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**Emotion processing in posttraumatic stress disorder: emotion recognition,  
interpretation of neutral facial expressions, and facial mimicry**

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### **3.2. Study 2: Perception of neutral facial expressions in traumatized individuals**

**Reference:** Passardi, S., Peyk, P., Fares-Otero, N. E., Schnyder, U., & Pfaltz, M. C. (revise and resubmit). Perception of neutral facial expressions in traumatized individuals. *European Journal of Psychotraumatology*.

#### ***Abstract***

**Background:** Individuals with high prevalence of childhood adversities, e.g., those suffering from borderline personality disorder, tend to see neutral facial expressions as negative. **Objective:** Our aim was to assess whether this bias is present in individuals with posttraumatic stress disorder (PTSD) and whether it is linked to childhood trauma. **Methods:** Thirty-nine PTSD participants, 44 traumatized healthy, and 35 non-traumatized healthy controls watched 300 one-second movies showing neutral and emotional facial expressions, and indicated whether a neutral or one of 9 emotional facial expressions were presented. **Results:** PTSD individuals performed more poorly than control groups ( $p$ 's < .03) in recognizing neutral facial expressions and misinterpreted neutral facial expressions more often as anger and contempt ( $p$ 's < .01). Higher levels of self-reported childhood sexual and emotional abuse and physical neglect were linked to more misinterpretations of neutral facial as expressions of anger, sadness and contempt ( $p$ 's < .01). Comparisons of statistical model fits suggested that childhood sexual and emotional abuse and physical neglect play a more important role in the observed misinterpretations than PTSD diagnosis. **Conclusions:** Traumatic experiences, especially in childhood, may shape the interpretation of neutral facial expressions. Future research should explore if the observed biases extend to real-life situations. If so, therapists might improve the therapeutic relationship by paying more attention to their non-verbal communication and their traumatized patients' responses to it. Furthermore, similarly to individuals with borderline personality disorder, training emotion regulation skills might counteract emotion recognition difficulties in individuals with PTSD.

## ***Introduction***

Emotional facial expressions provide important cues that help humans to interpret social interactions. *Neutral* facial expressions can be interpreted and responded to in different ways, due to lacking or ambiguous information on the emotional state of the person or her relationship towards the interaction partner. In children, neutral facial expressions (especially if they occur suddenly) can be perceived as threatening and lead to increased negative affect, decreased positive affect, and physiological stress reactions (Mesman et al., 2009). Individuals with autism spectrum disorders (Eack et al., 2015), depression (Bourke et al., 2010), schizophrenia (Kohler et al., 2003), and borderline personality disorder (BPD) (Daros et al., 2013; Mitchell et al., 2014) show abnormal amygdala responses to neutral facial expressions (Donegan et al., 2003; Harms et al., 2010; Sheline et al., 2001) and tend to misinterpret them. For example, individuals with BPD interpret neutral facial expressions as more negative than healthy controls and tend to interpret them as anger (Daros et al., 2013; Mitchell et al., 2014) or sadness (Meehan et al., 2017). Likewise, when in a trauma-related emotional state, individuals with dissociative identity disorder perceive neutral faces as highly threatening (Schlumpf et al., 2013).

Many individuals with BPD and also those with dissociative identity disorder report childhood traumatic experiences (Battle et al., 2004; Schlumpf et al., 2013), which can lead to persistent alterations in emotional processing (De Bellis, Spratt, & Hooper, 2011). For individuals with childhood trauma, neutral expressions might trigger memories of neglect or abuse, potentially contributing to the above-mentioned findings (Schlumpf et al., 2013). In fact, adverse childhood experiences are linked to negative interpretations of neutral facial expressions in children (Pollak et al., 2000), to impaired recognition of neutral facial expressions in adults (Wagner & Linehan, 1999), and to emotion recognition deficits in individuals with BPD (Lowyck et al., 2016).

Given the consistent negative interpretation biases for neutral facial expressions in BPD, individuals with PTSD – who show high rates of traumatic childhood experiences (Gabbay et al., 2004) - may show similar interpretation biases. Next to lasting effects of adverse childhood experiences on emotional processing (De Bellis et al., 2011), including the interpretation of neutral facial expressions, interpretation biases in PTSD might be expected to occur based on dysfunctional thinking styles (e.g. negative beliefs about oneself and the world) which are part of the DSM-5 criteria for PTSD and resemble negative thinking styles in BPD (Baer, Peters, Eisenlohr-Moul, Geiger, & Sauer, 2012).

Studies on facial expressions in PTSD have, to date, focused on deficits in recognition of positive and negative facial expressions (Passardi et al., 2018; Poljac et al., 2011) and in

theory of mind (Mazza et al., 2012; Nazarov et al., 2014; Nietlisbach et al., 2010; J. Z. Schmidt & Zachariae, 2009), a construct related to but not identical with emotion recognition. They found deficits in the recognition of positive (Passardi et al., 2018) and negative (fear and sadness) emotions (Poljac et al., 2011) and controversial findings regarding theory of mind, ranging from generalized (Mazza et al., 2012; J. Z. Schmidt & Zachariae, 2009) to no deficit (Nazarov et al., 2014; Nietlisbach et al., 2010). Only one study has analyzed recognition of neutral facial expressions in adults with PTSD and found no abnormalities (Nazarov et al., 2014). However, this study used static images, only depicting the ocular region of the face and has assessed the recognition of complex mental states (positively valenced, negatively valenced and neutral mental states) as part of a theory of mind task. While no study has assessed interpretation of neutral (whole) facial expressions in PTSD, as seen in everyday situations, there is evidence that individuals with PTSD - on a cortical level - fail to differentiate between threatening (angry) and non-threatening (neutral) facial expressions (Felmingham et al., 2003).

The present study aimed at assessing whether individuals with PTSD show a negative interpretation bias for neutral facial expressions by using stimuli close to facial expressions found in everyday life. Based on previous studies in individuals with childhood trauma (Pollak et al., 2000; Wagner & Linehan, 1999) and individuals with BPD (Daros et al., 2013; Meehan et al., 2017; Mitchell et al., 2014), we hypothesized that individuals with PTSD would show poorer recognition of neutral expressions and more confusions of neutral expressions with negative expressions than healthy traumatized (TC) and healthy non-traumatized controls (HC). Assuming that biases seen in other clinical populations (Daros et al., 2013; Meehan et al., 2017; Mitchell et al., 2014; Schlumpf et al., 2013) might be linked to adverse childhood experiences and associated learning processes (Guitart-Masip et al., 2009; Pollak et al., 2000; Wagner & Linehan, 1999), we furthermore predicted that individuals with more childhood traumatic experiences would show more confusions of neutral with negative facial expressions than individuals with fewer childhood traumatic experiences, and that negative thinking styles would be positively associated with negative interpretations of neutral facial expressions.

## ***Method***

### *Participants*

Thirty-nine participants with PTSD, 44 TC and 35 HC were recruited via online platforms, newspaper advertisements, mailing lists, postings, from a pool of former study participants, from patients of the University Hospital Zurich, and via external mental health professionals. Individuals aged 18–65 years with normal or corrected-to-normal vision and mother tongue German or equivalent proficiency with a verbal IQ > 70 (according to a German multiple-choice vocabulary test, WST; K. Schmidt & Metzler, 1992) were included. Exclusion criteria were antipsychotic medication, benzodiazepines or tricyclic antidepressants, acute suicidality, lifetime psychotic symptoms, substance abuse or dependency (past 12 months), and physical health problems affecting psychophysiological measurements (which will be reported elsewhere). The PTSD group met current PTSD diagnosis according to DSM-5. Lifetime PTSD diagnosis and current mental disorders were exclusion criteria for control groups. HC had never experienced a trauma according to DSM-5, whereas TC experienced at least one traumatic event.

Table 6 illustrates the characteristics of the samples. Index traumas within the PTSD group were 95% man-made ( $n = 37$ ), 64% type II ( $n = 25$ ), and 74% deliberately caused trauma ( $n = 29$ ) (TC: 82% man-made,  $n = 36$ ; 11% type II,  $n = 5$ ; 34% deliberately caused trauma,  $n = 15$ ). Index traumas were accidents (PTSD:  $n = 7$ ; TC:  $n = 18$ ), natural disasters (PTSD:  $n = 0$ ; TC:  $n = 3$ ), non-sexual assault by family members or acquaintances (PTSD:  $n = 7$ ; TC:  $n = 5$ ), non-sexual assault by strangers (PTSD:  $n = 2$ ; TC:  $n = 3$ ), sexual assault by family members or acquaintances (PTSD:  $n = 15$ ; TC:  $n = 2$ ), sexual assault by strangers (PTSD:  $n = 2$ ; TC:  $n = 2$ ), life-threatening illness (PTSD:  $n = 1$ ; TC:  $n = 2$ ), work-related trauma (PTSD:  $n = 0$ ; TC:  $n = 2$ ), mix of different trauma types (PTSD:  $n = 1$ ; TC:  $n = 2$ ), and other traumatic experiences (PTSD:  $n = 4$ ; TC:  $n = 4$ ). Comorbid disorders in PTSD participants were major depression ( $n = 23$ ), dysthymia ( $n = 10$ ), panic disorder ( $n = 11$ ), agoraphobia ( $n = 16$ ), social phobia ( $n = 7$ ), generalized anxiety disorder ( $n = 7$ ), obsessive-compulsive disorder ( $n = 2$ ), and bulimia nervosa ( $n = 1$ ). The study was approved by the Cantonal Ethics Committee of Zurich. All participants gave written consent prior to participation.

Table 6.

## Characteristics of the Samples

|                       | PTSD individuals<br>(n=39) |      | Traumatized healthy controls<br>(n=44) |      | Non-traumatized healthy controls<br>(n=35) |      | Group comparisons                               |
|-----------------------|----------------------------|------|--|------|--|------|---|
|                       | N                          | %    | N                                      | %    | N  | %    |   |
| Female gender         | 29                         | 74   | 15                                     | 66   | 9  | 74   | ns  |
|                       | Mean                       | SD   | Mean                                   | SD   | Mean                                       | SD   |   |
| Age                   | 38.7                       | 12.8 | 36.5                                   | 12.0 | 36.6                                       | 10.2 | ns  |
| School years          | 11.4                       | 2.6  | 12.1                                   | 3.3  | 12.4                                       | 3.3  | ns  |
| BDI                   | 24.5                       | 8.8  | 3.3                                    | 3.3  | 2.6  | 5.0  | PTSD > TC <sup>1</sup> , PTSD > HC <sup>1</sup> |
| PDS                   | 36.3                       | 8.7  | 8.7                                    | 7.1  | -  | -    | PTSD > TC <sup>1</sup>                          |
| CTQ emotional abuse   | 13.5                       | 6.6  | 6.7                                    | 3.1  | 6.8  | 3.1  | PTSD > TC <sup>1</sup> , PTSD > HC <sup>1</sup> |
| CTQ physical abuse    | 9.8                        | 5.3  | 6.2                                    | 2.5  | 5.4  | 0.9  | PTSD > TC <sup>1</sup> , PTSD > HC <sup>1</sup> |
| CTQ sexual abuse      | 15.2                       | 8.3  | 6.2                                    | 3.1  | 5.3  | 0.9  | PTSD > TC <sup>1</sup> , PTSD > HC <sup>1</sup> |
| CTQ emotional neglect | 16.9                       | 5.5  | 11.3                                   | 5.2  | 9.6  | 4.5  | PTSD > TC <sup>1</sup> , PTSD > HC <sup>1</sup> |
| CTQ physical neglect  | 9.9                        | 3.8  | 7.0                                    | 2.7  | 6.2  | 1.5  | PTSD > TC <sup>1</sup> , PTSD > HC <sup>1</sup> |

*Note.* PTSD = Posttraumatic stress disorder, BDI = Beck Depression Inventory, PDS = Posttraumatic Diagnostic Scale (modified according to DSM-5), CTQ = Childhood Trauma Questionnaire, ns = not significant.

<sup>1</sup>  $p < .001$

### Diagnostic Instruments and Psychometric Measures

Current and past PTSD diagnoses were determined by the German Clinician-Administered PTSD Scale for DSM-5 (CAPS) (Müller-Engelmann et al., 2018). Internal consistencies for symptom cluster severity scores were high (re-experiencing:  $\alpha = 0.91$ , avoidance:  $\alpha = 0.81$ , negative alterations in cognitions and mood:  $\alpha = 0.92$ , hyperarousal:  $\alpha = 0.87$ ). Current diagnoses of other mental disorders were ascertained by the Mini International Neuropsychiatric Interview (M.I.N.I.) (Ackenheil et al., 1999). We assessed trauma history with the Posttraumatic Diagnostic Scale (PDS), part II (Ehlers et al., 1996).

Childhood trauma were assessed by the German short version of the Childhood Trauma Questionnaire (CTQ) (Wingenfeld et al., 2010), comprising 28 items rated on five-point scales belonging to five subscales (emotional abuse, physical abuse, sexual abuse, emotional neglect, physical neglect). Internal consistency for the total score and subscores were high (total score:

$\alpha = .90$ , emotional abuse subscale:  $\alpha = 0.92$ , physical abuse subscale:  $\alpha = 0.82$ , sexual abuse subscale:  $\alpha = 0.96$ , emotional neglect subscale:  $\alpha = 0.93$ ), except for the physical neglect subscale ( $\alpha = 0.68$ ), which is in line with the literature (Wingenfeld et al., 2010).

### *Emotion Recognition Task*

Participants watched 300 filmed facial emotion expressions (plus 10 practice trials) from the Amsterdam Dynamic Facial Expression Set–Bath Intensity Variations (ADFES-BIV) (Wingenbach et al., 2016), the adaptation of the ADFES (Van Der Schalk et al., 2011), presented in E-Prime 2.0 (Psychological Software Tools Inc.). Two hundred seventy of these one-second-video sequences showed a facial expression, changing from neutral into one of nine emotions (joy, pride, sadness, fear, anger, disgust, contempt, embarrassment, or surprise). Data for these sequences are reported elsewhere (Passardi et al., 2018). Thirty video sequences showed neutral expressions of one of five male and five female actors that remained neutral for the total video duration. After each video, a blank screen appeared for 500ms, followed by the answer screen, which contained ten response fields that were labelled with “neutral” or with one of the nine emotional expressions each. Participants were asked to identify as quickly as possible whether a neutral or one of the emotional expressions had been presented by clicking on the respective field. Thereafter, a blank screen appeared for 500ms. Each trial started with a fixation cross in the middle of the screen, remaining for 1000ms, 1500ms, 2000ms, 2500ms or 3000ms (randomized duration).

### *Procedure*

Participants were screened for inclusion and exclusion criteria by phone. For potential TC and PTSD participants, we administered the PDS, part III, during this phone interview to assess presence and severity of PTSD symptoms. Since at the time of data collection, PDS for DSM-5 was not available, we created a modified PDS version to cover the DSM-5 criteria for PTSD. Eligible participants scheduled an appointment for a first assessment in the laboratory, during which graduate psychology students administered the CAPS-5 and the M.I.N.I..

Prior to starting with the emotion recognition part of the study, which took part within one week after the interview, participants completed the Beck Depression Inventory (BDI) (Hautzinger et al., 1994) and additional questionnaires reported elsewhere. During the second study part, participants first completed the WST. Thereafter and for the rest of the study, facial electromyography, electrodermal activity, respiratory rate, and electrocardiogram, which will be reported elsewhere, were recorded. After a 5-minute baseline measurement serving psychophysiological assessments, participants completed the emotion recognition task. Thereafter, they completed self-ratings of their current emotional states (joy, sadness, disgust,

fear, anger, surprise, shame, contempt, pride, neutral) on a scale ranging from 0 (not at all) to 5 (extremely). Finally, they were reimbursed for their participation.

### *Statistical Analyses*

All analyses were carried out using SPSS (IBM SPSS statistics, version 23). For each participant, the number of correctly identified neutral expressions was calculated. We then conducted Generalized Estimating Equations Analyses including the between-subject factor group (PTSD, TC, HC) and the dependent variable ‘number of correct responses’. Childhood trauma (CTQ subscale scores) were substantially correlated with diagnostic group and could therefore not be entered into the same statistical model. To retrieve an estimate of the impact of the group variable and of childhood trauma on the dependent variables, we additionally conducted the described analyses using groups based on quantiles of the CTQ subscale scores and compared the model fit (QICC: corrected quasi-likelihood information criterion) of the resulting models (alternative models) to the original group design based on diagnostic groups (standard model). We performed one analysis for each of the five CTQ subscales with groups based on median splits (high and low CTQ subscale groups).

We inspected the distributions of dependent variables using quantile-quantile-plots and selected the regression models accordingly (binomial distributions and a logit link). The “unstructured” working correlation matrix type was selected for all models to provide the best model fit. Model-based estimations were used. Significant effects were explored using one-tailed post-hoc marginal mean comparison. Bonferroni-Holm corrections were applied.

For the standard model and all alternative models with a better model fit than the standard model, confusions patterns in recognition of neutral expressions were analyzed using multinomial logistic regression with the respective grouping variable (diagnostic group or CTQ half-split) as between factor and the nine possible misidentifications as response categories.

To assess if misidentifications were associated with negative thinking styles, we correlated the CAPS-5 symptom cluster severity scores for criterion D with the number of misidentifications of neutral expressions with negative emotions (Spearman correlation, one-tailed).

## Results

### Recognition of Neutral Expressions

A main effect for group (Wald  $X^2(2) = 16.6, p < .001$ ) and post-hoc tests revealed that PTSD individuals performed more poorly than TC ( $p < .001$ ) and HC ( $p = .029$ ) at detecting neutral expressions. Recognition of neutral expressions did not correlate with the BDI sum score ( $r_s(115) = -.062, p = .510$ ). Likewise, PTSD individuals with and without depression did not perform differently regarding recognition of neutral faces ( $U = 175.0, p = .810$ ).

In all models based on CTQ groups, the high CTQ group performed more poorly than the low CTQ group (see Table 7). QICC comparisons showed that groups based on the CTQ subscales sexual abuse, physical neglect and emotional abuse (but not groups based on the CTQ subscales physical abuse and emotional neglect) fitted the data better than the standard model (see Table 7).

Table 7.

*Recognition Accuracy of Neutral Expressions: Model Fit (QICC) and Effect Statistics (Wald  $X^2$ ) for Models with Alternate Grouping Variables (GVs)*

| GV                                      | QICC      | Wald $X^2$ | Posthoc tests                                    |
|---|-----------|------------|--|
| Group                                   | 24423.511 | 16.554**   | PTBS < TC**, PTBS < HC*,<br>TC > HC ( $p=.086$ ) |
| <b>CTQ sexual abuse<sup>1</sup></b>     | 22468.292 | 82.232**   | High < low CTQ **                                |
| <b>CTQ_physical neglect<sup>1</sup></b> | 24037.146 | 29.077**   | High < low CTQ **                                |
| <b>CTQ_emotional abuse<sup>1</sup></b>  | 24082.043 | 27.465**   | High < low CTQ **                                |
| CTQ_physical abuse                      | 24556.295 | 12.056*    | High < low CTQ *                                 |
| CTQ_emotional neglect                   | 24681.592 | 7.883*     | High < low CTQ *                                 |

Note. GV = Grouping variable, CTQ = Childhood Trauma Questionnaire,

<sup>1</sup>better model fit, \*\* = significant effect,  $p < .001$ , \* = significant effect,  $p < .01$

### Confusion Analyses

The odds for the PTSD group to confuse a neutral expression with anger and contempt (and with fear) was significantly increased compared to HC and to TC (compared to TC) (see Figure 7).

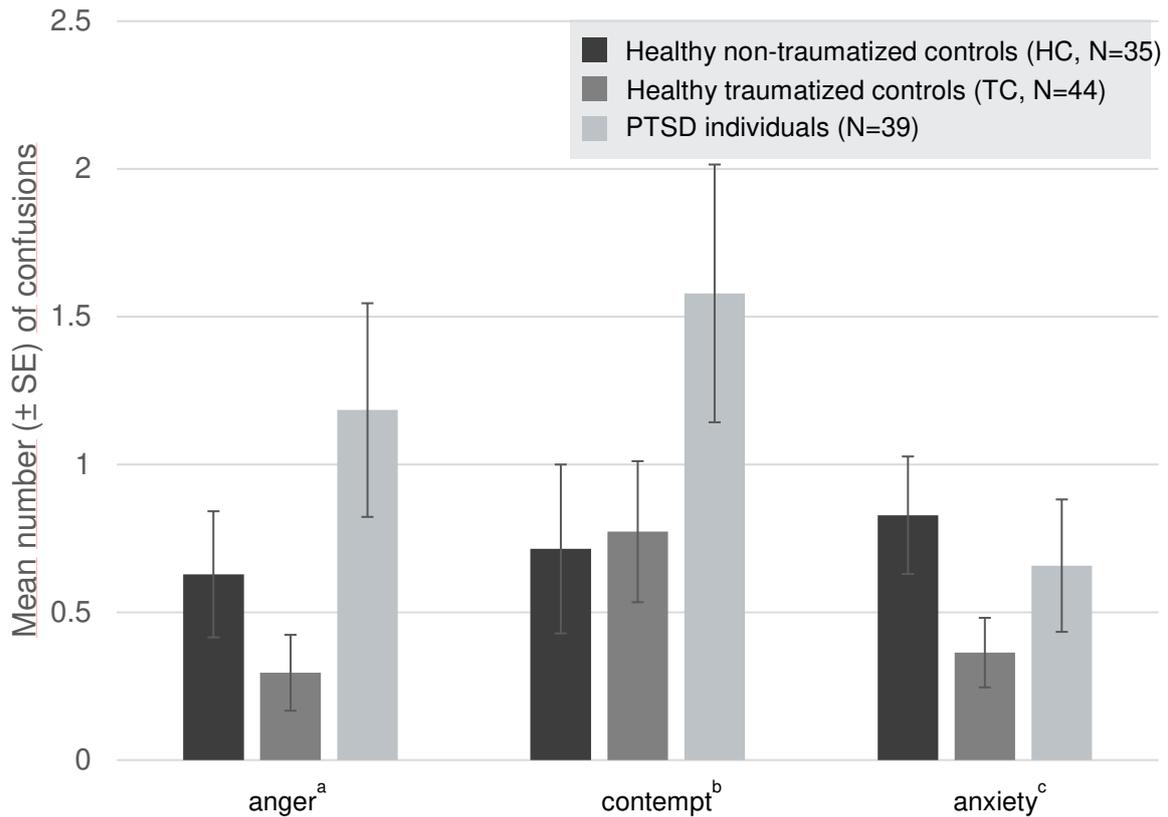


Figure 7. Confusions of neutral expressions with negative emotions in healthy non-traumatized controls, healthy traumatized controls and PTSD individuals. Error bars indicate standard errors.

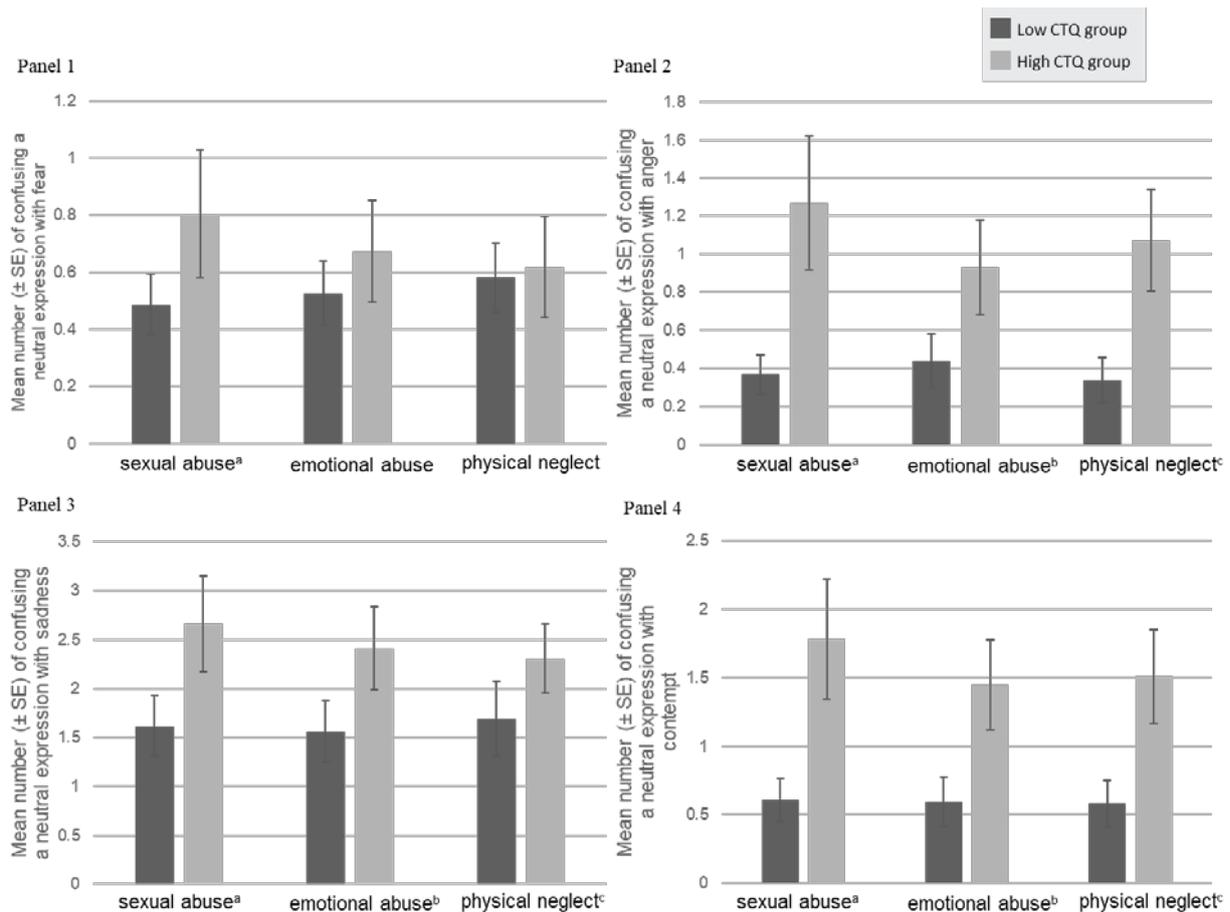
<sup>a</sup>Significantly increased odds for PTSD individuals to confuse a neutral expression with anger compared to HC (Wald  $X^2(1) = 7.25$ ,  $\exp(b) = 2.04$ ,  $p = .007$ ) and compared to TC (Wald  $X^2(1) = 22.18$ ,  $\exp(b) = 4.47$ ,  $p < .001$ )

<sup>b</sup>Significantly increased odds for PTSD individuals to confuse a neutral expression with contempt compared to HC (Wald  $X^2(1) = 12.90$ ,  $\exp(b) = 2.39$ ,  $p < .001$ ) and compared to TC (Wald  $X^2(1) = 14.12$ ,  $\exp(b) = 2.28$ ,  $p < .001$ )

<sup>c</sup>Significantly increased odds for PTSD individuals to confuse a neutral expression with fear compared to HC (Wald  $X^2(1) = 4.72$ ,  $\exp(b) = 2.02$ ,  $p = .030$ )

In the alternative models with better model fits than the standard model (CTQ subscales sexual abuse, physical neglect, and emotional abuse), the odds to confuse a neutral expression with anger, sadness, and contempt were significantly increased for the high compared to the low CTQ groups. Furthermore, the odds to confuse a neutral expression with fear was significantly increased for the high compared to the low sexual abuse group (see Figure 8).

CAPS-5 symptom cluster severity score for criterion D did not correlate with the mean number of confusions of neutral with negative expressions (across study groups and within PTSD,  $p's > 0.30$ ).



**Figure 8.** Confusions of neutral expressions with negative emotions in low and high CTQ groups. Error bars indicate standard errors. Groups based on median splits on the sexual abuse ( $Mdn = 5$ ), emotional abuse ( $Mdn = 6.5$ ), and physical neglect CTQ ( $Mdn = 6$ ) subscales.

<sup>a</sup> Significantly increased odds for the high sexual abuse group to confuse a neutral expression with fear (Wald  $X^2(1) = 6.96$ ,  $\exp(b) = 1.90$ ,  $p = .008$ ), anger (Wald  $X^2(1) = 33.39$ ,  $\exp(b) = 3.40$ ,  $p < .001$ ) sadness (Wald  $X^2(1) = 21.27$ ,  $\exp(b) = 1.89$ ,  $p < .001$ ), and contempt (Wald  $X^2(1) = 39.97$ ,  $\exp(b) = 3.34$ ,  $p < .001$ ) compared to the low sexual abuse group.

<sup>b</sup> Significantly increased odds for the high emotional abuse group to confuse a neutral expression with anger (Wald  $X^2(1) = 11.23$ ,  $\exp(b) = 2.25$ ,  $p = .001$ ), sadness (Wald  $X^2(1) = 12.81$ ,  $\exp(b) = 1.65$ ,  $p < .001$ ), and contempt (Wald  $X^2(1) = 21.75$ ,  $\exp(b) = 2.60$ ,  $p < .001$ ) compared to the low emotional abuse group.

<sup>c</sup> Significantly increased odds for the high physical neglect group to confuse a neutral expression with anger (Wald  $X^2(1) = 24.08$ ,  $\exp(b) = 3.53$ ,  $p < .001$ ), sadness (Wald  $X^2(1) = 9.27$ ,  $\exp(b) = 1.52$ ,  $p = .002$ ), and contempt (Wald  $X^2(1) = 27.39$ ,  $\exp(b) = 2.89$ ,  $p < .001$ ) compared to the low physical neglect group.

## Discussion

The present study assessed recognition and misinterpretations of neutral facial expressions in individuals with PTSD, as compared to traumatized and non-traumatized healthy controls. PTSD participants performed more poorly than controls in recognizing neutral expressions. They misidentified neutral facial expressions more often as anger and contempt than HC and TC, and more often as fear than TC. Furthermore, individuals with high versus low levels of childhood experiences of sexual abuse, emotional abuse and physical neglect

misinterpreted neutral expressions more frequently as anger, sadness and contempt. Moreover, individuals with high versus low levels of childhood sexual abuse misinterpreted neutral expressions more frequently as fear.

#### *Findings Based on Diagnostic Groups*

This is the first study that demonstrated deficits in the recognition of neutral facial expressions in individuals with PTSD. The attributions of anger and contempt to neutral expressions do not seem to be a function of depressive symptoms or emotional states, because they were unrelated to severity of depressive symptoms and to the presence of comorbid major depression. It is interesting that misinterpretations in PTSD were restricted to negative facial expressions and, more specifically, to expressions (anger and contempt) that might point to potential dangers to the perceivers' physical and / or mental integrity. However, the frequency of these misinterpretations was unrelated to self-reported PTSD symptoms of negative alterations in cognitions and mood. The found interpretation bias may thus be related more strongly to (childhood) trauma history than to the development of PTSD. This interpretation is supported by the better fit of most statistical models based on adverse childhood experiences compared to the model based on diagnostic groups.

#### *Findings Based on Childhood Trauma Groups*

Individuals with high levels of childhood sexual abuse, physical neglect or emotional abuse misinterpreted neutral expressions more often as anger, contempt and sadness than individuals with low scores. There is some evidence that neutral facial expressions can trigger traumatic memories in individuals with dissociative identity disorder - a condition associated with severe childhood trauma (Schlumpf et al., 2013). In an fMRI study in individuals with dissociative identity disorder, masked neutral faces activated brain processes related to arousal/vigilance and brain areas that have been linked to re-experiencing of traumatic events, and this response was even more pronounced than responses of individuals with dissociative identity disorder to masked angry faces (Schlumpf et al., 2013). As suggested by anecdotal evidence, traumatic childhood experiences like sexual or physical abuse can be preceded, accompanied or followed by neutral facial expressions. Individuals with adverse childhood experiences may thus have learned to not trust the seemingly calmness of neutral expressions, due to expectations that neutral situations are followed by aversive experiences (Schlumpf et al., 2013). Finally, neutral facial expressions might be reminders of emotional neglect, unavailability or invalidating responses of caretakers (Guitart-Masip et al., 2009; Schlumpf et al., 2013). In sum, negative interpretations of neutral facial expressions in individuals with adverse childhood experiences may thus reflect learning processes taking place in neglectful

and / or abusive environments. While these learning processes may be adaptive in the initial environment, e.g., by alerting children to potentially harmful situations, they may have negative consequences on the building and maintenance of interpersonal relationships in adulthood.

Childhood sexual abuse seems to have the broadest impact on misidentifications of neutral facial expressions: Individuals with high levels of childhood sexual abuse misinterpreted neutral expressions particularly frequently as anger, contempt, fear or sadness. Several authors describe the detrimental impact of childhood sexual abuse on psychological, neurocognitive and neurobiological functioning (e.g., De Bellis et al., 2011). A recent representative epidemiologic study in Germany found that the highest prevalence of complex PTSD, which is characterized by severe impairments in affect dysregulation, negative beliefs about oneself and problems in relationships (World Health Organization, 2017), are found in individuals with childhood sexual abuse and rape (Maercker et al., 2018). Together with the association between sexual trauma and poorer performance on social cognition found in individuals with BPD (Preissler, Dziobek, Ritter, Heekeren, & Roepke, 2010), this suggests that childhood sexual abuse may have a particularly pronounced, detrimental impact not only on affected individuals' cognitive and emotional development but also on social skills, including the ability to correctly identify facial expressions. According to our previous findings (Passardi et al., 2018), deficits in the recognition of facial expressions in individuals with childhood sexual abuse (and other adverse childhood experiences) may extend to the recognition of positive facial expressions.

### *Limitations and Conclusions*

One limitation of this study is the difference between the PTSD and TC groups regarding the distribution of trauma types, with more type II trauma reported by the PTSD group. However, risk for PTSD is higher after type II trauma (Brewin et al., 2000), making it difficult to find comparable control groups when assessing samples with mixed trauma types. Second, while our experimental stimuli are closer to real-life interactions than static images, or images restricted to the eye region of the face, future research should assess recognition of neutral expressions as they occur in interactive processes in – and ultimately – outside the laboratory, to enhance ecological validity. Third, our task does not allow to distinguish between (language based) cognitive and (intuitive) non-verbal processes that may have contributed to our findings. Using non-language based recognition tasks and eye tracking to assess attentional or avoidance processes in future studies could help to reveal underlying processes. Finally, our childhood trauma groups were based on median splits of participants' CTQ scores. Our high adverse childhood experiences subgroup may thus have comprised participants who did not reach the

threshold for established criteria of childhood sexual abuse, maltreatment or neglect and we may thus have missed deficits restricted to individuals with particularly high levels of childhood adverse experiences.

It is important to identify individuals prone to misinterpret neutral expressions as negative because they will likely feel uncomfortable in social interactions, including psychotherapeutic interactions, and, potentially, show reactions that may cause interactive and thus relationship problems that are common in traumatized individuals (Cloitre, Scarvalone, & Difede, 1997). There is evidence that specific facial expressions of therapists are associated with patient perceived therapeutic relationship quality (Sharpley, Jeffrey, & McMahan, 2006). If the negative interpretation bias extends to real-life situations, future research should explore if the therapeutic relationship with traumatized individuals can be improved by increasing therapists' awareness of their facial expressions and of their patients' responses to and interpretations of nonverbal signals of therapists and other interaction partners. Additionally, future research should explore whether the deficits found extend to other non-verbal communication channels such as the tone of the voice or speed content, as found in individuals with BPD (Niedtfeld et al., 2017). In individuals with BPD, difficulties in detecting (neutral) facial expressions can be counteracted by emotion regulation strategies like effortful control of emotions, impulses and thoughts (Meehan et al., 2017). If deficits and bias in recognition of (neutral) facial expressions in individuals with PTSD extend to real-life situations, future research should explore if effortful control moderates difficulties in recognizing neutral facial expressions in individuals with PTSD and if training in emotion regulation strategies improves emotion recognition abilities. Further elaborating on our results may contribute to better understanding of emotional processing, including emotion recognition, in (childhood) traumatized individuals, possibly helping them to create more satisfying social interactions.