedback stimuli and with larger effects of facial expression (more positive VPP to disgusted than to happy faces) on VPP amplitude. Figure 1 presents grandaverage ERPs at Cz to illustrate these effects. No significant main effects of color, facial expression and fear of failure were found, and none of the other interaction effects was significant (all $F_s < 2.88$, all $p_s > .10$).

Next, we performed a repeated measures ANCOVA with N400 amplitude as the dependent variable, color (red vs. green) as within subjects factor, and LWm and FoF as covariates. The main effect of LWm was significant, $F(1,24) = 7.35$, $p < .05$. Higher maternal use of love withdrawal was associated with a more negative N400 (i.e., more negative voltage to incongruent compared to congruent feedback). No significant main effects of color and FoF were found, and none of the interaction effects were significant (all $F_s < 2.47$, all $p_s > .10$). Figure 2 presents grandaverage ERPs at CP4 time-locked to the onset of congruent and incongruent feedback stimuli, and the incongruent – congruent difference wave, illustrating the main effect of maternal use of love withdrawal.

Because no significant effects of FoF were found in any of the analyses described above, we repeated the analyses with fear of failure as the only covariate (i.e., excluding LWm from the analyses). No significant main effects of or interactions involving FoF were found (all $F_s < 1.10$, all $p_s > .10$).

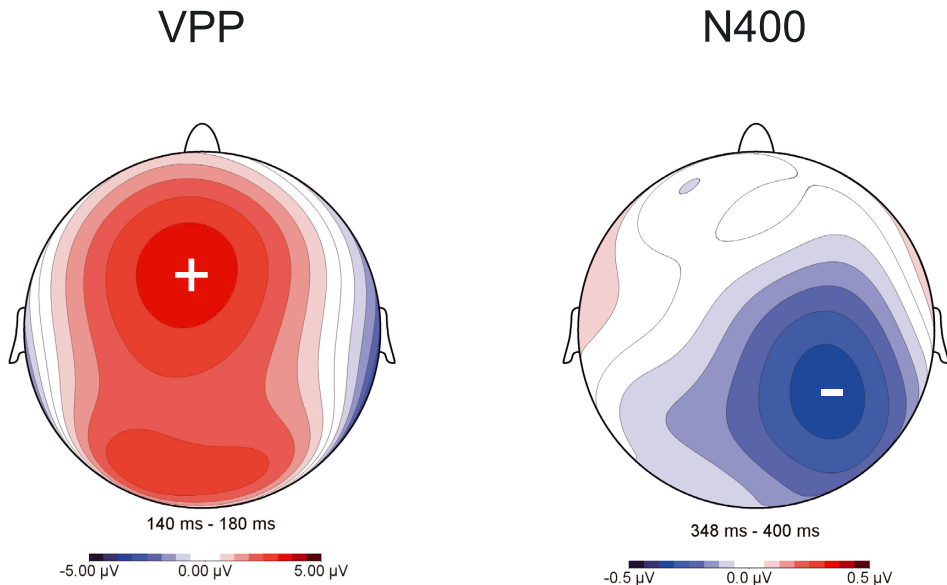


Figure 3. Scalp voltage distributions of VPP and N400. VPP: Voltage distribution of the ERP (averaged over all feedback stimuli) across the 140-180 ms post-stimulus interval. N400: Voltage distribution of the incongruent – congruent difference wave across the 348-400 ms post-stimulus interval. The maximum of the VPP is marked with '+', the minimum of the N400 with '-'.

Discussion

Maternal use of love withdrawal was related to the processing of the feedback stimuli as indexed by VPP and N400 amplitudes, independent of fear of failure. Consistent with our hypothesis, we found that maternal use of love withdrawal significantly predicted the VPP. Participants reporting relatively high maternal use of love withdrawal thus showed heightened processing of faces with emotional expressions.

In addition, we found that maternal use of love withdrawal was related to the difference between VPP amplitudes in response to happy and disgusted facial expressions. For participants reporting higher maternal use of love withdrawal the amplitude of the VPP was clearly larger in response to disgusted compared to happy facial expressions, whereas for participants reporting lower maternal use of love withdrawal this effect of disgust was smaller or absent. Amplitude differences in both VPP and N170 (a functionally similar component, Joyce & Rossion, 2005) to positive and negative facial expressions are thought to reflect the preferential processing of negative expressions, because of their biological significance as signals of threat and danger (Williams et al., 2006; Krombholz et al., 2007). Our results thus suggest a more pronounced preferential processing of disgusted faces compared to happy ones in participants reporting high maternal use of love withdrawal. A possible explanation is that in a performance situation disgusted facial expressions are more relevant or more threatening for them, because of the association between these expressions and the negative relational consequences linked to failure.

Higher levels of maternal love withdrawal were, as was predicted, also related to larger amplitudes of the N400. Participants reporting higher maternal use of love withdrawal thus seem to be more sensitive to a mismatch (incongruence) between the feedback and facial expression accompanying that feedback.

Areas involved in generating the N400, in particular the inferior frontal gyrus (and adjacent anterior insula) and superior temporal sulcus, have been found to contain mirror neurons that respond to emotional expressions and emotional prosody (Gazzola, Aziz-Zadeh, & Keysers, 2006; Wildgruber, Ackermann, Kreifelts, & Ethofer, 2006). Mirror systems are both active when an individual performs an action and when another individual performs an action from the same class of actions or an action with a similar goal or meaning (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992). Mirror neurons have been found to be involved in affect mirroring, understanding others' actions, and some aspects of empathy, and areas containing mirror neurons are involved in judging the appropriateness of facial affect (Gazzola et al., 2006; Kim et al., 2005). It is likely that mirror neurons are involved in affect mirroring and contingency detection in mother-child interactions that are central to the development of emotional self-awareness, self-control, and empathy from infancy through adolescence (Feldman, 2007; Fonagy, Gergely, & Target, 2007; Gergely & Watson, 1996). This system is thus a likely candidate for parenting strategies like love withdrawal to take effect.

In contrast to Tops and Wijers (2011) we did not find any effects of fear of failure, measured using the same questionnaire, on VPP and N400 amplitudes. This raises some debate about whether and how fear of failure may be related to these components. Our results suggest that maternal use of love withdrawal, rather than fear of failure, relates to the amplitudes of the VPP and N400, and as maternal use of love withdrawal and fear of failure were significantly, but not perfectly, correlated, one possibility is that the participants reporting high fear of failure in the Tops and Wijers (2011) study would have scored high on maternal use of love withdrawal as well. Another possibility is that our method of sampling affected the distribution of scores on the questionnaire measuring fear of failure (because love withdrawal and fear of failure were correlated). The mean and standard deviation we obtained ($M = 23.00$, $SD = 6.73$) do however not differ significantly (SD : $F(26,15) = 1.61$, $p > .10$; M : $t(41) = 0.81$, $p > .10$) from those reported by Tops and Wijers (2011; $M = 24.6$, $SD = 5.3$), suggesting the distributions were similar. Additional studies are needed to clarify the respective involvement of love withdrawal and fear of failure.

One factor that may have influenced our results is the difference in the frequency of presenting green and red stimuli. Because participants committed about 16% errors, they were presented with more green than red stimuli. Future studies could (additionally) use more difficult tasks resulting in higher error percentages and thus more equal numbers of green and red feedback stimuli. Furthermore, we measured maternal use of love withdrawal and fear of failure with self-report questionnaires. There are obvious limitations to the accuracy and reliability of participants' self-reports. A word of caution should also be added regarding the generalizability of our findings. Although our selection procedure ensured a normal distribution of scores on the love withdrawal questionnaire within the current sample, in comparison to the pool of 391 students that the sample was drawn from high maternal use of love withdrawal was overrepresented, and the current sample may not be representative of the general population. Lastly, our participants were all female. We chose to include only women in this study, because most of the studies on the behavioral/ psychological outcomes of love withdrawal focus on maternal use of love withdrawal with daughters (e.g., Elliot & Thrash, 2004; Renk et al., 2006). It would be interesting to study the same processes in men.

In conclusion, our results suggest that maternal use of love withdrawal is related to the processing of feedback stimuli that combine performance feedback with emotional facial expressions. The findings of a more negative N400, a more positive VPP, and larger VPP responses to disgusted than to happy faces with higher levels of maternal love withdrawal are consistent with the idea that a firm link between performance and affective relationships is established through the experience of love withdrawal, increasing the relevance of and focus on emotional expressions in performance situations, which makes the violation of the expected combination of feedback and emotional expression an especially salient event.

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