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Changes in facial emotion expression during a psychotherapeutic intervention for patients with borderline personality disorder

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ABSTRACT

Emotional dysregulation is one of the main features of Borderline Personality Disorder (BPD). Therefore, it constitutes a central therapeutic objective of the interventions that have proven to be effective for these patients, including the Acceptance and Commitment Therapy (ACT). However, benefits on emotional regulation have been evaluated through self-report instruments, and an anatomically based, objective, and precise measurement of the ability to change the type, duration and frequency of emotions is still needed. Objective: To assess facial emotion expression, valence and arousal during an ACT based intervention, between initial, middle and final therapeutic sessions for BPD patients. Method: Using the FaceReader 7.0, 29 recordings of individual therapeutic sessions for BPD patients during an ACT intervention trial were analyzed. Results: Happiness and fear intensity increase from the beginning to the end of the sessions, while sadness decreases. Emotional valence exhibits a significant decrease in its negative value during sessions from −0.13 (S.D. = 0.12) at the initial part of the sessions to −0.06 (S.D. = 0.08) by the end of the sessions, with a moderate effect size (Cohen d = 0.69). Emotional arousal increased from the beginning to the end of sessions and whole intervention. Conclusion: The emotional valence and arousal differed according to the psychotherapeutically process involved during ACT intervention, suggesting that the systematic analysis of facial expressions allows a rigorously examination of the relations between emotions, physiological processes, and instrumental behavior experimented though a psychotherapeutically process.

1. Introduction

Emotional dysregulation is one of the main features of Borderline Personality Disorder (BPD) (American Psychiatric World Medical Association, 2013; Herman, 1997; Strosahl, 2004), and has been associated with substance abuse, suicidal behaviors, explosive outbursts of anger, depression and anxiety, as well as the maintenance of post-traumatic and dissociative symptoms, which in turn notably decrease the self-image and quality of life of affected patients (Farilholme et al., 2010).

From a contextual behavioral perspective, BPD is conceptualized as a severe problem of experiential avoidance (Hayes et al., 1996). The interaction between biological and historical antecedents results in the presence of unusual and negative emotional experiences, leading to severely dysfunctional behaviors aimed at reducing psychological distress in the short term yet which threaten survival, the satisfaction of personal goals and the establishment of personal identity (Morton and Shaw, 2012).

In this respect Acceptance and Commitment Therapy (ACT) (Hayes, 2004), designed to promote psychological flexibility, has demonstrated benefits in affective and posttraumatic stress symptoms (Siang-Yang, 2011), interpersonal relationships (Morton and Shaw, 2012) and quality of life in patients with BPD (Yust & Pérez-Díaz, 2012), particularly when combined with strategies from Dialectical Behavior Therapy (DBT) and Functional Analytic Psychotherapy (FAP) (Apsche, DiMeo, 2012; Waltz et al., 2010).

In order to determine whether the ability to regulate negative emotions –by changing their nature, duration and frequency-is indeed the mechanism of change of this intervention, accurate, anatomically-based, objective, methods for their measurement should be used, to avoid the bias of self-report instruments. For example, the Facial Action Coding System (FACS) proposed by Ekman and Friesen (1978) specified

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Table 1
Demographic features and number of videos of the patients included in the study.

Variables	*Patient 1*	*Patient 2*	*Patient 3*	*Patient 4*	*Patient 5*	*Patient 6*
Sex	Female	Female	Female	Female	Female	Female
Age (years)	27	41	31	25	41	21
Marital status	Single	Married	Single	Single	Single	Single
Education	Bachelor degree	Bachelor degree	High-school	High-school	Postgraduate	High-school
Occupation	Student	Housewife	Student	Unemployed	Employed	Student
Total videos	3	1	2	2	3	6
Initial	2	1	2	1	1	2
Intermediate	1	0	0	2	2	1
Final	0	0	0	0	0	3
BEST Score	25	35	37	35	34	40
Variables	*Patient 7*	*Patient 8*	*Patient 9*	*Patient 10*	*Patient 11*	*Patient 12*
Sex	Female	Female	Female	Female	Female	Female
Age (years)	26	22	48	28	27	43
Marital status	Single	Single	Single	Married	Married	Single
Education	High-school	Bachelor degree	Bachelor degree	Bachelor degree	Bachelor degree	Bachelor degree
Occupation	Student	Student	Employed	Employed	Unemployed	Employed
Total videos	2	5	1	2	1	1
Initial	2	1	0	1	1	1
Intermediate	0	3	1	1	0	0
Final	0	1	0	0	0	0
BEST Score	52	25	44	33	39	31

the muscles involved in every change of appearance or expressive behavior in each region of the face, allowing a rigorous examination of the link between expressions, physiological processes, and instrumental behavior by a previously trained assessor (Cohen et al., 1986; Ekman et al., 1983; Fridlund et al., 1984; Rusalova et al., 1975; Schwartz et al., 1976). Nowadays, this type of evaluations can be systematically performed using software such as the FaceReader 7.0.

The aim of this study was to assess facial emotion expression, valence and arousal during an ACT-based psychotherapeutic intervention, between the initial, middle and final therapeutic sessions for patients with BPD. We hypothesize that the intensity of expression of facial emotions, valence and arousal will be modified during the ACT therapeutic trial depending on the process involved.

2. Methods

2.1. Ethical statement

All procedures complied with the ethical standards of the Helsinki Declaration of 1975 (World Medical Association, 2013), and were approved by the Ethics Review Board of the Ramón de la Fuente National Institute of Psychiatry (Instituto Nacional de Psiquiatría Ramón de la Fuente Muñíz, Spanish acronym INPFRM), in Mexico City, where patients were recruited. Participation was voluntary and all the patients gave their written informed consent after the research objectives and procedures had been fully explained.

2.2. Patients

This was an observational study that included 12 female adult patients recruited at the Borderline Personality Disorder Clinic at the outpatient services at the INPRFM, a specialized mental health center in Mexico City. All participants were undergoing treatment for BPD as part of routine care with ACT-based therapy. The mean age of the patients was 31.6 years (S.D. = 9.0, range 21–48). Most of them were single (75.0%, n = 9) and were currently students (41.7%, n = 5) or engaged in paid employment (33.3%, n = 4). Over half held a bachelor's degree (58.3%, n = 7). Illness severity, assessed through the Borderline Evaluation of Severity Over Time (BEST) (Prohl et al., 2009) was moderate, with a total mean score during the initial phase of the therapeutic intervention of 35.8 (S.D. = 7.5, range 25–52).

2.3. Procedures

ACT based treatment is a combined intervention resulting from the integration of ACT (Hayes, 2004), reinforced with DBT (Linehan, 1996) and FAP strategies (Tsai et al., 2012). This therapeutic approach emphasizes the validation and acceptance of personal psychological experiences and distinguishes them from the use of avoidant experiential behaviors that lead to emotional dysregulation. Therapeutic strategies focus on strengthening the acceptance of psychological distress, training in effective emotional regulation skills and the use of a variety of interpersonal reinforcement techniques (Reyes, 2013). The intervention includes 16 individual and 18 group sessions. In both modalities, sessions are guided by a psychologist trained in all therapeutic strategies. For the present study, only individual sessions were analyzed.

All participants receiving specialized treatment at the Borderline Personality Disorder Clinic signed an informed consent form, authorizing the recording of their therapeutic sessions. All videos were filmed with a Canon XA10–HD in the consulting room where patients received individual therapeutic intervention. This was a well-lit room without loud ambient noise. Given that patients normally look at the therapist during individual sessions, the camera was placed in front of where the patient sits at an approximate distance of 1.5 m to focus on the patient's face and allow facial expression recording and subsequent analysis using FaceReader 7 software. In order to avoid altering the usual routine of the session or influencing the interaction between the patient and the therapist, patients were not instructed to look at the camera. As a result, some videos lacked sufficient quality to be processed given the loss of data continuity due to the lack of follow-up of the patient's face.

This process resulted in 29 naturalistic, spontaneous videos from some of the therapy sessions of the 12 patients recruited. Thus, the 29 videos analyzed do not represent a follow-up of the 12 patients. For some patients, only one video was able to be analyzed, whereas for other patients, more videos could be analyzed.

Accordingly, we regarded the video of each session as an independent unit for comparison purposes. Videos were classified according to the stage of the session during the therapeutic intervention when it was recorded and according to the time frames during each session. Stages were classified as: initial (sessions 1 to 3), intermediate (sessions 4 to 7) and final (sessions 8 to 11). For time classification, the first and last 10 min of each session were used. Patient's characteristics

Table 2
Factorial ANOVA test results for intensity of emotions, emotional valence and arousal.

	Sessions		*Values*		*Analysis of Variance*		*Effect Tests*			*Shapiro-Wilk W Test*	
Emotion	Stage	Time	Mean	S.D.	$F_{(5, 52)}$	*p*	Session	F	*p*	W	*p*
Neutral	Initial	FM	0.555	0.098	1.54	0.19	Time	0.32	0.57	0.97	0.24
		LM	0.609	0.108							
	Intermediate	FM	0.639	0.092			Stage	2.69	0.08		
		LM	0.640	0.090							
	Final	FM	0.570	0.064			Time x Stage	0.61	0.55		
		LM	0.562	0.073							
Happiness (T)	Initial	FM	0.047	0.048	3.21	0.01[a]	Time	9.40	0.003[a]	0.97	0.12
		LM	0.057	0.043							
	Intermediate	FM	0.022	0.017			Stage	2.19	0.12		
		LM	0.068	0.044							
	Final	FM	0.058	0.047			Time x Stage	1.10	0.34		
		LM	0.106	0.064							
Sadness (T)	Initial	FM	0.158	0.104	1.67	0.16	Time	7.34	0.009[a]	0.99	0.92
		LM	0.098	0.040							
	Intermediate	FM	0.129	0.101			Stage	0.22	0.80		
		LM	0.092	0.039							
	Final	FM	0.155	0.061			Time x Stage	0.68	0.51		
		LM	0.086	0.065							
Anger (T)	Initial	FM	0.020	0.018	1.25	0.30	Time	2.98	0.09	0.98	0.32
		LM	0.016	0.011							
	Intermediate	FM	0.011	0.011			Stage	1.03	0.36		
		LM	0.018	0.013							
	Final	FM	0.009	0.004			Time x Stage	1.16	0.32		
		LM	0.015	0.005							
Surprise (T)	Initial	FM	0.059	0.046	1.11	0.37	Time	2.84	0.10	0.99	0.74
		LM	0.068	0.035							
	Intermediate	FM	0.044	0.045			Stage	1.06	0.35		
		LM	0.057	0.030							
	Final	FM	0.047	0.005			Time x Stage	0.10	0.90		
		LM	0.068	0.030							
Fear (T)	Initial	FM	0.027	0.030	2.32	0.06	Time	5.39	0.024[a]	0.99	0.95
		LM	0.034	0.019							
	Intermediate	FM	0.012	0.012			Stage	1.61	0.21		
		LM	0.027	0.019							
	Final	FM	0.020	0.010			Time x Stage	0.54	0.58		
		LM	0.025	0.008							
Disgust (T)	Initial	FM	0.009	0.008	1.62	0.17	Time	3.23	0.08	0.97	0.10
		LM	0.010	0.010							
	Intermediate	FM	0.012	0.010			Stage	2.22	0.12		
		LM	0.019	0.017							
	Final	FM	0.005	0.002			Time x Stage	0.85	0.43		
		LM	0.013	0.005							
Contempt (T)	Initial	FM	0.014	0.013	1.00	0.43	Time	1.78	0.19	0.97	0.12
		LM	0.016	0.013							
	Intermediate	FM	0.007	0.006			Stage	1.06	0.36		
		LM	0.011	0.004							
	Final	FM	0.014	0.013			Time x Stage	0.43	0.65		
		LM	0.019	0.019							
Valence	Initial	FM	−0.140	0.131	1.90	0.11	Time	7.33	0.009[a]	0.98	0.37
		LM	−0.080	0.080							
	Intermediate	FM	−0.130	0.101			Stage	0.80	0.46		
		LM	−0.060	0.062							
	Final	FM	−0.120	0.106			Time x Stage	0.14	0.87		
		LM	−0.010	0.125							
Arousal	Initial	FM	0.320	0.110	6.14	< 0.001[a]	Time	20.36	< 0.001[a]	0.98	0.58
		LM	0.390	0.050							
	Intermediate	FM	0.220	0.110			Stage	4.45	0.016[a]		
		LM	0.360	0.060							
	Final	FM	0.310	0.110			Time x Stage	1.34	0.27		
		LM	0.450	0.070							

(T) Indicates that the original data were transformed; **FM** = First minutes; **LM** = Last minutes.
[a] Indicates statistically significant differences. Session Time df = 1, Session Stage df = 2, Session Time x Stage df = 2.

as well as the number of videos of each patient analyzed and the stage of the session of every video are shown in Table 1.

In addition, the emotions, arousal and valence of patients with at least one video from the three stages of the therapeutic intervention will be presented.

2.4. Analysis of facial expression emotion

FaceReader software version 7 was used to analyze facial expressions. This program undertakes an automatic analysis of the six basic emotions (happiness, sadness, anger, surprise, fear and disgust) as well as contempt or neutral emotional expression in facial images and videos, on a frame-by-frame basis (each frame captures every 0.04 s)

(Ekman, 1970; Ekman and Oster, 1979). The program works in three general stages (van Kuilenburg et al., 2005; den Uyl, van Kuilenburg, 2005; van Kuilenburg, den Uyl, 2008): 1) face detection, 2) face modeling in a previously set algorithm based on the Active Appearance method describing over 500 key face points (Cootes, Taylor, 2000), and 3) classification of expressions performed by a trained artificial neural network (Bishop, 1995). FaceReader can recognize facial expressions with an accuracy of 90%. For some emotions, accuracy is higher, for others lower, ranging from 84.8% for disgust to 95.9% for happiness (Loijens et al., 2015).

Each identified expression is reported as a measure of the intensity of the emotion in values between 0 (the expression is absent) and 1 (the expression is fully present). Facial expression is usually a mixture of several emotions that occur simultaneously with different levels of intensity. Accordingly, the sum of the intensity values for the emotions reported by FaceReader is normally not equal to 1.

2.5. Valence and arousal

Valence and arousal are two other variables analyzed by FaceReader 7. Valence indicates whether the emotional state of the subject is positive or negative. *Happiness* is the only positive expression whereas *sadness*, *anger*, *fear, contempt* and *disgust* are negative. Valence is therefore calculated as the intensity of *happiness* minus the intensity of the negative expression with the highest intensity. For this calculation, *surprise* is not considered, since it can either be a positive or negative expression. Arousal, on the other hand, indicates the degree of the subject's activation or excitement in values between 0 (not active at all) and 1 (highest activation) based on Russell's circumflex model of affect (Russell, 1980). Thus, it is not considered a measure of movement, but rather a measure of the intensity of the 20 facial action units of the Facial Action Coding System (FACS).

2.6. Statistical analysis

Mean values for the intensity of each emotion, valence and arousal are presented as means and standard deviations (S.D.). Generalized linear models (GLM) with factorial ANOVA and Tukey HSD tests were used to assess mean changes in intensity of emotions, valence and arousal among the *Stages* of sessions, within *Time* and to test the interaction effect of *Stage xTime*. The distribution of the factors analyzed was verified by the Shapiro-Wilk test. For those data not normally distributed, Box-Cox transformations were applied, as this method can make distributions more normal and stabilize variance, and new factorial ANOVA tests were applied. Effect size (Cohen *d*) was computed for significant results in the ANOVA model. Significance was set at a level of 0.05. All statistical procedures were performed using JMP v.11 software.

3. Results

Significant effects were observed in the full-factorial ANOVA model for happiness intensity and arousal, with the latter showing differences in the sessions classified by *Stage* and also in the *Time* sessions (Table 2).

The comparison of arousal by *Time* shows that arousal increases from the beginning to the end of therapeutic sessions. For the comparison by *Stage*, a significant decrease in arousal can be observed between the initial and intermediate sessions, which increases again in the final sessions (Fig. 1). A moderate size effect was observed in the *Stage* comparison between initial and intermediate sessions (Cohen $d = 0.69$) and a large size effect was observed between the intermediate and final sessions (Cohen $d = 0.87$) and in the comparison by Time (Cohen $d = 1.17$).

As for the analyses of intensity of emotions, although happiness displays a significant full factorial effect, the largest effect was observed in the comparison of sessions by *Time*. This difference was also observed in the comparison of the intensity of fear, sadness and emotional valence (Table 1), all of which had moderate size effects (happiness $d = 0.78$; sadness $d = 0.67$; fear $d = 0.69$).

The intensity of happiness and fear increases from the beginning to the end of the sessions, while sadness decreases (Fig. 2). As a result of these changes, emotional valence undergoes a significant decrease in its negative value during sessions from -0.13 (S.D. $= 0.12$) during the initial stage of the sessions to -0.06 (S.D. $= 0.08$) at the end of the sessions, with a moderate effect size (Cohen $d = 0.69$).

Videos of two patients (#6 and #8, see Table 1) include the three stages of the therapeutic intervention (initial, intermediate and final sessions) and changes in facial emotion expression and arousal are shown in Fig. 3. In a visual review of the emotional expression and arousal of these patients, no clear pattern of change is observed in emotions as Sadness, Anger, Fear, Disgust and Contempt, while Sadness and Neutral exhibit different patterns in each patient. Happiness and surprise show a similar pattern of decrease during the intermediate sessions and a moderate increase in the final sessions. Arousal appears to be the variable with the most significant changes during the therapeutic interview, with a major increase being observed between the intermediate and final sessions. This is similar to the pattern observed when the videos were analyzed as independent units, where changes were significant as previously mentioned. The level of arousal did not correlate with the patients' symptom severity.

4. Discussion

This study sought primarily to clarify, by using an objective, accurate method of evaluation, whether psychotherapy (ACT-based intervention) can change emotion regulation strategies in ways that reduce the negative emotions frequently experienced by patients with BPD (American Psychiatric World Medical Association, 2013; Fairlholme et al., 2010; Herman, 1997; Strosahl, 2004), which lead to extremely dysfunctional behaviors (Morton and Shaw, 2012). We begin the discussion of our results regarding changes observed at the end of the individual psychotherapeutic sessions (using only videos as units of analysis), and subsequently proceed to interpret changes over time (from the beginning to the end of the intervention) shown through both the analysis of changes by stage of intervention, using videos as units of analysis, and in patients of whom follow-up was possible.

4.1. Changes in facial emotion expression during sessions

According to our data, the psychotherapeutic intervention was related to positive changes in the emotional valance of participants, increasing happiness and decreasing sadness by the end of the sessions (regardless of the stage of the intervention), which may indicate that ACT-based interventions could improve the emotional wellbeing of patients with BPD, and explain their adherence to the psychotherapeutic process.

Interestingly, fear and emotional arousal increased between the beginning and end of the sessions. This could have several explanations related to the therapeutic relationship and/or process. First, fear at the end of the sessions could be related to the perception of losing the security figure the therapist represents; or could be explained by the fact that the last part of the sessions focused on committed action, which corresponds to a behavior involving what is valuable for the patient. This commitment, developed as part of psychological flexibility, can create fear as a primary emotion, when the patient faces contexts related to previous life risks, or physical or emotional integrity. The patient creates value and seeks positive reinforcement but is also afraid of possibly adverse situations and behaving incoherently in the relational networks that originally prompted the experiential avoidance patterns. ACT has been considered for the treatment of psychological difficulties where emotional avoidance is visible, as it helps patients to experience, accept and commit to the emotional reactions they have avoided. One

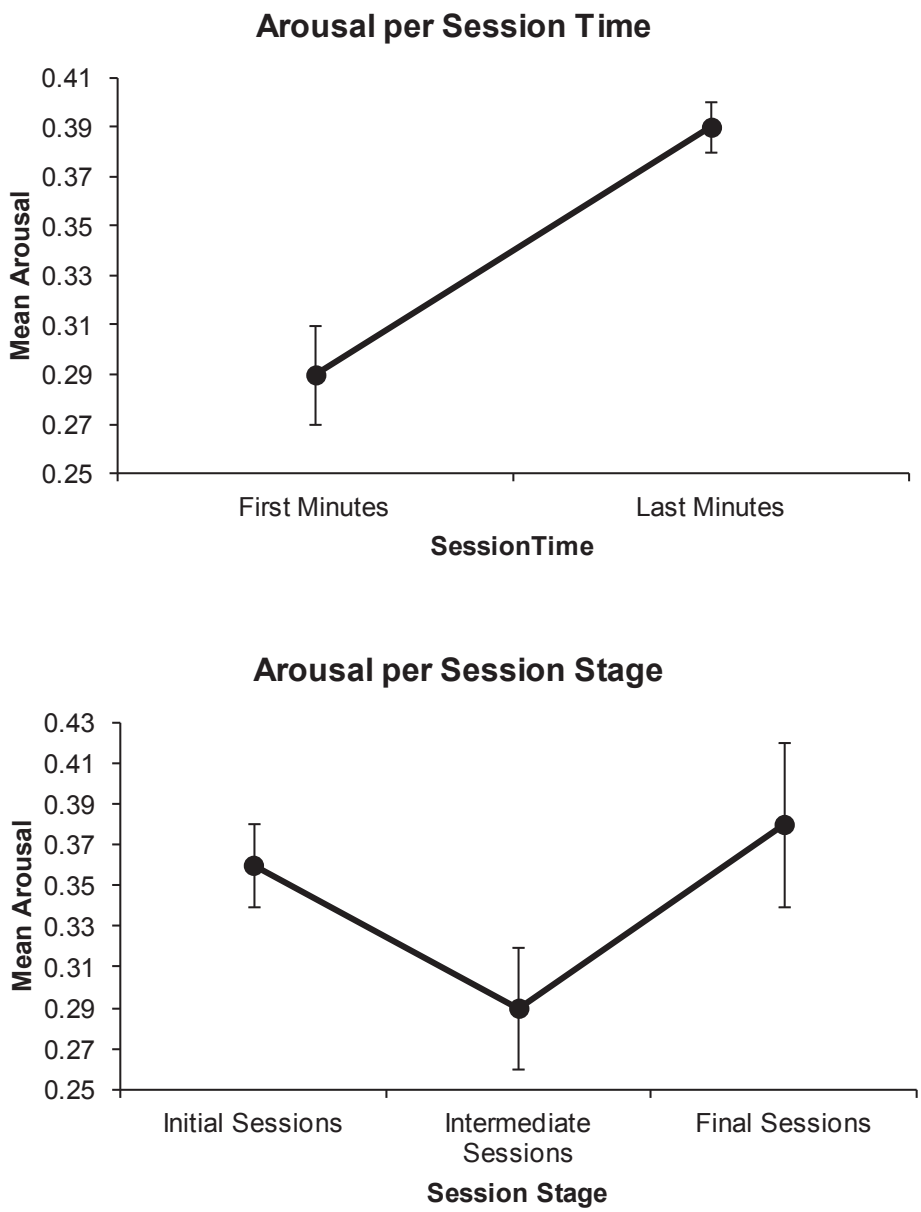


Fig. 1. Mean values and changes in arousal in sessions by *Time* and *Stage*
*Points represent the average, lines represent the increase or decrease, and bars represent the standard error.

of the goals of ACT is to develop committed, value-oriented patterns of action. Committed action will trigger unpleasant experiences in a natural way (Pérez, 1996).

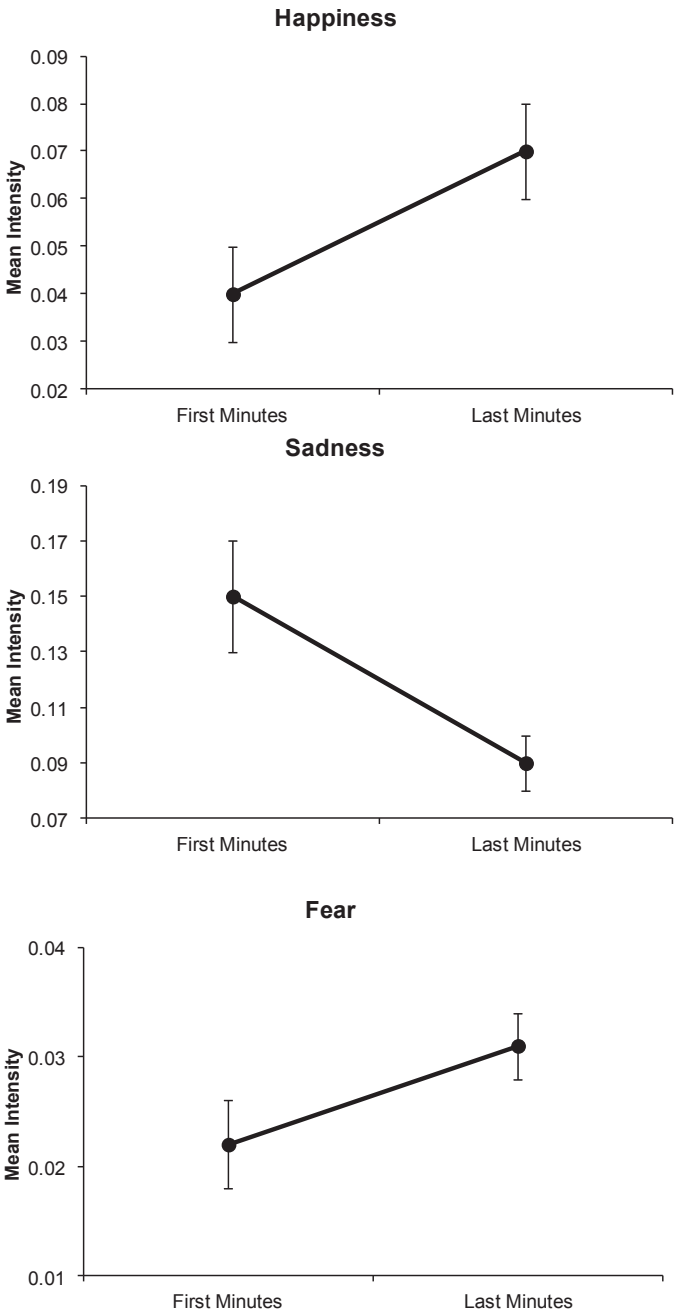
Moreover, the FAP component of the intervention, which emphasizes interpersonal functioning focusing on strategies to work on *in vivo* interpersonal skills as they occur during therapy (Kohlenberg and Tsai, 1991), contains structured activities that promote intimacy in the therapeutic relationship, causing feelings of vulnerability, which may be expressed as fear. These activities may elicit clinically relevant behaviors that allow the therapist to model more adaptive and functional behaviors that facilitate reaching goals (Nelson et al., 2014). Moreover, the expression of fear in these patients could be an adaptive behavior that allows them to avoid their interlocutor to maintain physical distance and reduce social commitment. This feature has recently been studied by Fineberg et al. (2017) and should be borne in mind for future studies in the patient-therapist dyad.

One might expect that, because of the structure of the sessions, at the end of the session, patients would express fear associated with committed actions. It is important to note that from a contextual behavioral perspective, the presence of negative emotions is not considered a problem in itself, but rather a reflection of inflexible patterns of behavior in response to this type of experiences.

On the other hand, the increase in emotional arousal at the end of the sessions could be understood as a proxy of the patient's growing engagement as the interaction progresses, and/or as an expected outcome of experiencing personal emotions fully, lessening the defense present while behaving according to an experiential avoidance agenda, which is a therapeutical process experienced in all the sessions. Showing patients the importance of feeling emotions in their particular intensity is also important in allowing psychological flexibility and therefore emotion regulation (Boulanger et al., 2010).

4.2. Changes in facial emotion expression throughout the intervention

According to the analysis of videos as independent units, arousal was the only variable that shows significant changes though the different stages of intervention; it was moderate at the initial stage, decreased during the middle stage, and reached its highest value at the



*Points represent the average, lines represent the increase or decrease and bars represent the standard error.

Fig. 2. Changes of intensity of emotions during sessions.
*Points represent the average, lines represent the increase or decrease and bars represent the standard error.

final stage of the intervention. The same pattern was observed in patients where follow-up information was available (Fig. 3).

Finally, it should be noted that, in one of the patients in which the follow up was possible (with videos of the three stages of treatment), it was very clear that sadness decreased over time (from the beginning to the end of the intervention as a whole) (Fig. 3).

4.3. Limitations and suggestions

Given its limitations, this study should be regarded as a *very preliminary stage* of evidence about changes in facial emotion expression during a psychotherapeutic intervention for patients with borderline personality disorder. The relatively small number of patients followed up might explain why no significant changes during the stages of the intervention were found, which calls for replications in larger samples.

Thus, from a critical point of view, our results should be taken more as evidence of the usefulness of objective emotional measures (such as FaceReader software) in evaluating the effectiveness of interventions designed to improve emotional regulation in future clinical trials.

Conflicts of interest

The authors declare no conflict of interest.

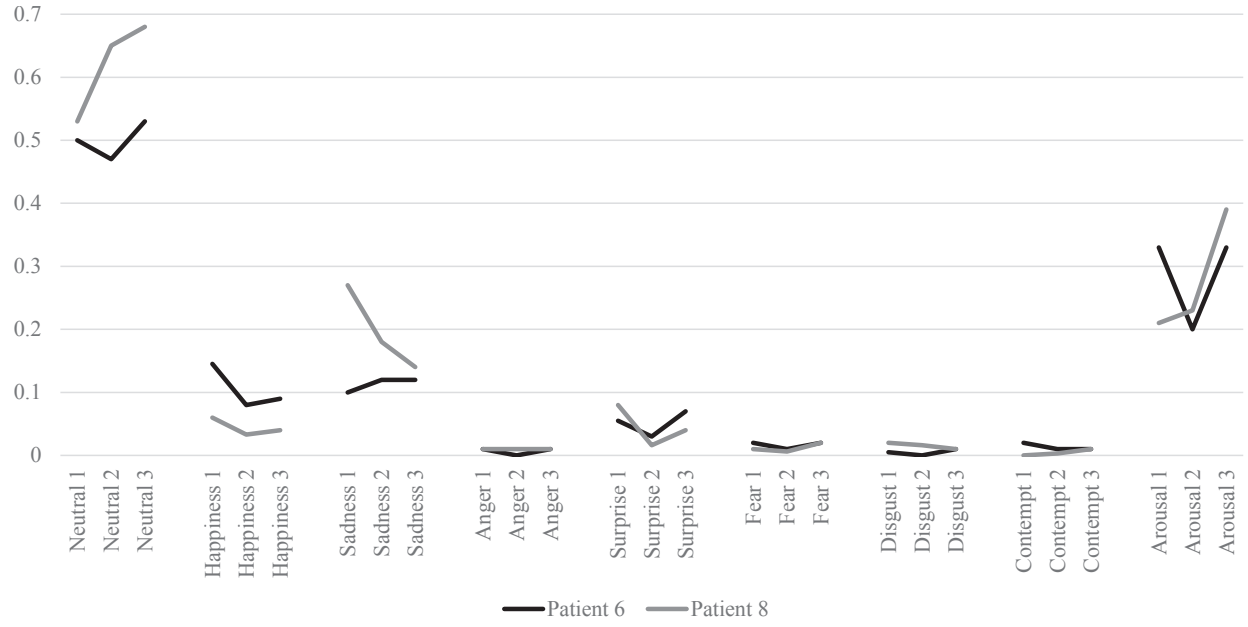


Fig. 3. Changes in facial emotion expression and arousal in BPD patients during the three stages of therapeutic intervention. Information about the two patients whose videos of the three stages of the intervention had adequate quality for the analysis using Face Reader software. The number next to each emotion and arousal indicates the type of therapeutic session evaluated, where "1" indicates the recording of an initial session, "2" an intermediate session and "3" a final session. In the case that there was more than one video associated with a stage of the session, the average intensity was obtained.

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