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The influence of personality traits on emotion expression in bulimic spectrum disorders: A pilot study

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Abstract

Facial expressions are critical in forming social bonds and in signaling one's emotional state to others. In eating disorder patients, impairments in facial emotion recognition have been associated with eating psychopathology severity. Little research however has been carried out on how bulimic spectrum disorder (BSD) patients spontaneously express emotions. Our aim was to investigate emotion expression in BSD patients and to explore the influence of personality traits. Our study comprised 28 BSD women and 15 healthy controls. Facial expressions were recorded while participants played a serious video game. Expressions of anger and joy were used as outcome measures. Overall, BSD participants displayed less facial expressiveness than controls. Among BSD women, expressions of joy were positively associated with reward dependence, novelty seeking and self-directedness, whereas expressions of anger were associated with lower self-directedness. Our findings suggest that specific personality traits are associated with altered emotion facial expression in patients with BSD.

Keywords: eating disorders; bulimic spectrum disorders; personality; emotion expression; serious video games.

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Introduction

Eating disorders (ED) are marked by acute difficulties in socio-emotional processing, which are reflected, inter alia, in difficulties attending to positive facial expressions, reduced eye contact when interacting with others and a tendency to avoid expressing emotions (Dapelo et al., 2015; Treasure, Corfield, & Cardi, 2012). Recent studies focusing on facial emotion expression using computer tasks have also described diminished emotion expression (Dapelo, Bodas, Morris & Tchanturia, 2016; Davies, Schmidt, Stahl, & Tchanturia, 2011; Tárrega et al., 2014) and attentional bias to negative social affective stimuli (Harrison, Sullivan, Tchanturia, & Treasure, 2010) in ED patients compared to healthy controls (HC). These impairments are believed to play a pivotal role as a maintenance factor of disturbed eating behavior (Treasure et al., 2012) and seem to be underpinned by overlapping alterations in brain circuits processing reward and social cognition (Via et al., 2015). Neuroimaging studies have also revealed altered neural responses to facial stimuli in patients with both bulimia nervosa (BN) (Ashworth et al., 2011) and anorexia nervosa (AN) (Fonville, Giampietro, Surguladze, Williams, & Tchanturia, 2014).

Apart from being common in ED, reduced emotion expression has also been associated with autistic spectrum disorders (McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006; Stel, Van Den Heuvel, & Smeets, 2008), neurological disorders such as Parkinson's disease (Clark, Nearing, & Cronin-Golomb, 2010) and other mental disorders (namely psychotic, obsessive, affective and personality disorders) (Davies et al., 2016; Bersani et al., 2012; Renneberg, Heyn, Gebhard, & Bachmann, 2005).

Facial expressions are crucial signals for social communication because they provide information about the mood and emotions that individuals are experiencing at a given moment. Therefore, facial

expressiveness is an essential factor in promoting effective communication and fostering relationships with others. In fact, it is known that facial expressions have an adaptive function and their importance in social interactions and social intelligence is extensively recognized (Schmidt & Cohn, 2001). For this reason, impairments in emotion expression are understood to contribute to poor social functioning and worsening clinical characteristics, and have become an important target in the treatment of ED patients (Lang et al., 2016).

Facial emotion expression can be understood as a behavioral facet of emotion regulation, whereby differences in personality traits manifest in specific facial expressions of emotions such as joy or anger (Tchanturia, Dapelo, Harrison, & Hambrook, 2015). In the case of ED patients, emotion regulation difficulties have been associated with greater ED severity (Danner, Evers, Stok, Van Elburg, & De Ridder, 2012), ED subtype (Wolz et al., 2015), more general psychopathology (Werner & Gross, 2010), and poor prognosis (Wallace, Masson, Safer, & von Ranson, 2014). It is important to note that difficulties in emotion regulation could depend on ED subtype (Danner, Sternheim, & Evers, 2014; Wolz et al., 2015). In this sense, it has been found that BN and binge eating disorder (BED) patients share similar emotional impairments, and that patients with BN or an Other Specified Eating or Feeding Disorder (OSFED) tend to show greater difficulties in emotion regulation than those with AN (Danner et al., 2014; Wolz et al., 2015). In both BN and BED, greater symptom severity is linked to less frequent use of adaptive emotion regulation strategies (such as cognitive reappraisal) and a greater tendency to regulate emotions using disadvantageous methods (mainly by suppressing negative emotions) (Danner et al., 2014). Furthermore, other studies on emotion regulation have found similar results regarding impulsivity in BN and BED (Brockmeyer et al., 2014; Svaldi, Griepenstroh, Tuschen-Caffier, & Ehring, 2012). Moreover, negative mood appears to be mediated by pathological behaviors in both disorders, such as binge

and vomiting. Thus, impulsive eating behaviors can act as an attempt to cope with aversive affect by providing short-term relief in either disease (Brockmeyer et al., 2014).

Given the presence of emotion regulation problems in these disorders, it could be hypothesized that patients with BN or a bulimic spectrum disorder (BSD) might show impairments in facial emotion expression, though there is a paucity of studies in the literature on the subject.

To our knowledge, even though there do exist some studies that have identified an association between facial emotion perception/recognition and personality traits (Andric et al., 2015; Mardaga & Iakimova, 2014), no studies to date have explored associations between these factors in BSD patients. It has been found that personality traits such as novelty seeking, harm avoidance, reward dependence and self-directedness play an important function in the development, maintenance and prognosis of BSDs (Atiye, Miettunen, & Raevuori-Helkamaa, 2015; Fassino, Amianto, Gramaglia, Facchini, & Abbate Daga, 2004). Other studies have suggested that facial expressiveness impairments in BSD patients that could contribute to problems in social functioning. For example, BN patients tend to show less facial expressions of anger even though they report feeling angry (Claes et al., 2012; Tárrega et al., 2014). This incongruence between their true feelings and their facial expressions suggests a tendency to suppress negative emotions. However, further research on the relationship between personality traits and emotion facial expressions are needed before such a conclusion can be reached.

As such, the primary objectives of the present study were threefold: 1) to compare facial emotion expression between **BSD** patients and HC; 2) to analyze the association between emotion expression (specifically joy and anger) and personality traits, after controlling for **ED severity**, **depressive symptomatology** and **body mass index (BMI)**; 3) **To find a model to predict facial**

emotion expression in BSD patients including personality traits, while controlling for ED severity, depressive symptomatology and BMI. Understanding this interaction has clinical implications as spontaneous facial expressions serve as a vital tool for showing empathy, establishing beneficial social bonds and in turn, improving treatment outcome (Arcelus, Haslam, Farrow, & Meyer, 2013; Hartmann, Zeeck, & Barrett, 2010).

Given the aforementioned evidence for impaired emotion expression in BN and the established links between BSD and specific personality traits (mainly novelty seeking, harm avoidance, reward dependence and self-directedness), we hypothesize that: 1) BSD patients will exhibit diminished facial emotion expression and more disparate personality traits compared to HC; 2) levels of facial emotion expression will be associated with specific personality traits (higher anger expression with novelty seeking; higher joy expression with reward dependence and lower joy expression with harm avoidance) in BSD patients, and 3) our model will be able to predict facial emotion expression levels via specific personality traits.

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Materials and Methods

Participants

A total of 43 participants were included in this study: 28 patients with **BSD**, namely BN ($n= 23$), **OSFED-purging subtype ($n = 1$)** and BED ($n = 4$), and 15 HC. Patients were diagnosed according to DSM-5 diagnostic criteria (American Psychiatric Association, 2013), by means of **the Spanish version the SCID-I** (First, Spitzer, Gibbon, & Williams, 1997). **All interviewers were conducted by experienced psychologists and psychiatrists.** Patients were consecutive referrals for assessment and outpatient treatment at Bellvitge University Hospital (**Barcelona, Spain**). The HC group comprised volunteer participants from our hospital staff and student interns.

All participants were female. The average age for HC was 29.5 (SD=6.5) years old, and 30.9 (SD=10.0) for patients. The average duration of the **BSD** for patients was 9.98 years (SD=7.5) and the mean number of weekly binge episodes was **4.5 (SD=3.6)**.

The inclusion criteria to participate in the study were being a female between the ages of **18 and 45**, and diagnosis of a **BSD [BN, BED or OSFED (BN, BED or purging subtype)]**. The exclusion criteria for both the patient group and the HC group were: a current or lifetime diagnosis of AN (or any other ED in the case of HC), being male, suffering from a primary psychiatric or neurological disorder (e.g. psychotic disorder, bipolar disorder, major depressive disorder, substance abuse-dependence disorder, etc.), and having a current or lifetime diagnosis of behavioral technology addictions (internet or video game addiction). **As participants were required to engage in different tasks during the recording of facial expressions, those with any psychiatric or neurological disorders**

that could interfere with the understanding of game instructions and/or performance (e.g. impairments in visual-spatial abilities, attentional problems, etc.) were excluded from the study.

The study was approved by the Ethics Committee of the Bellvitge University Hospital and written informed consent was obtained from all participants.

Assessment

Psychometric measures

Temperament and Character Inventory-Revised (TCI-R) (Cloninger, 1999): This is a 240-item, reliable and valid questionnaire that measures seven dimensions of personality: four temperament dimensions (harm avoidance, novelty seeking, reward dependence and perseverance) and three character dimensions (self-directedness, cooperativeness and self-transcendence). Performance of the Spanish version of the original questionnaire (Gutierrez et al., 2001) and the revised version (Gutiérrez-Zotes et al., 2004) has been documented. The scales in the latter showed an internal consistency (coefficient alpha) of 0.87. In the current study, this instrument was used as a measure of personality traits.

Eating Disorder Inventory 2 (EDI-2) (Garner, 1991): This is a reliable and valid 91-item multidimensional self-report questionnaire that assesses different cognitive and behavioral characteristics, which are typical in ED. When this instrument was validated in a Spanish population, a mean internal consistency of 0.63 (coefficient alpha) was found (Garner, 1998). In the current study, the total score was used as a measure of ED severity.

Symptom Check List-90 items-Revised (SCL-90-R) (Derogatis, 1990): This is a 90-item multidimensional self-report assessment measure for a broad range of psychological problems/symptoms. This scale has been validated in a Spanish population (Derogatis, 2002), obtaining a mean internal consistency of 0.75 (Coefficient alpha). In the current study, the depression dimension was used as a control variable as depression has been shown to influence facial expression (Trémeau et al., 2005).

Emotion expression measure

Facial recognition software: As described in previous studies (Claes et al., 2012; Fernandez-Aranda et al., 2012; Jimenez-Murcia et al., 2009), this facial affect recognition software was designed and developed for a serious game platform named “Playmancer”. Serious games are games designed for a specific purpose beyond pure entertainment (Gaudet-Blavignac & Geissbuhler, 2012). They can be applied with an explicit goal in contexts such as defense, education and healthcare. In healthcare, these games are used for educational, preventive and/or therapeutic purposes (Gaudet-Blavignac & Geissbuhler, 2012). Playmancer is usually used as an additional therapeutic tool, combined with standard psychological ED treatment (Fernandez-Aranda et al., 2012; Jimenez-Murcia et al., 2009). The main goal of this intervention is to improve self-control, to reduce impulsivity and to learn how to regulate emotions (such as frustration and anxiety) when the player is confronted with several challenges through different activities (mini-games). The video game consists of three mini-games: (1) *The Face of Cronos*: The player has to climb up a cliff in which obstacles appear depending on the player’s arousal level (based on biofeedback); (2) *Treasures of the Sea*: A swimming game in which the player has to collect different objects and fish while conserving their oxygen supply. High arousal makes the task more difficult; (3) *Sign of the Magupta*: A relaxation game in which

the player connects a constellation of stars through breathing control. Slow deep breathing allows the connections between stars to form. Facial expression levels were measured while subjects played the video game. Specific facial expressions were detected by an integrated camera and processed by the facial tracking component. For this study, we used anger and joy emotions as outcome measures (**Figure 1**). For a more detailed description of previously conducted experiments to calibrate the facial recognition software, see Claes et al., 2012. The measure provided by this tool is the total amount of time (in seconds) that subjects express a particular emotion throughout the duration of the first video game session. Facial expression levels have previously been tested in AN as well as in BN groups using this instrument (Claes et al., 2012; Tárrega et al., 2014).

--- Insert Figure 1 ---

Procedure

Before starting the video game intervention, both groups completed the self-report questionnaires (TCI-R, EDI-2 and SCL-90-R) that form part of the assessment and diagnostic protocol that is followed in our established treatment program. Participants from the HC group were recruited from the local hospital/university community and were invited to take part in one session of the video game intervention. In the case of the BSD group, video game sessions took place on the same days patients were present for their standard treatment (i.e. Cognitive Behavioral Therapy –CBT–). Emotion expression data from all participants were obtained from the facial recognition software and only data from the first video game session were used in our analysis.

Statistical analysis

Statistical analysis was carried out with Stata13.1 for Windows. First, means on the EDI-2, SCL-90-R, TCI-R questionnaires and BMI were compared between BSD patients and HC using t-test

procedures. The comparison of mean scores for the facial expression of the emotions joy and anger were compared between **BSD** and HC with Poisson Regression (a method used to model count data, which assumes that the dependent variable has a Poisson distribution and the logarithm of its expected values can be modeled by a linear combination of the parameters). Effect size for the mean comparisons was estimated through the Cohen's-*d* coefficient ($|d| > 0.50$ was considered moderate effect size and $|d| > 0.80$ was considered high effect size).

Second, partial correlations (adjusted for BMI and SCL-90-R depression scores) estimated the association between the personality traits measured through the TCI-R and emotion expression duration for the **BSD** sample ($n=28$). $|r| \geq 0.30$ was considered good effect size.

Finally, linear regression in two step/blocks assessed the incremental predictive capacity of the personality traits on the criteria emotion expression measures. These models were stratified (separately) for the **BSD** and HC group. For the **BSD** group: a) the first step/block included and set the covariates: BMI, ED severity (EDI-2 total score) and depression level (SCL-90R depressive score); b) the second step/block automatically selected the significant TCI-R scale predictors through a step-wise procedure. The same procedure was conducted to obtain the predictive model of emotion expression scores in the HC group, but for this group the first step only included BMI and the SCL-90-R depressive scores as covariates. The predictive capacity of each block was measured through the increase in R^2 coefficient (ΔR^2).

Due to the multiple statistical comparisons, Type-I error inflation was controlled through Bonferroni-Finner correction.

Results

*Comparison of clinical measures between **BSD** patients and HC*

Table 1 includes the distribution of the EDI-2, SCL-90-R, TCI-R raw scores and BMI in each group (**BSD** and HC), and the results of the mean comparisons obtained through t-test procedures. **BSD** patients obtained statistically higher BMI, as well as higher scores on all the scales for the EDI-2 and the SCL-90-R compared to HC group. Effect sizes for the mean differences (measured with the Cohen's-*d* coefficient) were in the high range (only the EDI-2 perfectionism scale achieved a mean difference with a moderate effect size, $d=0.67$).

For the personality traits measured with the TCI-R, the **BSD** group scored significantly higher on the harm avoidance scale compared to HC, while reward dependence and self-directedness scores were significantly lower for **BSD** patients.

--- Insert Table 1 ---

*Comparison of facial expression between **BSD** patients and HC*

Table 2 includes the mean comparison for the facial expression of joy and anger between **BSD** and HC groups. HC patients expressed more joy compared to **BSD**, but effect size for mean difference was poor ($d=0.18$). Facial anger expression was lower for **BSD** patients, and effect size for mean difference was in the moderate range ($d=0.50$).

--- Insert Table 2 ---

*Association between personality traits and facial expression in **BSD** patients*

Table 3 includes the partial correlations (adjusted for BMI, EDI-2 total and SCL-90-R depression scores) between the personality traits (TCI-R scores) and the expression levels of joy and anger in

the BSD group. Facial expressions of joy positively correlated with scores in novelty seeking, reward dependence and self-directedness (the higher the personality trait, the higher the joy expression score). Expression levels of anger negatively correlated with self-directedness.

--- Insert Table 3 ---

Predictive capacity of personality traits on facial expression

The first multiple regression in **Table 4** corresponds to the predictive model for the outcome of joy expression for the BSD group. After adjusting for the covariates BMI, ED severity (EDI-2 total score) and depressive symptomatology (SCL-90R depression score), TCI-R reward dependence and self-directedness scores were retained in the model since they obtained significant predictive capacity: higher scores in these personality traits predicted higher joy expression levels. The specific incremental validity of the reward dependence and self-directedness score on the facial joy measure was $R^2=.304$ ($p=.018$).

The second multiple regression in **Table 4** includes the parameters of the predictive model for the outcome of anger expression. After adjusting for the same covariates as the previous model, the TCI-R self-directedness score was entered and retained. A significant negative association was obtained between this predictor and the criterion: lower scores in this self-directedness predicted higher levels of anger expression. The specific incremental validity of the self-directedness score on the facial anger level was $R^2=.221$ ($p=.026$).

--- Insert Table 4 ---

Table S1 (Supporting Information) includes the predictive models for the HC sample. After adjusting by the covariates BMI and SCL-90R depression level, the reward dependence score was

retained in the second block of the regression models and their predictive capacity was only quasi-significant ($p=.077$ for the expression of joy and $p=.064$ for anger).

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Discussion

The aim of the present study was to explore the association between facial emotion expression and personality traits in patients with **BSD** compared to HC. We also sought to develop a model to predict emotion facial expression in **BSD** patients, including personality traits. Our initial hypotheses were supported in that **BSD** patients showed diminished facial expression compared to HC and more **altered** personality traits. **BSD** patients scored significantly higher for harm avoidance than the HC group and also had significantly lower reward dependence and self-directedness.

As expected, we found significant positive associations between facial expressions of joy and reward dependence. **Contrary to our hypothesis, we did not find any significant associations with harm avoidance. In contrast, facial expressions of joy positively correlated with novelty seeking.** This association between heightened emotion expression and novelty seeking is of clinical relevance as other research has found that high novelty seeking is common in BN patients with impulse control disorders (Fernández-Aranda et al., 2006), and that these traits can favor the maintenance of binge eating syndromes (Castellini et al., 2012) or be predictive of treatment dropout (Agras et al., 2000).

Interestingly, higher self-directedness was positively correlated with expressions of joy and negatively correlated with expressions of anger. Our step regression model also associated higher anger expression with poorer self-directedness **and greater joy expression with higher self-directedness.** Self-directedness is defined as the ability to regulate and adapt behavior to the demands of a situation in order to achieve a chosen goal (Cloninger, Svrakic, & Przybeck, 1993) and people with low self-directedness are described as being reactive and as suffering from maladaptive emotion activation which leads them to act out rashly. Self-directedness is known to be

a predictor of long-term outcomes in patients with BN (Rowe et al., 2011) and BN patients with a predisposition to anger have been found to have high rates of treatment dropout (Fassino, Abbate-Daga, Piero, Leombruni, & Rovera, 2003). People with low self-directedness are hypothesized to suffer from an all-or-nothing form of dichotomous reasoning which produces a sense of frustration (Cloninger, Przybeck, Svrakic, & Wetzel, 1994). As such, this line of thinking could hinder the establishment and maintenance of a therapeutic relationship with BN patients. A crucial aspect of CBT treatment involves acceptance of responsibility for one's choices and promoting a positive attitude towards change (Dalle Grave et al., 2007; Fairburn, Marcus, & Wilson, 1993) and patients with greater facial anger expression may be in particular need of approaches that also target the mature development of self-directed behavior. The use of facial reactivity to ascertain whether low self-directedness needs to be addressed could be helpful in planning targeted temperament-based treatments specifically for BSD patients (Kaye et al., 2015).

Our statistical model points to higher reward dependence being a predictor of greater facial expression of joy when controlling for clinically-relevant variables such as BMI, ED symptom severity and depressive symptomatology. The study adds to earlier studies which suggest that highly reward dependent individuals may use facial expressions of joy to look for social approval and avoid rejection, and are hence, more vulnerable to societal pressures (Ioannou & Fox, 2009). Likewise, reward dependence has been found to be correlated to higher body dissatisfaction in ED patients (Segura-García, Chiodo, Sinopoli, & De Fazio, 2013) and further reaffirms the importance of needing to please others, not only through the use of facial expression but also by one's physical appearance. Recovered BN patients have been found to decrease the level of discordance between their implicit and explicit emotions indicating that, after remission, BN patients are able to exhibit a more authentic emotional response (Tárrega et al., 2014). Novel approaches which address these

concerns have thus far provided positive results though further studies in larger samples are need to fully confirm their effectiveness (Davies, Schmidt, & Tchanturia, 2013; Tchanturia et al., 2015).

This study has several strengths, primarily its novel tracking of facial activity without the use of emotion-specific stimuli. Although facial reactivity has previously been studied in BN (Claes et al., 2012; Tárrega et al., 2014), this is, to the extent of our knowledge, the first time that the relationship between personality traits and spontaneous emotion expression has been explored in BSD patients.

Information linking personality traits to facial expressiveness could potentially be used by clinicians to identify which patients have greater impairments in expressing emotion and hence are in greater need of interventions that address social functioning issues.

Nonetheless, this study has several limitations worth mentioning. First, the study's small sample size greatly limited its power and we strongly suggest readers err on the side of caution when interpreting our results. We must stress that we have conducted a pilot study and that larger and more diverse samples are needed before confirming the generalizability of these results. Future studies should explore the influence of personality and facial recognition in other ED groups. The other main limitation of the study is that our measure only included two emotions (joy and anger) and the possibility that BSD patients expressed additional emotions (sadness, boredom, etc.) must be considered.

In conclusion, our findings indicate that patients with a BSD have altered emotion expression compared to HC and that emotion expression levels are influenced by personality traits in these patients. Given the importance of facial expressiveness in interpersonal interactions and the maintaining role that social impairment has in patients with BSD, this study supports the notion that

facial expressiveness and effective communication strategies should be addressed in treatment interventions in order to improve social functioning and overall outcomes.

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Tables

Table 1. Comparison of BMI, EDI-2, SCL-90-R and TCI-R mean values between groups.

	α	HC (n=15)		BSD (n=28)		t-test		Cohen's
		Mean	SD	Mean	SD	T (df=41)	¹ p	d
Body mass index (kg/m ²)		21.09	1.88	26.34	6.23	2.60	.014	1.14
EDI-2: Drive for thinness	.908	1.40	3.40	15.57	4.33	10.97	<.001	3.64
EDI-2: Body dissatisfaction	.934	2.73	4.08	19.96	6.25	9.61	<.001	3.26
EDI-2: Interoceptive awareness	.881	0.40	0.91	12.68	5.48	8.56	<.001	3.12
EDI-2: Bulimia	.885	0.13	0.52	10.18	5.42	7.13	<.001	2.61
EDI-2: Interpersonal distrust	.890	0.27	0.59	5.54	5.16	3.92	<.001	1.43
EDI-2: Ineffectiveness	.928	0.67	1.54	11.82	7.34	5.78	<.001	2.10
EDI-2: Maturity fears	.700	3.13	3.25	6.39	4.54	2.46	.037	0.83
EDI-2: Perfectionism	.740	3.13	2.92	5.61	4.33	1.98	.055	0.67
EDI-2: Impulse regulation	.778	0.33	0.90	6.71	5.23	4.66	<.001	1.70
EDI-2: Ascetism	.648	1.00	1.36	8.07	3.37	7.77	<.001	2.75
EDI-2: Social insecurity	.890	0.47	0.64	8.04	5.04	5.76	<.001	2.11
EDI-2: Total score	.976	13.67	13.52	110.82	37.11	9.75	<.001	3.48
SCL-90: Somatization	.956	0.40	0.35	2.02	1.09	5.56	<.001	2.00
SCL-90: Obsessive/compulsive	.922	0.46	0.38	2.06	0.86	6.81	<.001	2.40
SCL-90: Interpersonal sensitivity	.936	0.38	0.43	2.11	0.98	6.49	<.001	2.29
SCL-90: Depressive	.952	0.46	0.32	2.22	0.95	6.92	<.001	2.48
SCL-90: Anxiety	.933	0.31	0.28	1.80	0.97	5.76	<.001	2.08
SCL-90: Hostility	.942	0.24	0.29	1.38	1.06	4.06	.003	1.47
SCL-90: Phobic anxiety	.878	0.07	0.16	1.06	0.98	3.84	.005	1.40
SCL-90: Paranoid Ideation	.885	0.36	0.45	1.43	0.87	4.46	.001	1.55
SCL-90: Psychotic	.908	0.14	0.20	1.25	0.78	5.37	<.001	1.94
SCL-90: GSI score	.989	0.32	0.22	1.83	0.82	6.93	<.001	2.51
SCL-90: PST score	.989	22.33	15.30	64.36	17.83	7.72	<.001	2.53
SCL-90: PSDI score	.989	1.21	0.38	2.42	0.57	7.45	<.001	2.53
TCI-R: Novelty seeking	.820	104.13	12.05	102.32	16.01	0.38	.704	0.13
TCI-R: Harm avoidance	.933	89.80	14.84	121.00	18.35	5.66	<.001	1.87
TCI-R: Reward dependence	.819	111.93	8.35	101.75	14.99	2.43	.045	0.84
TCI-R: Persistence	.875	117.13	14.17	109.11	19.68	1.39	.279	0.47
TCI-R: Self-directedness	.899	150.07	14.71	113.04	18.42	6.71	<.001	2.22
TCI-R: Cooperativeness	.823	141.47	14.73	135.25	15.31	1.29	.288	0.41
TCI-R: Self-Transcendence	.838	21.09	1.88	26.34	6.23	0.99	.370	0.31

SD: standard deviation. HC: healthy controls. BSD: bulimic spectrum disorder. ¹p-value includes Bonferroni-Finner's correction.

GSI: global severity index. PST: positive symptom total. PSDI: positive symptom distress index.

α : Cronbach's alpha in sample. Bold: moderate ($|d| > 0.50$) to high ($|d| > 0.80$) effect size for mean difference.

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Table 2. Comparison of facial expression (joy and anger) mean scores between groups.

	HC (<i>n</i> =15)		BSD (<i>n</i> =28)		Mean comparison		Cohen's
	Mean	SD	Mean	SD	Wald (χ^2)	¹ <i>p</i>	<i>d</i>
Facial joy (seconds)	975.33	(545.91)	880.00	(504.38)	94.23	<.001	0.18
Facial anger (seconds)	179.33	(302.29)	65.71	(166.39)	902.6	<.001	0.50

SD: standard deviation. HC: healthy controls. **BSD: bulimic spectrum disorder**. ¹*p*-value includes Bonferroni-Finner's correction.

Bold: moderate ($|d|>0.50$) to high ($|d|>0.80$) effect size for mean difference.

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Table 3. Associations between facial emotion expression (joy and anger) and personality traits: partial correlations **adjusted for BMI, ED severity (EDI2-total) and SCL-90-depression.**

	Joy	Anger
TCI-R: Novelty seeking	.360	.280
TCI-R: Harm avoidance	-.191	.069
TCI-R: Reward dependence	.441	.236
TCI-R: Persistence	-.020	.109
TCI-R: Self-directedness	.348	-.473
TCI-R: Cooperativeness	.253	-.089
TCI-R: Self-Transcendence	.160	-.166

Bold: good effect size ($|r| > .30$). Analysis for **BSD sample** ($n=28$).

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Table 4. Predictive model of the emotions joy and anger.

	B	SE	Beta	t-stat.	p	95%CI(B)		ΔR^2	p
Criterion: facial joy.									
<i>Block 1</i>									
Constant	36.23	553.68		0.07	.948	-1115.22	1187.68	.116	.451
Body mass index (kg/m ²)	26.15	16.99	.322	1.54	.139	-9.18	61.49		
ED severity: EDI-2 total	3.22	4.17	.227	0.77	.449	-5.45	11.88		
SCL-90-R: depressive	-97.48	159.51	-.181	-0.61	.548	-429.20	234.24		
<i>Block 2</i>									
Constant	-4034.40	1396.06		-2.89	.009	-6956.38	-1112.41	.304	.018
Body mass index (kg/m ²)	24.61	14.65	.303	1.68	.109	-6.04	55.27		
ED severity: EDI-2 total	11.56	4.50	.814	2.57	.019	2.14	20.97		
SCL-90-R: depressive	-144.99	137.05	-.270	-1.06	.303	-431.83	141.85		
TCI-R: reward dependence	16.57	6.53	.492	2.54	.020	2.91	30.23		
TCI-R: self-directedness	14.34	6.89	.491	2.08	.050	0.09	28.76		
Criterion: facial anger									
<i>Block 1</i>									
Constant	61.99	201.45		0.31	.761	-356.96	480.94	.012	.096
Body mass index (kg/m ²)	0.40	6.18	.014	0.06	.949	-12.46	13.26		
ED severity: EDI-2 total	-0.58	1.52	-.118	-0.38	.707	-3.73	2.57		
SCL-90-R: depressive	27.19	58.04	.147	0.47	.644	-93.51	147.88		
<i>Block 2</i>									
Constant	957.42	414.88		2.31	.032	91.98	1822.85	.221	.026
Body mass index (kg/m ²)	2.32	5.64	.083	0.41	.685	-9.44	14.08		
ED severity: EDI-2 total	-2.64	1.62	-.541	-1.64	.118	-6.01	0.73		
SCL-90-R: depressive	27.98	52.40	.151	0.53	.599	-81.31	137.28		
TCI-R: self-directedness	-6.36	2.65	-.633	-2.40	.026	-11.89	-0.84		

Results obtained in multiple regression for **BSD** sample ($n=28$).

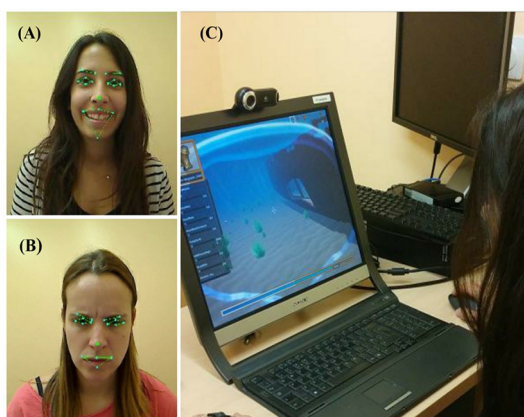
ED: eating disorder. ΔR^2 : change in R^2 coefficient for the block-step.

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Figure legend

Figure 1. (A) Joy expression detection (B) Anger expression detection (C) Scene from the video game interface.

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