

# Comprehension of affective prosody in women with post-traumatic stress disorder related to childhood abuse

Nazarov A, Frewen P, Oremus C, Schellenberg EG, McKinnon MC, Lanius R. Comprehension of affective prosody in women with post-traumatic stress disorder related to childhood abuse.

**Objective:** Although deficits in memory and cognitive processing are evident in post-traumatic stress disorder (PTSD), difficulties with social cognition and the impact of such difficulties on interpersonal functioning are poorly understood. Here, we examined the ability of women diagnosed with PTSD related to childhood abuse to discriminate affective prosody, a central component of social cognition.

**Method:** Women with PTSD and healthy controls (HCs) completed two computer-based tasks assessing affective prosody: (i) recognition (categorizing foreign-language excerpts as angry, fearful, sad, or happy) and (ii) discrimination (identifying whether two excerpts played consecutively had the 'same' or 'different' emotion). The association of performance with symptom presentation, trauma history, and interpersonal functioning was also explored.

**Results:** Women with PTSD were slower than HCs at identifying happiness, sadness, and fear, but not anger in the speech excerpts. The presence of dissociative symptoms was related to reduced accuracy on the discrimination task. An increased severity of childhood trauma was associated with reduced accuracy on the discrimination task and with slower identification of emotional prosody.

**Conclusion:** Exposure to childhood trauma is associated with long-term, atypical development in the interpretation of prosodic cues in speech. The findings have implications for the intergenerational transmission of trauma.

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Key words: social perception; speech; stress disorders; post-traumatic; adult survivors of child abuse; dissociation

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Accepted for publication October 14, 2014

## Significant outcomes

- Compared with healthy women, women with post-traumatic stress disorder (PTSD) related to childhood abuse were slower to identify prosodic cues conveying fear, happiness, and sadness but not anger. Increased severity of childhood trauma was associated with longer latencies in identifying affective prosody and decreased sensitivity in discriminating between different emotions in speech.
- The presence of dissociative symptoms was related to decreased sensitivity in discriminating between different emotions in speech.

## Limitations

- Limitations of this study include the retrospective nature of self-report measures, the modest sample size, and the cross-sectional design.
- Our findings cannot be generalized to men, individuals who experienced single-incident trauma, or to individuals exposed to trauma occurring outside of developmentally critical periods.

### Introduction

Difficulties in emotion regulation are considered central to the onset and maintenance of post-traumatic stress disorder (PTSD) (1–4) and are thought to contribute to interpersonal dysfunction (e.g. family, friendship) that is often observed among trauma survivors (3). Emotional competence contributes to psychological and social wellbeing (5–7), which implies that social cognition is an important area of investigation for improving our understanding of psychopathology, including PTSD, and related emotional and interpersonal difficulties. Critically, exposure to chronically abusive environments during developmentally critical periods may result in alterations of social cognitive processes (e.g. Theory of Mind – ToM) that remain evident in safer contexts, even in adulthood.

In a pattern similar to that observed in patients with mood disorders (8–11), patients with PTSD display altered performance across several domains of social cognition, including ToM (12, 13), empathy (14, 15), and emotion recognition (16, 17). Auditory and visual stimuli are used to judge behaviour, intentions, and mental states of others. It is therefore surprising that most studies examining the ability to recognize emotion among patients with psychopathology (e.g. depression, schizophrenia) focus primarily on the ability to recognize emotions as depicted in facial expressions, with the ability to recognize emotions conveyed through speech (affective prosody) being largely overlooked. Indeed, only one study has investigated comprehension of affective prosody in PTSD. Freeman et al. (18) found that, in comparison with age-matched controls, Vietnam veterans with current and lifetime PTSD experienced difficulty identifying and discriminating affective prosody. Although this result reveals evidence of alterations in the recognition of affective prosody among adult trauma survivors, it does not inform how early developmental experiences of trauma may affect this core social cognitive ability. Moreover, no data were presented concerning how alterations in the ability to recognize affective prosody may differ across the particular emotions that are conveyed.

Post-traumatic stress disorder due to chronic, developmental trauma may be different from PTSD stemming from exposure to a single event or to trauma occurring in adulthood, with developmental trauma being associated with a unique symptom cluster (19) and higher burden of illness (4, 20). Trauma occurring during childhood, particularly that which is

chronic, may disrupt highly sensitive, developing brain systems responsible for core affective and cognitive processes, resulting in dysfunction that extends into adulthood (21–23). Patients with PTSD due to developmental trauma are also at a heightened risk of developing symptoms of dissociation (20, 24–26), which may further exacerbate potential alterations in social cognitive processes through disruption of attentional resources (27–31), disorganized interpersonal attachment (32), and phobias of experiencing emotions (33), factors that collectively may influence the comprehension of emotion (34, 35). Because the ability to decode affective prosody emerges at around age 4 and continues to develop into adolescence (36), early life experiences that alter key affective and cognitive processes are likely to influence the optimal development of this ability and thus translate into prosodic dysfunction that may be observed during adulthood.

### Aims of the study

The primary aim of this study was to investigate the comprehension of affective prosody in patients with post-traumatic stress disorder stemming from adversity in early life. Because the ability to decode and comprehend prosody develops over the course of childhood and adolescence, we predicted that exposure to chronic trauma in childhood would disrupt the comprehension of prosody in speech. Our paradigm also allowed us to assess separately the processing of four basic emotions (happiness, sadness, fear, and anger), as opposed to an omnibus analysis of aprosodia. Finally, we examined whether severity of childhood trauma and dissociative symptoms would predict prosodic comprehension.

### Material and methods

#### Participants

Fifty women were recruited to participate in this study, 29 individuals with a primary diagnosis of current PTSD related to childhood abuse [PTSD group; mean age 42.0 (SD = 12.3) years] and 21 healthy controls [HC group; mean age 39.9 (SD = 14.7) years]. The groups were matched for age and sex. Women with PTSD were recruited at the London Health Sciences Centre (LHSC; London, ON, Canada) through out-patient programmes. The HC subjects were recruited through word of mouth and local advertisements at LHSC and

St. Joseph's Healthcare Hamilton (Hamilton, ON, Canada). HC participants had no current or lifetime history of psychiatric illness. The study sample was drawn from the same pool of participants described in Nazarov et al. (12).

Diagnosis of PTSD was confirmed via the *Structured Clinical Interview for DSM-IV* (SCID) (37). PTSD symptom severity was assessed using the *Clinician-Administered PTSD Scale* (CAPS) (38), and depression symptom severity was measured with the *Beck Depression Inventory* (BDI) (39). Symptoms of dissociation and histories of childhood trauma were assessed by the *Multiscale Dissociation Inventory* (MDI) (40) and the *Childhood Trauma Questionnaire* (CTQ) (41) respectively. Demographic and clinical summaries are provided in Table 1. HCs were administered the same measures to rule out the presence of current and past psychiatric illness and history of childhood maltreatment. Exclusion criteria for all groups were (i) substance-use-related disorder within the past 6 months as determined by the SCID, (ii) use of alcohol or illicit psychoactive substance within 48 h of testing, (iii) significant medical illness, (iv) history of head injury with loss of consciousness lasting more than 60 s, (v) history of neurological disease, and (vi) knowledge of the Hebrew language (see below).

Table 1. Clinical and demographic characteristics of study sample

Characteristic	Control ( <i>n</i> = 21)	PTSD ( <i>n</i> = 29)
	<i>n</i>	<i>N</i>
Sex		
Male	0	0
Female	21	29
	Mean	Mean
Age	39.9 (14.7)	42.0 (12.3)
Education	16.3 (2.5)	13.7 (2.3)*
CAPS	0.1 (0.5)	80.1 (15.4)*
BDI	3.5 (5.7)	32.0 (12.0)*
Childhood Trauma Questionnaire		
Emotional abuse	6.1 (1.5)	18.5 (5.2)*
Physical abuse	5.5 (1.1)	13.0 (5.7)*
Sexual abuse	5.2 (0.4)	15.5 (7.3)*
Emotional neglect	7.4 (2.2)	17.9 (4.9)*
Physical neglect	6.2 (1.7)	11.6 (5.5)*
MDI (total)	34.7 (6.0)	75.1 (21.9)*
Disengagement	7.6 (2.4)	17.0 (4.0)*
Depersonalization	5.2 (0.4)	10.8 (5.1)*
Derealization	5.5 (1.7)	11.7 (4.2)*
Emotional constriction	5.5 (1.1)	13.0 (6.1)*
Memory disturbance	5.6 (1.5)	12.1 (4.5)*
Identity dissociation	5.2 (0.5)	10.6 (6.2)*

BDI, Beck Depression Inventory; CAPS, Clinician-Administered PTSD Scale; MDI, Multiscale Dissociation Inventory; PTSD, post-traumatic stress disorder.

Values are *n* or mean (standard deviation).

\*Significant group effect ( $P < 0.05$ ).

## Affective prosody tasks

All participants completed two computer-based behavioural tasks that assessed the recognition and discrimination of prosodic cues to emotion. The stimuli were created specifically for this study. The stimuli were prerecorded 2-s excerpts spoken in Hebrew by a female speaker. There were 16 stimuli in total: four semantically neutral sentences spoken in four different ways such that the prosodic cues clearly expressed happiness, sadness, fear, or anger.

Stimuli were presented over headphones at a comfortable volume, which participants could control individually. Response options were presented on a monitor in a  $2 \times 2$  grid of equidistant boxes for the identification task and a  $1 \times 2$  grid of equidistant boxes for the discrimination task. The response options, their locations, and the visual parameters, did not vary across trials. Participants used a computer mouse to click on the appropriate response for each trial. They were instructed to respond as quickly and as accurately as possible. Each trial was preceded by a 'ready?' prompt. By pressing the space bar, participants indicated that they were ready for the next trial. For both tasks, trials were presented in randomized order. Each trial had one correct answer. Accuracy and reaction times (RT) were recorded by a computer for each trial.

In the recognition task, participants were required to determine which one of four basic emotions (happiness, sadness, anger, or fear) was conveyed in each speech excerpt. All 16 stimulus sentences were presented, preceded by four practice trials.

In the discrimination task, participants heard a standard and a comparison sentence presented consecutively. This task utilized all 16 stimulus sentences. On each trial, the two sentences always differed semantically. The task was to identify whether they conveyed the same emotion or different emotions. There were 24 trials, with 12 'same' emotions and 12 'different' emotions. For 'same' trials, each of the four sentences was paired with the three other sentences with identical emotions, in both orders. The sentences were paired identically for different trials except that the comparison sentence conveyed an emotion different from the standard. Sentences and emotions were counter-balanced so that each occurred equally often as standard and comparison. The task was preceded by two practice trials.

## Statistical methods

To examine group differences on the demographic and clinical variables, two-tailed independent-samples *t*-tests were used. All analyses were pre-

ceded by the Shapiro–Wilk test of normality. Identification accuracy measures could not be transformed (i.e. scores were integers between 0 and 4), remained non-normal, and were analyzed using a mixed-effects model for nonparametric data (42) (this analysis has been shown to be more powerful in comparison with chi-squared as it takes into account the within- and between-factors present in our experimental design). RT measures were log-transformed to adjust for non-normality and Winsorized to 95% of the distribution to account for outliers. Group differences in RT were analyzed using a mixed-design ANOVA, with diagnosis as a between-subjects factor and emotion (happy/sad/angry/fearful) or discrimination type (same/different) as a repeated measure. Bonferroni corrections were applied for follow-up comparisons. Associations were calculated using Pearson’s  $r$  or Spearman’s  $r_s$  (two tailed). Effect sizes were estimated by partial eta-squared ( $\eta_p^2$ ) and Cohen’s  $d$ . Significance was set at  $\alpha = 0.05$  for all analyses. Analyses were conducted with SPSS 21 (IBM, Armonk, NY, USA) and R 3.0 statistical software (R Foundation for Statistical Computing, Vienna, Austria).

**Results**

The clinical and demographic characteristics of the study sample are displayed in Table 1. As expected, the PTSD group had significantly higher scores on all clinical variables (CAPS, BDI, CTQ, and MDI,  $P_s < 0.05$ ). Age of participants did not differ significantly between groups.

For the recognition task, there were no group differences in accuracy because the stimuli were constructed to be emotionally unambiguous. On average, performance was very good, which provided evidence for stimulus validity. Recognition accuracy was 89%, 84%, and 83% correct (chance = 25%) for sentences intended to portray

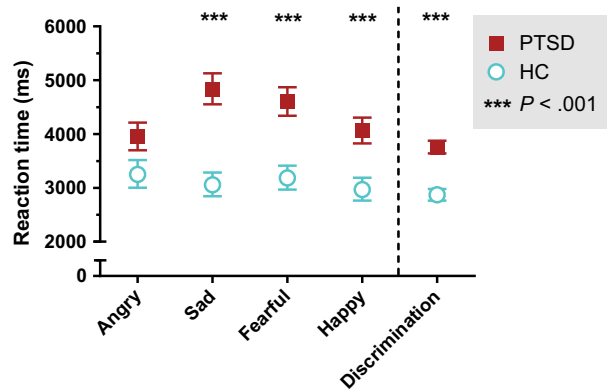


Fig. 1. Mean RT for identification of affective prosody between groups (±SE).

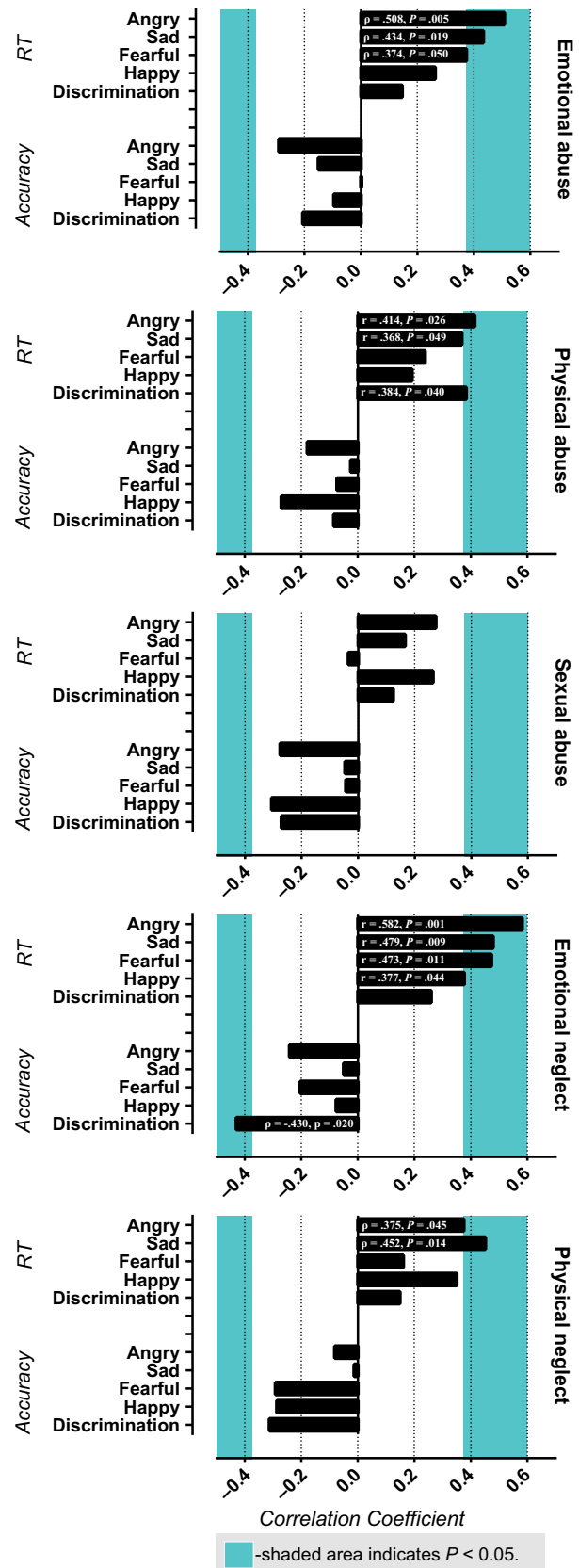


Fig. 2. Correlation matrix between childhood trauma scores (on the CTQ) and comprehension of prosody.



anger, sadness, and happiness respectively. Performance was lower (54%) for fearful-sounding stimuli, presumably because of confusions based on arousal level or valence (43) and associated acoustic cues (44). There was, however, a main effect of group on RTs ( $F_{1,45} = 20.1$ ,  $P < 0.001$ ,  $\eta_p^2 = 0.31$ ). Compared with HCs, women with PTSD were significantly slower at identifying emotions. The interaction between group and emotion ( $F_{3,135} = 2.57$ ,  $P = 0.057$ ,  $\eta_p^2 = 0.054$ ; Fig. 1) approached statistical significance. RTs were slower in the PTSD than in the HC group for fearful ( $t_{46} = 4.00$ ,  $P < 0.001$ ,  $d = 1.12$ ), happy ( $t_{48} = 4.04$ ,  $P < 0.001$ ,  $d = 1.12$ ), and sad ( $t_{48} = 5.26$ ,  $P < 0.001$ ,  $d = 1.51$ ) sentences, but not for angry sentences ( $t_{47} = 1.18$ ,  $P > 0.05$ ).

For the discrimination task, there were no differences in accuracy between groups. There was a significant main effect of diagnosis on RTs, however ( $F_{1,48} = 28.5$ ,  $P < 0.001$ ,  $\eta_p^2 = 0.373$ ), because women with PTSD were significantly slower at discriminating emotions.

When we examined only the women with PTSD, we found negative associations between severity of childhood trauma history (as assessed by the CTQ) and RTs on the identification task (Fig. 2). Specifically, increased latency to recognize angry and sad emotions was related to increased reports of emotional abuse, emotional neglect, physical abuse, and physical neglect. Longer latencies for recognition of fear were related to increased reports of emotional abuse and neglect. Longer latencies for recognition of happiness were related to increased reports of emotional neglect and marginally associated with increased physical neglect. On the discrimination task, longer latencies were related to increased reports of physical abuse. There was also an association between history of childhood trauma and accuracy on the discrimination task: Women with a more severe history of emotional were less accurate at discriminating emotions. A similar but marginal association was evident with physical neglect.

For dissociative symptoms (as assessed by the MDI), the ability of women with PTSD to discriminate between different emotions was negatively associated with identity dissociation ( $r_s = -0.484$ ,  $P = 0.008$ ) and depersonalization ( $r_s = -0.429$ ,  $P = 0.020$ ), and marginally associated with derealization ( $r_s = -0.345$ ,  $P = 0.067$ ).

## Discussion

This is the first study to demonstrate altered comprehension of affective prosody in women with PTSD stemming from childhood trauma. In com-

parison with matched healthy subjects, women with PTSD exhibited increased latencies in identification of happy, sad, and fearful prosody, but not for anger. Patients with a more severe history of childhood trauma and increased dissociation symptoms (driven particularly by identity dissociation and depersonalization) displayed lower accuracy for discriminating prosodic patterns that are markers of different emotions. RT across all emotions were strongly associated with increased severity of reports of childhood trauma in women with PTSD, particularly emotional abuse, emotional neglect, and physical neglect.

Although identification was slowed in response to happy, sad, and fearful expressions, women with PTSD performed as well as controls in response to expressions of anger. Several studies have demonstrated selective deployment of attention toward angry cues in individuals exposed to childhood maltreatment (45–48). For example, maltreated children who are presented with facial expressions that are morphed between sad and angry emotions are more likely to attribute ambiguous expressions as angry (49). Preservation of a normal reaction to anger among women with PTSD is consistent with the findings from maltreated childhood and suggests that maltreatment leads to heightened *sensitivity* rather than habituation to anger, which allows individuals to anticipate aversive encounters.

Nevertheless, we also found that increased severity of childhood maltreatment was related to slowed responding across *all* emotions, including happiness, sadness, and fear as well as anger. Exposure to childhood trauma may lead to heightened sensitivity to expressions of emotion that are most pertinent to one's safety (e.g. recognition of angry as opposed to happy emotions), but chronicity may create further alterations in higher-cognitive networks that contribute to global psychomotor slowing and attentional deficits, manifesting in slowed RT to emotional stimuli in general. Future research could explore the interaction between trauma chronicity, sensitization of emotion processing, and frontal-lobe activation patterns in response to emotionally evocative stimuli.

In our PTSD sample, we found that increased severity of childhood trauma (particularly emotional and physical neglect) was also related to decreased ability to *discriminate* prosodic cues that signal different emotions. Among children, the ability to discriminate faces that express different emotions is impaired for those who are neglected but not for those who are abused (48). Considered jointly, these findings suggest that

different childhood emotional experiences during abuse and neglect create distinct developmental trajectories that involve deficits in emotion processing. Moreover, maladaptive emotional experiences may have global effects on emotion processing that manifest within multiple sensory domains.

The cortico-limbic inhibition model of dissociative PTSD hypothesizes that the detachment from emotional experience may be due to affective dampening and overmodulation by higher cortical regions (for review see Ref. 50). In line with this view, we found that discrimination accuracy for affective prosody decreases in tandem with increasing symptoms of dissociation, particularly identity dissociation and depersonalization. Individuals presenting with higher dissociation symptoms may have experienced overmodulation of affective processing, which, in turn, could lead to decreased sensitivity to emotional stimuli in general and ultimately to discrimination errors between different emotions. Implementation of neuroimaging in future studies may elucidate whether individuals with stronger symptoms of dissociation exhibit inhibited neuronal activation patterns in response to prosodic cues to emotion.

Finally, our results parallel our previous finding of altered ToM performance in complex PTSD related to childhood trauma (12). There is still much debate regarding the interaction of basic emotion comprehension with higher-level socio-cognitive processing (e.g. decoding abilities in ToM) and whether deficits in these socio-cognitive domains act independently (51, 52). To determine whether comprehension of basic emotions acts as an independent contributor to social-cognition performance, future studies could assess the contributions of each socio-cognitive domain to successful interpersonal functioning and examine how deficits in one domain are accompanied by deficits in other domains.

Our findings have implications for the intergenerational transmission of trauma, where developmental alterations in prosodic ability may impact future parenting interactions with associated consequences for offspring. For example, parental PTSD contributes to the experience of trauma among children of Holocaust survivors (53, 54). Specifically, higher levels of emotional abuse and neglect are reported among children of parents with PTSD, factors that correlate with increased cortisol secretion among offspring (53). Accordingly, disruptions in emotion comprehension may relate to disrupted interpersonal attachments that contribute to a non-optimal parenting style and emotional neglect toward the child.

The limitations of the present study require consideration, particularly the retrospective nature of trauma assessments and the modest sample size. Furthermore, our study can only be generalized to women exposed to chronic childhood trauma. As our control sample consisted of women with minimal to no exposure to childhood maltreatment, we cannot distinguish between the effects of early trauma exposure and of PTSD on prosodic function. Thus, inclusion of a trauma-exposed non-PTSD control group is warranted. Future studies should also examine prosodic functioning in PTSD patients with and without the dissociative subtype. Moreover, matching for years of education should be considered in the future as covariation was not appropriate within our sample (55). Finally, although there have been null findings of alterations in psychomotor speed in non-combat-related PTSD (56–58), future studies of emotion recognition in PTSD could explore the contribution of psychomotor speed to individual differences in task performance.

The novel findings reported here point to altered comprehension of affective prosody in women with PTSD related to childhood trauma. In comparison with healthy women, women with PTSD showed slower identification of prosodic cues to happiness, sadness, and fear but not to anger. A more severe history of childhood trauma was associated with even slower recognition of emotions, and with a decreased ability to discriminate between distinctive patterns of acoustic cues that are associated with emotions expressed through prosody. The ability to discriminate such emotions was also associated with the presence of dissociation symptoms. Although a definitive causal pathway needs to be documented, the finding of prosodic alterations in our sample suggests strongly that exposure to childhood trauma leads to developmental changes in prosodic function.

### Acknowledgements

Support for this work was provided by grants from the Canadian Institutes of Health Research awarded to R.L., M.C.M., and P.F., the Ontario Mental Health Foundation awarded to M.C.M and P.F., and the National Alliance for Research in Schizophrenia and Affective Disorders awarded to M.C.M.

### Declarations of interest

None.

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