



UNIVERSITÀ DEGLI STUDI DI TORINO

*This is an author version of the contribution published on:
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*Di Tella M., Enrici I., Castelli L., Colonna F., Fusaro E., Ghiggia A., Romeo A.,
Tesio V., Adenzato M. (2018). Alexithymia, not fibromyalgia, predicts the
attribution of pain to anger-related facial expressions. Journal of Affective
Disorders, 227, 272-279. DOI: 10.1016/j.jad.2017.10.048*

*The definitive version is available at:
La versione definitiva è disponibile alla URL:*

[http://www.jad-journal.com/issue/S0165-0327\(17\)X0018-9](http://www.jad-journal.com/issue/S0165-0327(17)X0018-9)

Abstract

Background: Fibromyalgia (FM) is a syndrome characterized by chronic, widespread musculoskeletal pain, occurring predominantly in women. Previous studies have shown that patients with FM display a pattern of selective processing or cognitive bias which fosters the encoding of pain-related information. The present study tested the hypothesis of an increased attribution of pain to facial expressions of emotions (FEE), in patients with FM. As previous studies have shown that alexithymia influences the processing of facial expressions, independent of specific clinical conditions, we also investigated whether alexithymia, rather than FM per se, influenced attribution of pain to FEE.

Methods: One hundred and twenty-three women (41 with FM, 82 healthy controls, HC) were enrolled in this cross-sectional case-control study. We adopted two pain-attribution tasks, the Emotional Pain Estimation and the Emotional Pain Ascription, both using a modified version of the Ekman 60 Faces Test. Psychological distress was assessed using the Hospital Anxiety and Depression Scale, and alexithymia was assessed using the Toronto Alexithymia Scale.

Results: Patients with FM did not report increased attribution of pain to FEE. Alexithymic individuals demonstrated no specific problem in the recognition of basic emotions, but attributed significantly more pain to angry facial expression.

Limitations: Our study involved a relatively small sample size. The use of self-reported instruments might have led to underestimation of the presence of frank alexithymia in individuals having borderline cut-off scores.

Conclusions: Alexithymia, rather than FM per se, plays a key role in explaining the observed differences in pain attribution to anger-related facial expressions.

Keywords: Alexithymia; Anger; Emotion recognition; Fibromyalgia; Pain.

Introduction

Fibromyalgia (FM) is a syndrome characterized by chronic, widespread musculoskeletal pain, associated with a series of other conditions, such as fatigue, non-restorative sleep, irritable bowel, psychiatric disorders, cognitive impairment, and other functional complaints (Mease, 2005; Schmidt-Wilcke and Clauw, 2011). Its prevalence ranges from 3% to 6%, and it occurs predominantly in women (Branco et al., 2010). Growing evidence suggests that FM could be considered a *central sensitization syndrome*, caused by an increased sensitivity of the central nervous system to pain signals (Williams and Gracely, 2006).

A relevant and emerging topic of research is the emotional regulation and processing in patients with FM (Geenen et al., 2012; Weiss et al., 2013). With regard to emotional regulation, high affect intensity and low emotional expression are independently associated with a larger impact of FM. Although high affect intensity could be considered a general risk factor for emotional maladjustment, intense experience of emotions is not necessarily associated with maladaptive outcomes in patients with FM, as long as emotional expression is involved. However, suppression of emotions, i.e., not expressing strongly felt emotions, is a particularly maladaptive combination of emotional processing and regulation (Geenen et al., 2012). To our knowledge, till date only one study has specifically investigated the issue of emotional processing in patients diagnosed with FM (Weiss et al., 2013), and found an impaired recognition of emotional facial expression, indicating greater misclassification of emotional expressions (such as happy, angry, disgusted, anxious, sad, and neutral expressions) than controls, with no difference being observed in the ratings of arousal and valence dimensions of emotional experience. The distribution of specific misclassifications did not differ between healthy individuals and patients with FM, indicating generally reduced accuracy of recognizing emotional facial expression rather than a specific pattern of mistakes.

Facial expression of pain represents a highly salient stimulus for human beings, as it provides information about a potential danger or threat to the observer, and conveys a request for help from the sufferer (Williams, 2002). Previous studies have shown that patients with FM may display a

pattern of selective processing or cognitive bias, which fosters the encoding of pain-related information (Asmundson et al., 1997; Gonzalez-Roldan et al., 2013). The evaluation of pain in other individuals is considered to be modulated by several factors, including the level of empathy with the individual experiencing pain, the observer's previous experience with pain, and the presence of certain personality characteristics (Cheng et al., 2007; Wandner et al., 2012).

Evidences for the importance of emotions in FM pain are provided by neuroimaging studies that reported hyperactivity of brain regions mediating the affective component of pain rather than the structures related to the sensation of pain in patients with FM (Burgmer et al., 2010; Burgmer et al., 2009; Duschek et al., 2012). For example, differences in the time of pain anticipation without pain stimulation were reported in patients with FM compared to HC, with atypical brain activation in FM group in areas of the pain network, particularly in the anterior cingulate cortex (ACC), supplementary motor areas, and thalamus (Burgmer et al., 2009). These findings highlight the role of the cingulo-frontal network for central sensitization in FM, supporting the hypothesis of central pain augmentation in FM syndrome (Burgmer et al., 2010).

In addition, different studies reported an enhanced sensitivity to pain in patients with central sensitivity syndromes such as FM, with respect to a variety of psychophysical stimuli, including pressure, heat, and electricity, as well as environment stimuli, such as noise, stress, and chemical stimuli (Yunus, 2009). Moreover, in both healthy individuals and patients with FM, emotions have also been observed to increase pain, in particular those involving anger and sadness (Fernandez and Turk, 1995; Janssen, 2002; van Middendorp et al., 2010).

Patients with FM also show high levels of alexithymia, a personality disposition affecting emotional self-awareness (Castelli et al., 2012; Di Tella and Castelli, 2013, 2016). Alexithymia is mainly characterized by difficulty in identifying and describing subjective feelings, restricted process of imagination, and an externally oriented cognitive style (Sifneos, 1972; Taylor et al., 1999). Previous studies have indicated that alexithymia influences the processing of facial expressions of other individuals independent of a specific clinical condition, such as autism spectrum disorder,

somatoform disorders or eating disorders (Cook et al., 2013; Grynberg et al., 2012; Pedrosa Gil et al., 2009).

The presence of alexithymia has been related to impairment in the processing of facial expressions of other individuals, in both healthy individuals and specific clinical populations, including FM (Di Tella et al., 2015; Pedrosa Gil et al., 2009; Subic-Wrana et al., 2010). Human faces are considered the main source of information about feelings of other individuals (e.g., Adenzato and Garbarini, 2006; Enrici et al., 2015) (through internal feedback from the facial skin and muscles), and the accurate interpretation of facial expressions contributes in turn to an awareness of one's own emotions (Parker et al., 1993). The inability to correctly identify feelings and the somatic manifestations of emotions has also been associated with an intensification of the symptomology for alexithymic individuals, due to their tendency to misinterpret their emotional arousal as symptoms of disease (Lumley et al., 1996; Tuzer et al., 2011).

Based on these suggestions, the main aim of the present study was to test the hypothesis that the attribution of pain to emotional facial expressions (other than pain) is greater in patients with FM. To achieve this goal, a cross-sectional case-control study was conducted. In order to investigate the pain attribution processes, we distinguished pain estimation from pain ascription, in particular analysing the degree of pain associated with emotional facial expressions, namely *emotional pain estimation*, and the attribution of pain to emotional facial expressions, namely *emotional pain ascription*.

The presence of alexithymia in patients with FM and the impact of the alexithymic component on the attribution of pain to emotional facial expressions have also been discussed in this study.

Materials and methods

Participants

Forty-one women with FM were consecutively recruited from the Fibromyalgia Integrated Outpatient Unit at the 'Città della Salute e della Scienza' Hospital of Turin. All patients had a major diagnosis of

FM, made by an expert rheumatologist. Exclusion criteria used were as follows: less than 18 years old, low education level (<5 years), and the presence or history of a neurological or a severe psychiatric disorder, according to an expert psychiatrist examination. Eighty-two healthy women were recruited for the Healthy Controls (HC) group. Exclusion criteria used were the presence of rheumatic diseases or chronic pain, as well as the presence or history of a neurological or psychiatric disorder.

The study was approved by the ‘*Città della Salute e della Scienza*’ hospital ethics committee and was conducted in accordance with the Declaration of Helsinki. All the participants gave their written informed consent to the study.

Measures

Psychological distress

The presence of psychological distress was assessed using the Italian version of the Hospital Anxiety and Depression Scale (HADS) (Bjelland et al., 2002; Costantini et al., 1999). This consists of 14 items and is divided into two subscales, one for depression (HADS-D) and one for anxiety (HADS-A). A score of 8 or more suggests a clinically relevant level of depression/anxiety (Zigmond and Snaith, 1983). A score of 15 or more is, instead, considered the optimal cut-off point for the HADS total score (Bjelland et al., 2002; Herrmann, 1997).

Alexithymia

Alexithymia was assessed using the Italian version of the Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994; Bressi et al., 1996; Taylor et al., 2003), which provides a total score and three subscale scores: difficulty identifying feelings (DIF); difficulty describing feelings (DDF); externally-oriented thinking (EOT). The TAS-20 cut-off scores are as follows: ≤ 51 no alexithymia, 52–60 borderline alexithymia, ≥ 61 alexithymia.

Pain attribution

In order to evaluate the attribution of pain to facial expressions associated with basic emotions (other than pain), we adopted two pain-attribution tasks, the Emotional Pain Estimation and Emotional Pain Ascription task, both using a modified version of the Ekman 60 Faces Test (Ekman and Friesen, 1976).

The Emotional Pain Estimation task (Ekman Pain VAS) is a modified version of the Ekman 60 Faces Test in which the 60 stimuli of the original version of the test were modified by removing the labels of the six basic emotions usually displayed under each photograph (happiness, sadness, disgust, fear, surprise, and anger) and by adding a Visual Analogue Scale (VAS) under each photograph. Participants were required to evaluate how much pain, if at all, each image expressed, using the VAS ranging from 0 ('No pain') to 10 ('Worst pain'), and checking the point of the line which best corresponded to the amount of pain estimated for each face (Fig. 1a).

The Emotional Pain Ascription task (Ekman Pain label) is a modified version of the Ekman 60 Faces Test in which the 60 stimuli of the original version of the test were modified by adding a seventh label 'Pain' to the six basic emotion labels usually present under each image. Participants were asked to select one of seven emotion labels that best described the facial expression shown (Fig. 1b). The Emotional Pain Ascription task was used in order to clarify whether there was a specific tendency in participants toward the attribution of pain to human faces or a more basic deficit in the recognition of emotional facial expressions.

In both tasks, pictures of emotional facial expressions were presented on a computer screen one at a time in random order and no feedback was given as to the appropriateness of any response.

Figures 1 about here

Statistical analyses

The statistical analyses were carried out with the Statistical Package for Social Science, version 24.0 (IBM SPSS Statistics for Macintosh, Armonk, NY, USA: IBM Corp.). Normal distribution was assessed using asymmetry and kurtosis indices.

Planned comparisons between patients with FM and HC were performed by means of non-parametric equivalent tests or independent t-tests, as appropriate. The same, albeit unplanned, analyses were conducted on all the participants from both groups, taken together, and HC and FM individuals, considered separately, divided in two groups based on their total TAS-20 scores (alexithymic group: TAS-20 total score ≥ 61 vs. non-alexithymic group: TAS-20 total score < 61). In addition, a one-way Analysis of Covariance (ANCOVA) was run to control for the possible effect of psychological distress (HADS total score) on the pain-attribution task results. The effect size was determined by calculating Cohen's d or Pearson's correlation coefficient r , as appropriate. The level of significance for all statistical tests was set at $p < 0.05$.

Results

The FM and HC groups were matched for age (FM vs. HC, mean \pm SD: 50.8 ± 10.2 vs. 51.7 ± 8.4 , $t(121) = -0.52$, $p = 0.603$) and educational level (12.4 ± 3.8 vs. 12.8 ± 2.5 , $t(58.39) = -0.59$, $p = 0.555$).

The FM group reported significantly higher scores for both the HADS total score (FM vs. HC, mean \pm SD: 18.3 ± 6.7 vs. 12.8 ± 6.6 , $t(121) = 4.35$, $p < 0.001$) and the HADS subscale scores (HADS-D: 9.5 ± 4.4 vs. 5.9 ± 3.9 , $t(121) = 4.64$, $p < 0.001$; HADS-A: 8.9 ± 3.8 vs. 6.9 ± 3.5 , $t(121) = 2.86$, $p = 0.005$) in the assessment of psychological distress.

With regard to the prevalence of alexithymia, 26.8% (11) of the patients with FM obtained a total score ≥ 61 at TAS-20, while 12.2% (10) of the HC exceeded this cut-off point. Patients with FM reported significantly higher scores on the TAS-20 total score (FM vs. HC, mean \pm SD: 51.5 ± 14.1 vs. 44.6 ± 13.2 , $t(121) = 2.67$, $p = 0.009$) and DIF subscale (20.6 ± 8.0 vs. 15.1 ± 6.1 , $t(63.78) = 3.82$, $p < 0.001$), compared to the HC group. No significant difference between the two groups was

found on the DDF (13.8 ± 5.1 vs. 12.3 ± 5.1 , $t(121) = 1.54$, $p = 0.127$) and EOT (17.3 ± 5.3 vs. 17.2 ± 5.3 , $t(121) = 0.11$, $p = 0.914$) subscales of the TAS-20.

Contrary to our expectations, the results of the comparison between the FM and HC groups for pain-attribution tasks did not show any significant differences for all the six basic emotions of the Emotional Pain Estimation task. A similar pattern of results (i.e., no significant difference between the two groups for either the six basic emotions or pain) was obtained for the Emotional Pain Ascription task (Table 1).

Table 1 about here

Alexithymic vs. non-alexithymic participants

In three other series of unplanned analyses, we explored the possibility that an increased attribution of pain to emotional facial expressions might be mediated by the presence of alexithymia as opposed to chronic pain per se. To achieve this aim, we first compared alexithymic and non-alexithymic participants in total, and then compared alexithymic and non-alexithymic participants in both HC and FM groups.

For the comparison between alexithymic and non-alexithymic participants in total, the two samples were matched for age (alexithymic vs. non-alexithymic, mean \pm SD: 49.9 ± 10.7 vs. 51.7 ± 8.7 , $t(121) = 0.84$, $p = 0.404$) and educational level (11.2 ± 3.6 vs. 12.9 ± 2.8 , $t(25.36) = 2.02$, $p = 0.054$).

Significantly higher values were reported for the alexithymic group for both the HADS total score (alexithymic vs. non-alexithymic, mean \pm SD: 19.9 ± 7.5 vs. 13.6 ± 6.6 , $t(121) = -3.93$, $p < 0.001$) and the HADS subscale scores (HADS-D: 10.0 ± 4.2 vs. 6.5 ± 4.2 , $t(121) = -3.43$, $p = 0.001$;

HADS-A: 10.0 ± 4.3 vs. 7.0 ± 3.4 , $t(121) = -3.41$, $p = 0.001$) in the assessment of psychological distress.

With respect to the attribution of pain (Table 2), the alexithymic group reported higher scores, i.e., higher pain-attribution, for all the six basic emotions of the Emotional Pain Estimation task (with the only exception of happiness), compared to non-alexithymic group, though a statistically significant difference between the two samples was found only for the emotion ‘anger’ (Fig. 2) (Fig. 3 in the Supplementary Material). Given the high levels of psychological distress exhibited by the alexithymic participants, a one-way ANCOVA was further conducted to determine if a statistically significant difference between alexithymic and non-alexithymic participants on Emotional Pain Estimation on the anger emotion, was still present after controlling for psychological distress (HADS total score). The results of ANCOVA indicated a significant effect of alexithymia on the anger scores after controlling for HADS total score $F(1, 120) = 7.57$, $p = 0.007$. The ANCOVA also revealed a non-significant effect of psychological distress on the scores for anger; $F(1, 120) = 1.01$, $p = 0.318$. Finally, no significant difference was observed between alexithymic and non-alexithymic participants for the Emotional Pain Ascription task.

Table 2 and Figure 2 about here

For the HC group, alexithymic and non-alexithymic healthy participants were matched for age (alexithymic vs. non-alexithymic, mean \pm SD: 53.2 ± 9.4 vs. 51.5 ± 8.3 , $t(80) = -0.60$, $p = 0.552$) and educational level (12.6 ± 3.8 vs. 12.8 ± 2.4 , $t(80) = 0.21$, $p = 0.837$).

Significantly higher values were reported for the alexithymic healthy group for both the HADS total score (alexithymic vs. non-alexithymic, mean \pm SD: 16.8 ± 8.0 vs. 12.3 ± 6.3 , $t(80) = -2.07$, $p = 0.042$) and the HADS-D subscale score (8.4 ± 4.3 vs. 5.6 ± 3.7 , $t(80) = -2.23$, $p = 0.029$) in

the assessment of psychological distress. No significant difference was obtained for the HADS-A subscale (8.4 ± 4.4 vs. 6.7 ± 3.4 , $t(80) = -1.46$, $p = 0.147$).

With regard to pain-attribution (Table 3), alexithymic healthy group reported higher scores, i.e., higher pain-attribution, for all the six basic emotions of the Emotional Pain Estimation task (with the only exception of happiness), compared to non-alexithymic healthy group, with a strong tendency towards statistical significance for the emotion 'anger' (Fig. 2) (Fig. 3 in the Supplementary Material). No significant difference between alexithymic and non-alexithymic healthy samples was obtained for the Emotional Pain Ascription task.

Table 3 about here

Finally, with respect to the FM group, alexithymic and non-alexithymic FM participants were matched for age (alexithymic vs. non-alexithymic, mean \pm SD: 46.9 ± 11.3 vs. 52.2 ± 9.6 , $t(39) = 1.50$, $p = 0.142$), but not for education (10.0 ± 3.0 vs. 13.2 ± 3.7 , $t(39) = 2.57$, $p = 0.014$).

Significantly higher values were reported for the alexithymic FM group, for both the HADS total score (alexithymic vs. non-alexithymic, mean \pm SD: 22.7 ± 6.2 vs. 16.7 ± 6.2 , $t(39) = -2.75$, $p = 0.009$) and the HADS-A subscale score (11.4 ± 3.9 vs. 7.9 ± 3.3 , $t(39) = -2.80$, $p = 0.008$) in the assessment of psychological distress. No significant difference was observed for the HADS-D subscale (11.4 ± 3.6 vs. 8.8 ± 4.4 , $t(39) = -1.71$, $p = 0.095$).

With respect to pain-attribution (Table 4), the alexithymic FM group reported higher scores, i.e., higher pain-attribution, for all the six basic emotions of the Emotional Pain Estimation task (with the only exception of happiness), compared to the non-alexithymic FM group, with a tendency towards statistical significance for the emotion 'anger' (Fig. 2) (Fig. 3 in the Supplementary Material). Finally, a significant difference between alexithymic and non-alexithymic FM samples

was observed for the emotion ‘surprise’ in the Emotional Pain Ascription task, with alexithymic FM participants getting higher scores.

Table 4 about here

Discussion

The present study aimed at verifying the hypothesis that attribution of pain to facial expression of basic emotions (other than pain) increases in patients with FM, distinguishing emotional pain estimation, i.e., the degree of pain associated to facial expressions of emotions, and pain ascription, i.e., the attribution of pain to emotional facial expressions. Our analysis revealed three major results. Firstly, patients with FM did not report increased attribution of pain to emotional facial expression, neither for estimation nor for ascription of pain. Contrary to our expectations, no significant differences were found between patients with FM and HC in our pain-attribution tasks. Secondly, alexithymia, and not FM per se, predicts an increased attribution of pain, specifically in the estimation of pain to an angry facial expression. A statistically significant difference was found in the estimation of pain between alexithymic and non-alexithymic participants in total, as well as a strong tendency towards statistical significance was found between alexithymic and non-alexithymic individuals in both HC and FM groups, with an increased estimation of pain specifically to anger-related facial expressions in the alexithymic individuals. Finally, although alexithymic individuals have an increased estimation of pain to angry facial expression they did not report ascription of pain to facial expression of emotions, showing no specific problem in the recognition of either anger or other basic emotions.

To the best of our knowledge, only a few studies investigated pain recognition in human faces in FM patients, with conflicting results (Gonzalez-Roldan et al., 2013; Lee et al., 2013). In their study,

Gonzalez-Roldan et al. (2013) found that patients with FM showed greater theta power in electroencephalography signals in response to faces expressing pain and anger, compared to HC. Conversely, Lee et al. (2013) found that patients with FM compared to HC did not show a greater pain response while observing pain in others, but generally showed lesser activation in cortical regions known to play a role in the processing of pain. The latter results, in association with ours, suggest that patients with FM might empathize less with other people in pain, possibly in order to lessen arousal and aversive self-oriented emotions (Lee et al., 2013). The failure to find significant differences between the groups used on the reported paradigm might thus indicate that patients with FM do not show a specific bias towards pain-attribution to faces of other individuals, but focus more on their own experience of pain.

Going further with our initial results, we hypothesized that factors, other than FM, could influence the individual evaluation of pain to emotional facial expression. Different studies have shown that alexithymia influenced the processing of the facial expressions of other individuals independently of the presence of a specific clinical condition, such as autism spectrum disorder, somatoform disorders or eating disorders (Cook et al., 2013; Grynberg et al., 2012; Pedrosa Gil et al., 2009). In addition, different authors have highlighted that alexithymia in FM does not emerge as a product of pain per se, but rather is intrinsic to this syndrome, and that high levels of alexithymia may interfere with correct classification of emotional expression (Sayar et al., 2004; Weiss et al., 2013). Moreover, alexithymia has been shown to be associated with pain in patients with different disorders and syndromes such as rheumatoid arthritis, systemic lupus erythematosus and migraine headaches (Lumley et al., 2005), chronic myofascial pain (Lumley et al., 2002), temporomandibular disorder (Glaros and Lumley, 2005), low back pain (Mehling and Krause, 2007), and FM (Castelli et al., 2012; Di Tella and Castelli, 2013; Huber et al., 2009). The broad spectrum of conditions in which alexithymia predicts pain suggests that this dimension may extend beyond the presence of FM (Hosoi et al., 2010).

In the present study, we reported that alexithymic participants in general, as well as HC and FM alexithymic individuals, separately considered, have an increased estimation of pain specifically to angry facial expression. On the other hand, no impairment was reported in the recognition and classification of emotions of other individuals (i.e., Emotional Pain Ascription task) for the alexithymic individuals.

This pattern of results suggests that alexithymic individuals may display difficulties in processing the emotions of other individuals when they are not provided emotional definitions to make faces meaningful (Nook et al., 2015). Indeed, the present group of alexithymic individuals misinterpreted emotional facial expressions of other individuals (attributing them to pain), only when emotions labels were not given to them, as in the case of the Emotional Pain Estimation task. These results are in line with a previous study of Nook et al. (2015), which found that individuals with alexithymia exhibited difficulties in recognizing emotions based on visual cues alone, but not when emotion labels were provided. The impairments observed in alexithymia may thus result from an inability to spontaneously apply emotional concepts, rather than an incapability of correctly understanding emotional terms.

Although very few studies have investigated processing of anger in alexithymia, similar results were found by Vermeulen et al. (2006) and Vermeulen et al. (2008). Using an affective priming paradigm, a moderating impact of alexithymia on the automatic processing of anger affective information was found after controlling for participants' current mood state, as well as for traits of anxiety and depression (Vermeulen et al., 2006). Moreover, in a further study, Vermeulen et al. (2008) found a categorical perception effect for emotional faces in HC but not in alexithymia individuals, showing a delayed categorical perception of emotional facial expressions in high alexithymic groups. Interestingly, their findings showed a suppressed categorical perception specific to angry faces. Finally, Kano et al. (2003) found convergent evidences on a specific effect of alexithymia on brain regions involved in the implicit processing of facial expression of anger as compared to neutral faces. They found that ACC and insula were less activated in alexithymic individuals in response to angry

faces than neutral faces, suggesting that individuals with alexithymia process facial expressions differently from individuals without alexithymia, particularly for anger. It is interesting to note that, similar to our results, the rating scores to emotion after each scan showed that individuals with alexithymia accurately recognize the emotions shown in facial expressions, and that the ACC involvement was not generalized to all facial expression of emotion but was specific to anger.

A possible interpretation for our results can thus rely on both neuroimaging data and clinical observations. On the one hand, the link between ACC activity, alexithymia severity and anger processing could contribute to explain the specific significance found for the attribution of pain to angry faces. Indeed, the involvement of ACC in alexithymia was found not only in the study of Kano et al. (2003), but also in other brain imaging studies (Aftanas et al., 2003; Berthoz et al., 2002), supporting the hypothesis of an ACC compromised functioning in individuals with high levels of alexithymia (Vermeulen et al., 2006). Empirical evidence also showed a positive association between the ACC reactivity and the intensity of anger (Blair et al., 1999), providing further support for the pattern of results found both in the present study and in the above-mentioned works. On the other hand, a crucial role in the development of emotional facial recognition abilities and affective regulation skills is played by the early relationship between an infant and his/her caregivers (Vermeulen et al., 2008). The development of affective awareness and emotional processing abilities is, in fact, enabled by the sharing and mirroring of emotional expressions with the caregiver (Taylor and Bagby, 2000; Taylor et al., 1999). Any impairment in this reciprocal sharing of emotions is likely to have negative outcomes for the child's emotional development and may represent an initial step towards the manifestation of alexithymic features. This could in turn impair the infant's ability to both regulate and identify his/her own feelings, and to correctly recognize emotions of other individuals, with negative consequences for social functioning (Vermeulen et al., 2008).

Finally, the significant impact of alexithymia on anger facial expressions we reported was still observed after controlling for psychological distress (HADS total score). This additional statistical analysis was conducted since the present group of alexithymic individuals reported significantly

higher scores on both the total and the subscales of the HADS, compared to non-alexithymic ones. The available evidence shows a positive relationship between the high levels of alexithymia and the presence of anxiety and depression symptoms, both in clinical and non-clinical alexithymic populations (Berthoz and Hill, 2005; de Waal et al., 2004; Eizaguirre et al., 2004), which may, in turn, negatively affect the processing of emotional facial expressions (Rossignol et al., 2005). However, in our study the psychological distress cannot be considered a significant predictor of the facial expressions of anger, supporting the idea that, though mood disorders and alexithymia share common variance, they are dissimilar constructs (Grynberg et al., 2012).

Limitations

The present study has some limitations that should be considered. Firstly, even though we enrolled an adequate number of participants, our study is still limited by a relatively small sample size, especially with regard to the alexithymic healthy group. Secondly, the use of self-reported instruments might have led to underestimation of, for example, the presence of frank alexithymic traits in individuals having borderline cut-off scores. Paradoxically, explicit self-report measures require the respondents to be aware of their reduced ability to identify and describe feelings (Adenzato and Poletti, 2013; Parling et al., 2010).

Future studies should thus use a more specific measure for the evaluation of pain to faces of other individuals and performance-based instruments for the analysis of alexithymia, in addition to traditional self-reported tests.

Conclusions

Taken together, the findings reported in the current study suggest that alexithymia, rather than chronic pain per se, plays a key role in explaining the differences we found in pain attribution to emotions. In particular, alexithymic individuals might display a bias for the encoding of negative facial expressions, which can lead them to see pain particularly in faces expressing anger.

These results provide an intriguing starting point for investigating the association between alexithymia and the processing of emotional facial expressions further, with particular regard to the attribution of pain to anger faces, in both healthy and clinical populations.

Clarifying to what extent alexithymia may affect the recognition of emotional facial expressions would allow clinicians to structure more specific and tailored interventions, based on each individual's needs.

Contributors

Study concept and design: MDT, IE, LC, MA. Data acquisition: MDT, AG, AR, VT. Patients recruitment: FC, EF. Data analysis and interpretation: MDT, IE, MA. Drafting of the manuscript: MDT, IE, MA. Statistical Analysis: MDT. Study supervision: MA. All authors have approved the final article.

Acknowledgements

We would like to thank the participants involved in the study and Francesca Miti for her help with data collection of HC sample.

Funding

Ivan Enrici, Mauro Adenzato e Lorys Castelli were supported by University of Turin grants (Ricerca scientifica finanziata dall'Università). Mauro Adenzato was also supported by MIUR of Italy (FIRB 2012-2017, RBFR12FOBD_001), Lorys Castelli was also supported by the CRT Foundation project "Efficacia della psicoterapia breve nel trattamento di pazienti con Sindrome Fibromialgica". The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflict of interest

All authors declare no conflict of interest.

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Table 1. Comparisons between FM and HC groups on the two pain-attribution tasks.

	FM Group (N = 41)	HC Group (N = 82)	Test (df)	<i>p</i>	Effect size
<i>Emotional Pain Estimation (Ekman Pain VAS)</i>					
Anger	28.0 (25.1)	29.0 (23.0)	t(121) = -0.22	0.825	<i>d</i> = -0.04
Sadness	45.1 (29.0)	40.4 (23.7)	t(67.36) = 0.90	0.374	<i>d</i> = 0.18
Fear	35.4 (30.5)	33.6 (23.8)	t(65.18) = 0.33	0.746	<i>d</i> = 0.06
Surprise	13.7 (14.8)	15.0 (14.6)	t(121) = -0.45	0.653	<i>d</i> = -0.09
Disgust	24.5 (23.5)	25.1 (20.8)	t(121) = -0.14	0.889	<i>d</i> = -0.03
Happiness	55.8	65.1	U = 1425.00	0.143	<i>r</i> = -0.13
<i>Emotional Pain Ascription (Ekman Pain label)</i>					
Total	46.1 (5.1)	45.5 (5.5)	t(121) = 0.62	0.539	<i>d</i> = 0.12
Anger	7.9 (1.4)	7.9 (1.5)	t(121) = 0.13	0.897	<i>d</i> = 0.02
Sadness	6.2 (2.0)	6.2 (1.8)	t(121) = 0.07	0.945	<i>d</i> = 0.01
Fear	5.2 (2.8)	4.6 (2.5)	t(121) = 1.12	0.266	<i>d</i> = 0.21
Surprise	57.2	64.4	U = 1485.00	0.244	<i>r</i> = -0.11
Disgust	65.8	60.1	U = 1525.00	0.392	<i>r</i> = -0.08
Happiness	60.5	62.8	U = 1619.00	0.653	<i>r</i> = -0.04
Pain	4.5 (2.7)	5.1 (3.5)	t(121) = -0.88	0.380	<i>d</i> = -0.18

df = Degrees of freedom; FM = Fibromyalgia; HC = Healthy Controls; VAS = Visual Analogue Scale.

Table 2. Comparisons between alexithymic and non-alexithymic participants in total on the two pain-attribution tasks

	Alexithymic Group (N = 21)	Non-alexithymic Group (N = 102)	Test (df)	<i>p</i>	Effect size
<i>Emotional Pain Estimation (Ekman Pain VAS)</i>					
Anger	40.4 (26.5)	26.2 (22.4)	t(121) = -2.56	0.012	<i>d</i> = 0.58
Sadness	47.4 (28.9)	40.9 (24.8)	t(121) = -1.07	0.287	<i>d</i> = 0.24
Fear	43.2 (30.6)	32.3 (24.9)	t(121) = -1.76	0.081	<i>d</i> = 0.39
Surprise	16.2 (14.2)	14.2 (14.8)	t(121) = -0.56	0.578	<i>d</i> = 0.14
Disgust	31.4 (21.6)	23.6 (21.5)	t(121) = -1.52	0.131	<i>d</i> = 0.36
Happiness	63.4	55.3	U = 931.00	0.315	<i>r</i> = -0.09
<i>Emotional Pain Ascription (Ekman Pain label)</i>					
Total	45.6 (4.2)	45.8 (5.6)	t(121) = 0.14	0.887	<i>d</i> = -0.04
Anger	7.7 (1.2)	7.9 (1.5)	t(121) = 0.72	0.473	<i>d</i> = -0.26
Sadness	6.7 (1.6)	6.1 (1.9)	t(121) = -1.41	0.163	<i>d</i> = 0.35
Fear	4.1 (2.7)	4.9 (2.6)	t(121) = 1.21	0.229	<i>d</i> = -0.29
Surprise	71.4	60.1	U = 873.50	0.142	<i>r</i> = -0.13
Disgust	52.5	64.0	U = 872.00	0.172	<i>r</i> = -0.12
Happiness	62.6	61.9	U = 1059.00	0.913	<i>r</i> = -0.01
Pain	5.0 (3.2)	4.9 (3.3)	t(121) = -0.08	0.939	<i>d</i> = 0.02

df = Degrees of freedom; VAS = Visual Analogue Scale.

Table 3. Comparisons between alexithymic and non-alexithymic healthy individuals on the two pain-attribution tasks.

	Alexithymic HC Group (N = 10)	Non- alexithymic HC Group (N = 72)	Test (df)	<i>p</i>	Effect size
<i>Emotional Pain Estimation (Ekman Pain VAS)</i>					
Anger	40.4 (26.5)	27.2 (22.7)	t(80) = -1.95	0.054	<i>d</i> = 0.66
Sadness	47.4 (28.9)	39.8 (23.8)	t(80) = -0.61	0.541	<i>d</i> = 0.21
Fear	43.2 (30.6)	32.5 (23.4)	t(80) = -1.14	0.259	<i>d</i> = 0.37
Surprise	16.2 (14.2)	14.8 (14.9)	t(80) = -0.29	0.776	<i>d</i> = 0.10
Disgust	31.4 (21.6)	24.1 (20.6)	t(80) = -1.25	0.213	<i>d</i> = 0.42
Happiness	63.4	41.5	U = 359.50	0.994	<i>r</i> = -0.00
<i>Emotional Pain Ascription (Ekman Pain label)</i>					
Total	43.8 (4.1)	45.8 (5.7)	t(80) = 1.05	0.298	<i>d</i> = -0.39
Anger	7.3 (1.2)	7.9 (1.6)	t(80) = 1.26	0.214	<i>d</i> = -0.46
Sadness	6.4 (1.5)	6.2 (1.8)	t(80) = -0.39	0.696	<i>d</i> = 0.14
Fear	4.1 (2.7)	4.7 (2.5)	t(80) = 0.65	0.517	<i>d</i> = -0.21
Surprise	42.6	41.4	U = 349.50	0.867	<i>r</i> = -0.02
Disgust	27.1	43.5	U = 215.50	0.037	<i>r</i> = -0.23
Happiness	38.6	41.9	U = 334.50	0.617	<i>r</i> = -0.06
Pain	5.4 (3.5)	5.0 (3.5)	t(80) = -0.30	0.763	<i>d</i> = 0.10

df = Degrees of freedom; HC = Healthy Controls; VAS = Visual Analogue Scale.

Table 4. Comparisons between alexithymic and non-alexithymic patients with FM on the two pain-attribution tasks.

	Alexithymic FM Group (N = 11)	Non- alexithymic FM Group (N = 30)	Test (df)	<i>p</i>	Effect size
<i>Emotional Pain Estimation (Ekman Pain VAS)</i>					
Anger	38.9 (30.8)	24.0 (21.9)	t(39) = -1.73	0.092	<i>d</i> = 0.56
Sadness	49.8 (34.3)	43.4 (27.3)	t(39) = -0.63	0.535	<i>d</i> = -0.21
Fear	44.7 (35.2)	31.9 (28.4)	t(39) = -1.20	0.240	<i>d</i> = -0.40
Surprise	16.1 (15.9)	12.8 (14.6)	t(39) = -0.63	0.530	<i>d</i> = -0.22
Disgust	30.2 (22.8)	22.5 (23.8)	t(39) = -0.93	0.360	<i>d</i> = -0.33
Happiness	17.9	22.1	U = 131.00	0.255	<i>r</i> = -0.18
<i>Emotional Pain Ascription (Ekman Pain label)</i>					
Total	47.2 (3.7)	45.8 (5.5)	t(39) = -0.79	0.435	<i>d</i> = -0.30
Anger	8.0 (1.2)	7.9 (1.5)	t(39) = -0.27	0.214	<i>d</i> = -0.01
Sadness	7.0 (1.8)	5.9 (2.1)	t(39) = -1.52	0.136	<i>d</i> = -0.56
Fear	4.2 (2.8)	5.5 (2.8)	t(39) = 1.33	0.192	<i>d</i> = 0.47
Surprise	27.5	18.6	U = 93.50	0.023	<i>r</i> = -0.35
Disgust	8.4 (1.0)	8.3 (1.3)	t(39) = -0.14	0.888	<i>d</i> = -0.05
Happiness	22.9	20.3	U = 144.50	0.434	<i>r</i> = -0.12
Pain	4.6 (3.1)	4.5 (2.6)	t(39) = -0.01	0.990	<i>d</i> = -0.01

df = Degrees of freedom; FM = Fibromyalgia; VAS = Visual Analogue Scale.

Figure 1

a)



No
Pain



Worst
Pain

b)



Disgust Pain Happiness
Fear Anger Surprise Sadness

Figure 2

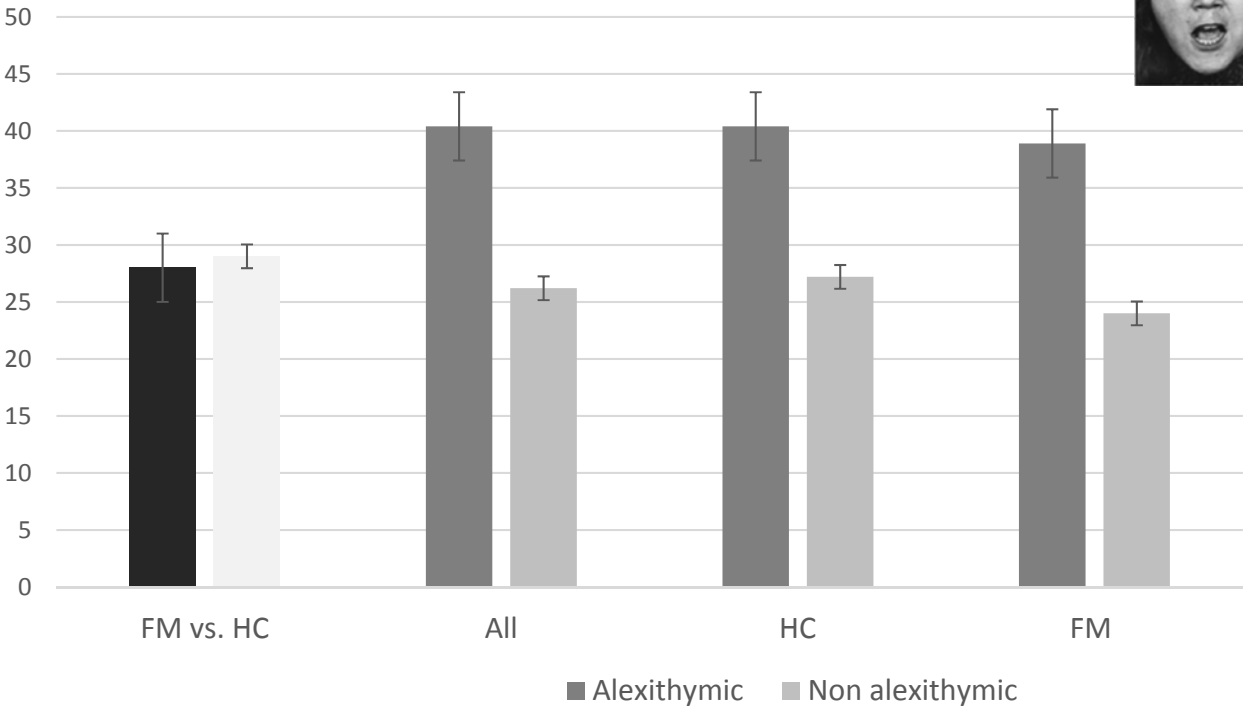


Figure Captions

Figure 1. A) Example stimulus of the Pain Estimation task used for the evaluation of pain attribution. The participants were provided with the following instructions: “Now you will see some pictures showing human faces. For each image, indicate if, in your opinion, that face expresses pain. Please answer by checking your response on the line ranging from "no pain" to "worst pain"”. **B)** Example stimulus of the Pain Ascription task used for the evaluation of pain attribution. The participants were provided with the following instructions: “Now you will see some pictures showing human faces. Among the seven labels provided under each photo, please choose the one that best describes the face showed”.

Figure 2. Emotional Pain Estimation scores for facial expression of anger in the planned analysis, i.e., fibromyalgia vs. healthy control samples (FM vs. HC), as well as in the three other series of unplanned analyses, i.e., alexithymic vs. non-alexithymic participants in total (All), healthy individuals (HC) and patients with fibromyalgia (FM).