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Date:

2025-06-01

Citation:

Korbut, S., Chanen, A. M., Terrett, G., Jovev, M., Rendell, P. G., Henry, J. D. & Pizarro-Campagna, E. (2025). Examining Negativity Biases in Facial Emotion Reactions in Young Persons First Presenting with Borderline Personality Disorder. *Psychopathology*, 58 (3), pp.173-186. <https://doi.org/10.1159/000542743>.

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Examining Negativity Biases in Facial Emotion Reactions in Young Persons First Presenting with Borderline Personality Disorder

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Keywords

Borderline personality disorder · Negativity bias · Facial emotional expression · Youth · Adolescent

Abstract

Introduction: Individuals with borderline personality disorder (BPD) are thought to experience specific biosocial vulnerabilities that give rise to a maladaptive negativity bias in the perception and expression of emotions. However, while this negative bias has been identified in adults with full threshold BPD or high BPD features, it is unclear whether it is evident earlier in the course of the disorder – that being, young persons with first-presentation BPD meeting three or more BPD features, as defined by early intervention models. **Methods:** The current study compared patterns of facial responding in individuals aged 15–25 years first presenting to a specialist outpatient service with three or more BPD features ($n = 32$) to age-matched healthy controls ($n = 46$). Facial electromyography was used to assess muscle activity associated with positive (zygomaticus major) and negative (corrugator supercilii) expression while participants viewed happy, angry, and neutral facial expressions. **Results:** The data revealed that negative facial emotional reactivity for the BPD

group did not significantly differ from the control group. However, the results for positive emotional reactivity were more nuanced, indicating that while there was not an overall between-group difference, there might be an effect of time suggestive of a slower positive emotional reaction to happy faces by the BPD group. **Conclusions:** These data provide initial evidence that negatively biased emotional expression, when responding with negative facial expressions to neutral, happy, or angry faces, is not evident in young persons first presenting to a specialist outpatient service for treatment of BPD. However, a bias may be demonstrated by what appears to be a slower positive affective response to happy faces. The implications of these findings are discussed, particularly in relation to factors associated with chronicity of illness that might potentially contribute to the development of a more pronounced negativity bias later in the course of the illness. We encourage further examination of negativity biases in the developmental sequelae of BPD via longitudinal design or cross-sectional designs that include BPD participants across the course of illness, as well as further research to explore the possibility that positive affective reactions in this group might not be grossly blunted but rather delayed.

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Published by S. Karger AG, Basel

Introduction

Borderline personality disorder (BPD) is a serious mental disorder characterised by a pattern of marked impulsivity, interpersonal dysfunction, affective instability, and identity disturbance [1]. Typically, diagnosis of BPD is made in adulthood where individuals have met full diagnostic criteria and demonstrated the pervasive nature of their symptoms [1]. However, a growing literature indicates that clinical features of the illness are evident and diagnosable between puberty and early adulthood [2]. Young people endorsing BPD features experience higher levels of clinical distress and psychosocial dysfunction compared with their aged-matched peers who do not [3]. In light of this evidence, researchers and clinicians are now adopting a clinical staging perspective for the development of BPD that recognises mental illness progression is typically preceded by subthreshold or transdiagnostic features that later develop into full-threshold, specific features of illness (e.g., chronic suicidality [4, 5]). In order to clarify how the clinical staging model applies to the aetiology of BPD, greater emphasis must be placed on understanding features evident early on in the disorder's course that give rise to disorder-specific traits characteristic of chronic or severe presentations.

One way in which BPD might develop from general transdiagnostic features into full-threshold, specific traits of illness is through the development of maladaptive cognitive biases, such as a negativity bias. Negativity biases are biases in the perception and interpretation of information. These biases encompass both normative and ubiquitous experiences such as negative stimuli having greater saliency, weight, and effect on one's psychological state and cognitive processes such as attention, memory, learning, and decision-making, than neutral or positive stimuli of an equal intensity [6]. They also include more maladaptive biases in the perception and recognition of neutral and positive stimuli, which has implications for the development of psychopathology [7–10]. While some aspects of a negativity bias serve evolutionary [6] and developmental functions [11], it might deviate from normative development and become pathological in the context of biological and early environmental vulnerabilities such as those outlined in Linehan's [12] biosocial model of the development of BPD (e.g., negative temperament, disruption in attachment, invalidating and abusive environments). For these individuals, biological vulnerability and chronic exposure to negative and invalidating environments interact bidirectionally to keep individuals "stuck" in a negative

cycle of hypervigilance, cognitive rigidity, and rumination, all of which perpetuate emotional dysregulation [13]. In contrast, typically developing children without these vulnerabilities go on to report positivity biases that facilitate emotion regulation and positive self-esteem [14–16]. From this perspective, individuals with BPD experience a divergence from normative socio-emotional development resulting from early biosocial vulnerabilities interacting with a negativity bias. However, despite the theoretical and clinical relevance of a maladaptive negativity bias in BPD, surprisingly limited research has been undertaken to understand this bias, particularly in early in the course of the disorder.

To date, there is some emerging evidence for a maladaptive negativity bias having implications for the perception and expression of emotions [7]. The most compelling data being those with BPD are likely to misperceive neutral expressions as negatively valenced (e.g., perceived as anger or disgust) compared with healthy controls (HCs) (see systematic reviews by Daros et al. [8], Mitchell et al. [10], Domes et al. [17]). In addition to misperceiving neutral expressions as negatively valenced, some studies have shown those with BPD report positive expressions as less pleasant and less intense compared to HCs [18–20]. Other studies have also demonstrated stronger orientation to negative facial expressions [21] and faster responsivity to negative stimuli, with difficulties disengaging from threat related stimuli [22].

However, this literature is not without inconsistencies particularly when considering young persons or first-presentation populations. For example, Jovev et al. [23] reported no differences in thresholds for the detection of negative emotional stimuli (i.e., emotion sensitivity assessed via Face Morph Task) in their cohort of youth with borderline personality features compared to healthy controls. Yet in a subsequent study, they reported that youth with borderline personality features were faster to respond to negative stimuli and had difficulties disengaging from threat related stimuli [22]. A separate research group, however, reported adolescents diagnosed with BPD had difficulties recognising both negative and positive emotional expressions of lower intensity compared to HCs [20]. While differences in methodology may account for these discrepancies, these inconsistencies might also be interpreted as evidence for an emerging negativity bias, where only specific aspects of emotion perception (e.g., attention) are implicated and later effect other domains. However, given the limited research on youths first presenting with BPD, this theory remains speculative.

While the above studies illustrate the role of the negativity bias on emotion *perception*, little is known regarding whether this perceptual bias may in turn impact the emotional *expression* of those with BPD. For instance, individuals with a maladaptive negativity bias may perceive greater negativity in transactions with others and subsequently internalise or “embody” this perception (e.g., furrow brows). Consequently, this elicits a process of negative feedback and emotional dysregulation in communication with others [24]. Relational models that emphasise dynamic transactional interpersonal processes posit that negatively biased perceptions of other’s intentions and emotions lead to heightened hostile and defensive behavioural responses from the perceiver [25, 26]. However, the empirical literature on this matter is more complex, and evidence for a negativity bias in facial emotional reactions in BPD is unclear.

To date, several studies have examined emotional expressivity in BPD via behavioural observation [27–30] and several others utilising more objective measurement such as facial electromyography (EMG) [31–35]. Behavioural studies have demonstrated variable patterns in emotional expressivity. Renneberg et al. [27], e.g., reported that their sample of inpatient adults with BPD had less facial emotional expressivity compared to HCs, whereas other adult studies have demonstrated fewer positive facial emotional expressions, greater negative expressions [30], and also mixed or unclear emotional expressivity [29]. Similarly, in a sample of university students with high versus low BPD traits, participants with higher BPD traits were regarded as having “difficult-to-read” emotions that had affected the ability of other participants to accurately identify their emotions [28]. While some of these studies provide evidence of a negativity bias, others reflect a mixed or inconsistent pattern of responding that might also impact interpersonal functioning in BPD.

Inconsistencies might also be in part related to the over-reliance on human-rated behavioural observations [27, 28, 36], including utilising standardised coding systems like Renneberg et al. [27] or self-report in Flury et al. [28]. Given, human-rated behavioural observations typically increase measurement error and can fail to capture more subtle and dynamic changes in emotional expressivity, it has been suggested that studies employ a more sensitive and objective measurement of facial muscle reactivity, such as facial EMG [37], as this approach allows for examination of facial reactions undetectable to the naked eye [38]. Nonetheless, results from current facial EMG studies are also mixed and require further clarification. For example, a paper by Matzke et al.

[33] reportedly demonstrated that BPD participants had greater negative facial reactivity and attenuated positive facial reactivity – both of which they concluded were indicative of a negativity bias in the expression of emotions. However, while they concluded this due to the decreased activation of levator labii muscles in the viewing of positive facial expressions, this muscle is implicated in expressions of disgust [39–42]. This, in conjunction with comparable zygomaticus muscle reactivity across groups, which is the primary muscle activated in expressions associated with smiling and feelings of happiness [43–46], only partially supports a negativity bias in facial emotional expressions. Additionally, other studies in adult BPD samples have documented a different pattern of facial reactivity. While an overall hypo-responsivity towards various positive and negatively valenced emotional expressions were reported in two adult BPD samples [31, 32], one other reported mixed facial EMG findings wherein muscle activation associated with negative emotional expression was comparable to HCs; however, muscle activation associated with positive expression was attenuated [35]. Given that some of these studies were also of adult in-patient populations [27, 29] or forensic populations [32], it is possible these adult BPD samples reflect not only the influence of BPD pathology but also secondary effects of duration of illness such as chronic psychosocial dysfunction and recurrent stressful life events and polypharmacy [47–49]. This makes it difficult to disentangle what behaviours (i.e., facial emotional reactions) are inherent to the disorder or simply reflect the consequence of living with BPD.

Indeed, the only study to date that has evaluated facial EMG in a first-presentation population reported no differences between BPD and HC groups [34]. However, the limited timeframe (i.e., 1,000 ms) was designed to provide a clearer understanding of early, initial responding. Therefore, the analysis in that study was unable to capture facial emotion reactions after initial responding. Importantly, no studies to our knowledge have analysed static facial EMG reactivity to neutral facial expressions. This is an important consideration, given that adults later in the course of BPD report a bias in the recognition of neutral expressions and perceive these as negatively valenced [50]. However, we do not know whether this has implications for facial emotional expression when viewing neutral expressions. This is an important gap to address in the context of a first-presenting cohort as it might clarify again the nature of attributional biases in the development of BPD and offer opportunities for targeted early intervention.

The current study used a first-presentation BPD sample and involved secondary analysis of data previously collected [51] and partially reported elsewhere [34] to assess whether an abnormal negativity bias in the expression of emotions is present in young people diagnosed with first-presentation BPD. This was predicted to occur over an extended timeframe (i.e., 5,000 ms) where emotional stimuli could be further deliberated [52, 53]. Based on theory and the empirical literature, it was hypothesised that relative to HCs, young people with first-presentation BPD (i.e., first presentation with three or more BPD features as defined by early intervention models; [54, 55]) would demonstrate exaggerated negative facial emotional responding, as indexed by corrugator supercillii muscle (brow) activity when viewing angry as well as neutral facial expressions. Further, it was hypothesised that compared with HCs, young persons with BPD would demonstrate an attenuated facial response, as indexed by zygomaticus (cheek) activity when viewing happy expressions.

Materials and Methods

Participants

Eighty-seven males and females aged 15–25 years (BPD, $n = 36$; HCs, $n = 54$) were recruited as part of a previous study [34]. Of these, 8 HC and 4 BPD participants were excluded due to movement artefacts such as jaw grinding or yawning; as well as electrical noise affecting the EMG signal [56]. Participants were excluded if they reported visual impairments, intellectual disability, history of epilepsy, brain infection, acquired brain injuries, alcohol/drug intoxication at the time of testing, or if they had insufficient English language skills to participate in the study.

All BPD participants were recruited from a specialist early intervention outpatient clinic in Melbourne, Australia, called the Orygen Helping Young People Early (HYPE) service. This service provides specialist early intervention to person's aged 15–25 years first presenting to a youth tertiary mental health service with three or more features of BPD. The BPD group were 20 (62%) young people who met 5 or more BPD features and 12 (37.5%) with 3 or 4 BPD features. BPD participants were excluded if they met criteria for psychosis, bipolar I, or psychiatric disorder due to a medical condition (SCID-II; [57]). Given that BPD has a high prevalence of co-occurring disorders [58, 59], participants were also characterised by a wide range of mental state disorders and other personality disorders. Please refer to online supplementary Table 1 for details (for all online suppl. material, see <https://doi.org/10.1159/000542743>).

HCs were recruited from geographically matched areas to the BPD sample as described elsewhere [34] via local advertising (e.g., libraries and train stations) and through social media. Exclusions were current or past history of DSM IV Axis I disorders or personality disorder [57]. The groups had comparable gender distributions, and there were no group differences for age or IQ. BPD participants reported significantly lower self-reported-positive affect and greater negative affect at the time of testing and also endorsed greater anxious and depressive symptoms. Please see Table 1 for descriptive data.

Experimental Measures and Equipment

Diagnostic and Screening Tools

The Research Version, Non-Patient Edition, Structured Clinical Interview for DSM-IV Axis I Disorders (SCID I/NP; [60]) and SCID-II Personality Questionnaire (SCID-II PQ; [57]) were administered to the control participants to screen for current or past mental illness and personality disorders. BPD participants were assessed for Axis-I disorders using the Structured Clinical Interview for DSM-IV Axis I Disorders (Patient Edition; SCID- I/P; [61]). Axis II disorders were assessed via Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II; [57]). All participants completed a standardised assessment of cognitive ability (Wechsler Abbreviated Scale of Intelligence, Full-Scale-2 Subtests IQ [WASI]; [62]).

Facial Reactivity

Facial EMG was used to measure muscle activity on the face throughout the duration of the experiment. Surface electrodes were placed on the left corrugator supercillii (brow, associated with negative facial expression) and zygomaticus major (cheek, associated with positive facial expression; [63]), as well as one ground electrode on the forehead [64]. To reduce effects of demand characteristics, an inactive electrode was placed on the left hand to detract from the face as the focal point. Participants were informed that this sensor measured sweat-gland activity [38]. Muscle activity was continuously recorded at a sampling rate of 1,000 Hz [56], using an integrated MP150 amplifier system and the AcqKnowledge 4.2 software package (Biopac Systems, Inc., Goleta, CA, USA). A 10–500-Hz band pass filter and a 50-Hz notch interference filter were applied [65, 66].

State Affect, Depression, and Anxiety Symptoms

Given the possible influence of state affect on facial emotion expression [67], the Short-form Positive and Negative Affect Schedule (S-PANAS) was used to assess self-reported positive and negative affect prior to testing. The short version of the PANAS has sound psychometric

Table 1. Sample characteristics for BPD and HC groups.

Variable	BPD, <i>n</i> = 32		HC, <i>n</i> = 46		<i>t</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Age, years	19.66	3.23	20.17	2.72	0.76	-0.17
IQ	106.68	13.03	107.46	12.08	0.27	-0.06
	Male	Female	Male	Female	χ^2	<i>p</i> value
Gender, <i>n</i>	8	24	17	29	0.85	0.36
HADS						
Anxiety	12.1	4.15	3.43	2.08	10.74***	2.64
Depression	9.16	3.92	1.2	1.77	10.95***	2.62
S-PANAS						
Positive affect	10.16	3.12	14.82	3.95	5.45***	-1.31
Negative affect	7.97	3.07	5.98	1.64	3.23**	0.81

High scores indicate greater endorsement of symptoms or affective state. HADS, Hospital Anxiety and Depression Scale; S-PANAS, Short-form Positive and Negative Affect Schedule. ***p* < 0.01. ****p* < 0.001.

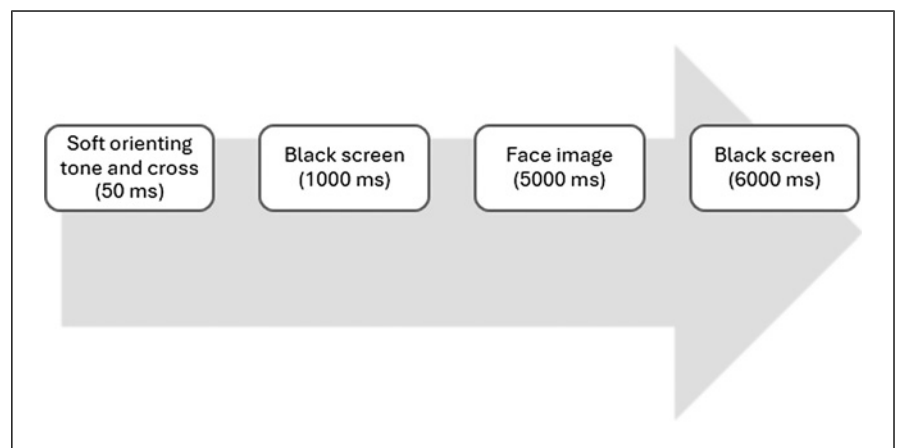


Fig. 1. Flowchart illustrating the order and length of stimuli presentation for each trial. Reproduced with permission from Pizarro-Campagna [51].

properties [68]. Additionally, the Hospital Anxiety and Depression Scale (HADS; [69]) was used to assess self-reported anxious and depressive symptoms endorsed by groups over the previous week. It has been well validated across various adult and adolescent populations [70]. This measure was used alongside the S-PANAS in the preliminary analyses to assess for possible confounds.

Procedure

Participants sat in front of a computer screen and were instructed to remain still throughout the experiment [71, 72]. Stimuli were presented in three separate affective blocks. Each block contained eight trials of neutral, happy, or angry black and white, male and female (50:50 ratio), Ekman facial emotional expressions [73]. There were 24 trials in total. The

neutral block was always presented first, followed by the happy and angry blocks, which were presented in a counterbalanced order. Faces within each block were presented in random order. See Figure 1 for flowchart of task sequence.

EMG Data Extraction and Reduction

EMG data underwent several procedures in preparation for analysis. Firstly, raw EMG electrical signal underwent root mean square transformations [56], and raw data were extracted over a 5-s period. This timeframe allowed for capturing facial emotion reactions susceptible to the influence of cognitive processes – such as those related to a negativity bias [52, 53]. Both raw data and participants' videos were visually screened for electrical noise and other movement artefacts [64]. Percentage change in EMG

Table 2. Associations between mean zygomaticus and corrugator activity, state affect (S-PANAS), anxiety and depression symptoms (HADS) for BPD participants

	1	2	3	4	5	6
1. Zygomaticus	—					
2. Corrugator	-0.326	—				
3. Positive affect (S-PANAS)	0.327	-0.174	—			
4. Negative affect (S-PANAS)	0.007	0.205	-0.024	—		
5. Depression (HADS)	-0.177	0.240	-0.186	0.392*	—	
6. Anxiety (HADS)	-0.285	-0.038	-0.095	0.573*	0.635**	—

High scores indicate greater endorsement of symptoms or affective state; $n = 31$. HADS, Hospital Anxiety and Depression Scale; S-PANAS, Short-form Positive and Negative Affect Schedule. * $p < 0.01$. ** $p < 0.001$.

Table 3. Associations between mean zygomaticus and corrugator activity, state affect (S-PANAS), anxiety and depression symptoms (HADS) for HC

	1	2	3	4	5	6
1. Zygomaticus	—					
2. Corrugator	-0.511*	—				
3. Positive affect (S-PANAS)	0.172	0.179	—			
4. Negative affect (S-PANAS)	0.292	-0.132	0.227	—		
5. Depression (HADS)	-0.163	-0.024	-0.029	0.277	—	
6. Anxiety (HADS)	-0.098	0.018	-0.074	0.413*	0.622**	—

$n = 45$. S-PANAS, Short-form Positive and Negative Affect Schedule; HADS, Hospital Anxiety and Depression Scale. * $p < 0.01$. ** $p < 0.001$.

activity from the baseline period (500 ms prior to stimulus) and over the first 5 s were then analysed in 500-ms epochs [63, 71]. In a previous study with the same sample, rapid facial reactions over the first 1,000-ms post-stimulus presentation were extracted to explore rapid facial mimicry in BPD [34]. This study, a secondary analysis, expanded that time frame to 5,000 ms to capture a period more susceptible to a negativity bias [53]. After extracting raw data, and calculating raw data to percentage change scores, further cleaning procedures were conducted in SPSS.

Statistical Analyses

Standard procedures for improving distributions and addressing outliers for EMG data were followed [65, 74]. Extreme outliers were first identified via visual inspection of histograms and box-plots and were then excluded. Remaining outliers (z -scores ± 3.29) were trimmed back within 2 SD of the mean [75]. Preliminary analyses comparing groups on sample characteristics were con-

ducted using independent samples t tests for continuous variables (i.e., baseline EMG, age, IQ, HADS, S-PANAS) and chi-square tests for categorical variables (i.e., gender).

An independent samples t test comparing groups on baseline EMG was also included in preliminary analyses as differences at baseline activity might have implications in the interpretation of results. Results for equal variances not assumed are reported where Levene's test for equality was significant. Further, Pearson's product-moment correlations were utilised to assess correlates between EMG activity, state affect (S-PANAS), and self-reported anxiety and depression symptoms (HADS) prior to the main analysis.

To examine differences in facial emotional expression in each group, a 2 (group: HC, BPD) \times 3 (emotion: angry, neutral, happy) \times 10 (epoch: 0–500 ms, 500–1,000, 1,000–1,500 ms, 1,500–2,000 ms, 2,000–2,500 ms, 2,500–3,000 ms, 3,000–3,500 ms, 3,500–4,000 ms, 4,000–4,500 ms, 4,500–5,000 ms) repeated-measures mixed-design ANOVA was carried out separately for

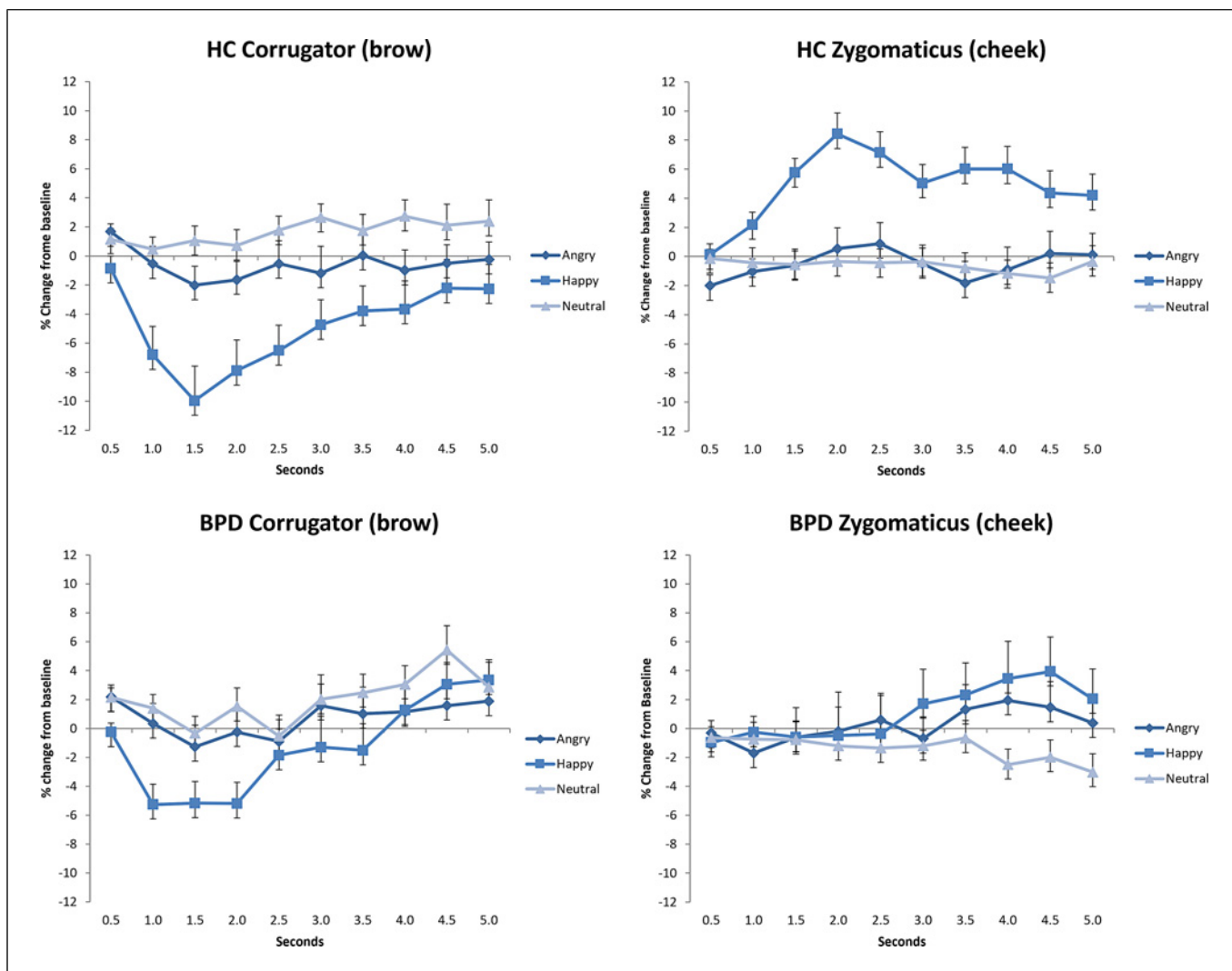


Fig. 2. Mean percentage change from baseline in muscle activity for HC and BPD participants.

zygomaticus and corrugator muscles. All main effects were reported; however, only interactions involving groups were followed up. Greenhouse-Geisser corrections were reported for variables that violated sphericity. A priori sample size calculation using G*Power [76] indicated that with a sample size of 30, and an alpha level of 0.05, there was sufficient power (over 0.80) to detect medium to large effect sizes (i.e., 0.6). In the results, effects sizes are reported for Cohen's d 0.2 = small, 0.5 = medium effect, and 0.8 = large and partial Eta squared (η_p^2 ; 0.01 = small effect; 0.06 = medium effect; 0.14 = large effect).

To mitigate the risk of type II errors, we carried out 30 separate exploratory independent samples t tests, one for each 500 ms epoch (10 epochs of 500 ms, from 0 to 5,000 ms) for each emotion (neutral, angry, happy). This was repeated for

each muscle region (corrugator, zygomaticus), resulting in a total of 60 t tests. Firstly, we ran these without correcting for multiple testing (which increases risk of type I error), and then we adjusted for multiple testing by applying the Bonferroni correction. Where Levene's test for equality of variances was violated, results for equal variances not assumed are reported.

Results

Preliminary Analyses

Baseline EMG

Independent samples t tests were conducted to assess whether baseline EMG activity (500 ms prior to stimulus) for zygomaticus and corrugator muscles differed across

the BPD and control groups. No group differences emerged for baseline zygomaticus activity prior to viewing happy ($t(67) = 0.29, p = 0.773, d = 0.07$), angry ($t(67) = 0.24, p = 0.813, d = 0.05$), or neutral ($t(67) = 0.46, p = 0.649, d = 0.11$) facial expressions. Similarly, no group differences emerged for baseline corrugator activity prior to viewing happy ($t(74) = 1.03, p = 0.309, d = 0.24$), angry ($t(74) = 1.20, p = 0.235, d = 0.28$), or neutral ($t(74) = 1.58, p = 0.120, d = 0.37$) facial expressions.

Intercorrelations between S-PANAS, HADS, and EMG Activity

Pearson's product-moment correlations were calculated to assess the relationship between positive and negative facial responding (indexed by overall mean zygomaticus and corrugator muscle activity, respectively), positive and negative affect (with respective S-PANAS subscales analysed separately), and anxiety and depression symptoms over the past week (indexed via the HADS). No significant associations emerged between positive or negative facial responding and state affect at the time of testing or self-reported anxiety and depressive symptoms over the last week (Tables 2, 3).

Main Analysis

The main analyses examined whether BPD participants demonstrated differences in facial emotional expression that would be consistent with a negativity bias. That is, whether BPD participants exhibited greater activation of the corrugator muscle when viewing neutral and angry expressions in comparison to HCs and an attenuated zygomaticus response while viewing positively valenced expression. Figure 2 shows the pattern of muscle activation for both groups when viewing happy, angry, and neutral facial expressions.

Corrugator Activity

While main effects were observed for emotion $F(2,118) = 9.57, p = 0.000, \eta_p^2 = 0.14$, time $F(3,204) = 10.27, p = 0.000, \eta_p^2 = 0.15$, and there was also an interaction between emotion and time $F(6,363) = 3.97, p = 0.001, \eta_p^2 = 0.06$, no main effects emerged for group $F(1,59) = 2.50, p = 0.120, \eta_p^2 = 0.04$, nor were there any interactions between emotion and group $F(2,118) = 0.96, p = 0.388, \eta_p^2 = 0.02$; time and group $F(3,204) = 0.92, p = 0.444, \eta_p^2 = 0.02$; or a three-way interaction of emotion, time, and group $F(6,363) = 1.04, p = 0.398, \eta_p^2 = 0.02$. To follow-up the main effect of emotion, pairwise comparisons indicated that all participants responded with greater corrugator activity to angry faces ($M = 0.07, SD = 1.28$) compared with corrugator responses to happy faces

($M = -3.08, SD = 3.50, d = 1.17; p = 0.012, d = 1.20$). Compared with corrugator responses to happy faces, all participants also responded with greater corrugator activity to neutral faces ($M = 1.84, SD = 1.31, p < 0.001, d = 1.86$).

Independent samples t tests for two epochs out of 30 corrugator muscle epochs indicated significant between-group differences. The BPD group responded with greater corrugator activity than the HC group when viewing neutral faces during epoch 9 (4,000–4,500 ms), $t(51.130) = 2.12, p = 0.039$, and when viewing happy faces during epoch 10 (4,500–5,000 ms), $t(74) = 2.04, p = 0.045$. Following Bonferroni correction, none of the 30 t tests remained significant (see online suppl. Table 2).

Zygomaticus Activity

The same exact pattern of effects emerged for the analyses focused on zygomaticus activity. Main effects again emerged for emotion $F(2,63) = 7.17, p = 0.003, \eta_p^2 = 0.16$, time $F(3,137) = 2.53, p = 0.049, \eta_p^2 = 0.06$, and there was again an interaction between emotion and time $F(7,270) = 2.34, p = 0.024, \eta_p^2 = 0.06$. Again, there was no main effect for group $F(1,38) = 1.44, p = 0.237, \eta_p^2 = 0.04$, nor any interaction effects between emotion and group $F(1,63) = 1.86, p = 0.170, \eta_p^2 = 0.05$; time and group $F(3,137) = 2.17, p = 0.083, \eta_p^2 = 0.05$; nor a three-way interaction between emotion, time, and group $F(7,270) = 1.48, p = 0.174, \eta_p^2 = 0.04$.

Pairwise comparisons indicated all participants responded with greater zygomaticus activity in response to happy faces ($M = 3.00, SD = 2.86$) compared with angry faces ($M = -0.15, SD = 1.09, p = 0.012, d = 1.46$). They also all responded with greater zygomaticus activity in response to happy faces compared with neutral faces ($M = -1.00, SD = 0.76, p = 0.008, d = 1.91$).

Independent sample t tests for 8 epochs out of 30 zygomaticus muscle epochs indicated significant between-group differences before adjusting for multiple testing. When viewing neutral faces, the BPD group responded with less zygomaticus activity than the HC group in epochs 8 (3,500–4,000 ms), $t(63) = 2.02, p = 0.048$, and 10 (4,500–5,000 ms), $t(55) = 2.32, p = 0.024$, only. When viewing happy faces, the BPD group responded with less zygomaticus activity than the HC group in six of ten epochs: 2 (500–1,000 ms), $t(61.535) = 2.54, p = 0.014$; 3 (1,000–1,500 ms), $t(57.469) = 2.68, p = 0.010$; 4 (1,500–2,000 ms), $t(49.674) = 3.46, p = 0.001$; 5 (2,000–2,500 ms), $t(59.393) = 2.03, p = 0.047$; 6 (2,500–3,000 ms), $t(49.265) = 2.06, p = 0.044$; and 10 (4,500–5,000 ms), $t(57.852) = 2.24, p = 0.029$. Following Bonferroni correction, only one of the 30 t tests remained

significant (zygomaticus response while viewing happy faces during the 1,500–2,000-ms epoch) (see online suppl. Table 3).

Discussion

This study provides the first test of whether young people first presenting to a BPD outpatient specialist service demonstrate a negativity bias by examining facial emotional reactions to positively, negatively, and neutrally valenced stimuli. Firstly, and contrary to expectations, the main analyses indicated that the BPD group did not exhibit exaggerated negative facial expressions when viewing angry or neutral facial expressions relative to the control group. There were no differences between the two groups in the magnitude of corrugator muscle responding to either of these two types of emotional stimuli. Follow-up analyses carried out to mitigate the risk of type II error corroborated this finding. Secondly, and again contrary to predictions, the main analysis indicated that the BPD group also did not exhibit attenuated positive facial expressions relative to controls. No differences emerged between the groups in the magnitude of zygomaticus muscle responding when viewing positive facial emotional expressions. However, follow-up analyses suggest that there might be some nuanced between-group differences, indicating that the BPD group responds with reduced positive facial expression when viewing happy faces, particularly around 1,500–2,000 ms following exposure to happy faces. Taken together, findings suggest that early in the course of BPD, there does not appear to be a maladaptive or heightened negativity bias as indexed by negative emotion expressivity when responding to observed emotions but that there might be a negativity bias whereby youth first presenting with BPD respond with reduced positive expression to positive emotions in others.

This finding that the BPD group's negative facial emotional responsivity to emotional expressions was comparable to HCs matched on age could be contextualised according to a clinical staging perspective of BPD [49, 77]. It is possible a maladaptive negativity bias occurs secondary to the negative stressful life events and iatrogenic harm associated later in the course of having BPD. This might include traumatic experiences [78], chronic devaluation as a result of delayed identification and treatment of BPD, and mental health discrimination and other adverse experiences within the mental health system [79, 80], as well as comorbid substance use [81] and psychosocial dysfunction [82, 83]. Each of these may

function to increase saliency of negative experiences and emotional sensitivity over time, potentially affecting the perception and expression of emotions later on [10, 33, 36, 50].

However, it is important to acknowledge that although maladaptive negativity biases have been evidenced in various aspects of emotion processing, memory, and attention [7, 8, 10], the current empirical data on how this impacts emotion perception and subsequent emotional expression are less clear. It is possible that as BPD progresses from early in its course to more severe and chronic presentations, a negativity bias develops in a similar staged process. For example, while Jovev et al. [84] demonstrated that those with early-stage BPD experience a negative attentional bias compared with healthy age-matched peers, two other studies that included similar cohorts found no evidence for a negativity bias in regards to emotional sensitivity [85] or autonomic facial mimicry [34]. Taken together, it could be that aspects of a negativity bias are evident earlier in the course of the disorder and later evolve into more pervasive and pronounced features such as negative attributional biases [50] and exaggerated negative emotional expression [33]. However, given the scarcity of research in young people earlier in the disorders course [34, 84–86], this remains speculative. Future studies examining the negativity bias across the course of BPD are therefore needed to establish the robustness of the present findings to other clinical cohorts and help develop a more refined understanding of the progression of the disorder [49, 87, 88]. Longitudinal studies would be of particular value here.

However, the findings are less clear regarding a negativity bias as might be captured by relatively reduced positive responses to positive emotions in others. Follow-up analyses suggested that young people first presenting with BPD perhaps do demonstrate attenuated positive facial reactions to happy faces relative to their healthy peers. Specifically, BPD participants responded with reduced positive facial expression when compared with their healthy counterparts when viewing neutral faces later within the 5,000-ms timeframe captured by the experiment (although this effect did not withstand correction for multiple comparison). They also responded with reduced positive facial expression when viewing happy faces for much of the early reaction, with one epoch withstanding correction for multiple testing. These data might indicate that compared with their peers, young people first presenting with BPD have a delayed smiling reaction when viewing happy faces, which might normalise in later epochs (i.e., over time). A delayed, rather than grossly blunted, positive facial emotional reaction to happy facial

expressions in others is reminiscent of the “slow echo” observed in children with autism spectrum disorder whose spontaneous facial responses were found to be delayed by 160 ms [89]. A deficit in positive emotion detection previously observed in BPD [90] might underpin the observed, though weak, pattern observed in these data. These findings also add to the limited research exploring positive affect reactivity in BPD, which has to date demonstrated either unaltered or reduced positive affect reactivity to pleasant stimuli [91–95]. Further research is needed to test this hypothesis and could include exposure to faces for longer periods (i.e., >5,000 ms), dynamic facial expressions, and to facial expressions with different levels of intensity, to enable a more substantial “recovery” period as well as greater ecological validity.

Understanding this issue is not only theoretically but also potentially practically important. This is because if a negativity bias is not evident, is only a subtle abnormality early in the disorder’s course, or is evident selectively for positively valenced emotions, it has implications for clinical treatment. It speaks to whether individuals first presenting with BPD would benefit more from a transdiagnostic approach addressing subthreshold difficulties and biosocial vulnerability (e.g., [96]), as well as early-intervention programs that preserve functioning and preclude pervasive psychosocial dysfunction (e.g., [97]). In contrast, interventions for those presenting with chronic BPD having endured symptoms for a longer period of time might require targeted treatment of a negativity bias and associated psychosocial dysfunction. This might include integrating interventions that target social cognition, such as social cognition interaction training [98] or facial feedback interventions [99] that have been used in treating socio-cognitive difficulties observed in other chronic mental health conditions such as schizophrenia [91].

Strengths and Limitations

This study had several important strengths – notably having addressed a large gap in the literature regarding the assessment of negativity biases early in the course of BPD, using facial EMG. However, several limitations also need to be acknowledged. Firstly, it is important to acknowledge that the current study was designed so that it was adequately powered to detect moderate to large-sized effects but did not have sufficient power to detect smaller ones. It is therefore possible that a group difference does in fact exist but that it is smaller than we were able to detect in the current study. Thus, the current findings indicate that if a true group difference does in fact exist, it

is not large in magnitude. Future research with a larger number of participants is now needed to establish whether smaller effects exist. Secondly, only three facial expressions were used as stimuli (angry, happy, neutral) in this study. It is of course possible that other facial expression not included here might evoke stronger (and differential) negative emotional reactions for first presenting populations with BPD compared with HCs, such as complex negative emotions (e.g., disgust) that are known to elicit schema relating to abandonment and rejection in adults with BPD [100]. However, the experience and expression of anger also closely relates to BPD pathology [101], and anger and happiness are often used in facial EMG research because these emotional expressions reliably and robustly index anger and happiness via the corrugator supercili and zygomaticus muscles, respectively [102, 103]. Although the current study did not set out to comment on the specificity of a maladaptive negativity bias to BPD separate from other disorders, this bias might also be a feature of disorders that are frequently comorbid with BPD, such as anxiety and depression [35]. To better understand negativity biases in the context of other co-occurring psychopathology, future studies might benefit from a clinical comparison group.

Thirdly, BPD participants were characterised as first presenting to specialist service targeting young people early in the course of disorder. This had also included individuals with sub-clinical features, and it is also possible that these features had been present in this group for some time. While including participants with three or more features might be considered a limitation of this study, a dimensional approach to personality disorders has increasing theoretical and empirical support [104]. Indeed, patients, including youth, with subthreshold BPD features (1–4) experience more severe mental illness and greater psychological morbidity than those with no features [3]. It is also of note that in the current sample, most of the BPD participants (63%) met five or more features of BPD, and 100 per cent of the HC group reported no BPD features.

Conclusions

To the authors’ knowledge, this study was the first to test whether a negativity bias exists in facial emotion reactivity in youths first presenting with BPD using facial EMG. The results of this study suggest that a negativity bias as indexed by negative emotion expressivity when responding to observed negative emotions is unlikely but might be evident in their early spontaneous positive

responses as indexed by positive emotion expression when responding to observed positive emotion. We suggest that a bias might develop as the disorder progresses, with greater severity and chronicity, or perhaps if present in the early stages of the disorder, may be relatively subtle. Future research with a larger number of participants is now needed to establish whether smaller effects exist. We also recommend that future research studies explore the possibility that positive affective reactions in this group might not be grossly blunted but rather delayed. Further work is also needed to establish whether the negativity bias that has been identified in some studies of later BPD is secondary to illness severity and chronicity or is evident but relatively subtle and/or restricted to only certain types of expressivity, in earlier presentations of the disorder.

Acknowledgments

We thank Orygen, and particularly the HYPE research team, who facilitated and supported the recruitment of BPD participants. We also thank the young people who generously gave up their time to take part in this study.

Statement of Ethics

This study protocol was reviewed and approved by the Melbourne Health Human Research and Ethics Committee (Approval No. 2014.190) and registered with the Australian Catholic University Human Research and Ethics Committee (Approval No. 201500037R). Written informed consent was obtained directly from participants aged 18 years and over and from parents/guardians of participants under 18 years.

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Conflict of Interest Statement

There are no conflicts of interest.

Funding Sources

This research was supported by an ACU Research Fund Grant (No. 2013000557) awarded to Peter G. Rendell and Gill Terrett. This grant funded the purchase of the EMG equipment used in this research.

Author Contributions

All the authors contributed significantly to this work. The research question was collaboratively developed by Elizabeth Pizarro-Campagna and Siobhan Korbit. The data were analysed and the manuscript was prepared by Siobhan Korbit as part of her Master of Psychology (Clinical). As the primary supervisor, Elizabeth Pizarro-Campagna oversaw Siobhan Korbit's work. Elizabeth Pizarro-Campagna collected the data as part of her PhD. The co-authors contributed their expertise and guidance in the areas of affective processes and their measurement (Gill Terrett, Peter G. Rendell, Julie D. Henry), data analysis (Peter G. Rendell), and borderline personality disorder (Andrew M. Chanen, Martina Jovev). All the authors provided critical feedback on the manuscript.

Data Availability Statement

The data that support the findings of this study are not publicly available due to their containing information that could compromise the privacy of research participants but may be made available by the corresponding author (Elizabeth Pizarro-Campagna).

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