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The perception of pain, discriminative touch and affective touch in patients suffering from Borderline Personality Disorder

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Abstract

Borderline Personality Disorder (BPD) is often characterized by self-injurious behaviors, with one-half to two-third of these patients reporting hypalgesic or analgesic phenomena during self-harming. Research on pain perception in BPD suggested abnormal processing of nociception either within the sensory-discriminative and/or motivational-affective systems of pain. Nevertheless, it is still unclear whether pain insensitivity could be generalized to other somatosensory submodalities. To investigate this question, 30 BPD patients and 30 matched healthy controls were enrolled in the current study and underwent a somatosensory battery composed of well-established psychophysical test assessing all the principal submodalities of somatosensation, namely pain perception (i.e., warm, cold and mechanical), discriminative touch (i.e., tactile acuity and tactile sensitivity) as well as affective touch. Results showed abnormal warm detection threshold, warm pain threshold, mechanical pain perception, and tactile sensitivity in BPD patients, but no differences emerged neither for tactile acuity nor for cold pain thresholds, cold tolerance, or for affective touch perception. Findings point to a deficit in nociception, as well as in tactile sensitivity in BPD individuals, and were discussed in relation to BPD clinical features including self-injurious behaviors.

Keywords: BPD; pleasant touch; gentle touch; nociception; somatosensation; tactile sensitivity; tactile acuity.

1. Introduction

According to the American Psychiatric Association (APA), Borderline Personality Disorder (BPD) is defined as a pervasive pattern of instability characterized by an intense fear of abandonment, impulsiveness, emotion dysregulation, chronic feelings of emptiness, inappropriate anger and unstable interpersonal relationships (APA, 2013). BPD is often complemented by self-harming and non-suicidal self-injurious behaviors, occurring in 70-80% of cases (Clarkin et al., 1983), which seems to represent unhealthy coping strategies to overcome emotional issues (Gratz, 2001; Haines & Williams, 1997; Linehan, 1993; Zanarini et al., 2008). Interestingly, one-half to two-third of these patients report hypalgesic or analgesic phenomena while committing self-injurious behaviors (Leibenluft et al., 1987), suggesting abnormal processing of nociception (Bohus et al., 2000; Schmahl et al., 2004, 2006).

Several authors have highlighted how much the skin is for BPD patients a space that conveys issues that are often not very well understood even by the patient himself. For example, it is not uncommon for these patients to cover their bodies with conspicuous tattoos and extreme piercings. (D'Ambrosio et al., 2013; Vizgaitis & Lenzenweger, 2019). Thus, it appears that, both in the case of painful piercings but, more importantly, in the case of self-injurious acts, BPD patients seem to feel, and seek out, physical pain in order to reduce unwanted internal states, particularly negative affect and/or aversive inner tension (Chapman et al., 2006; Linehan, 1993; Nock & Prinstein, 2004).

Researchers have wondered about the possible alteration of the somatosensory system in this population. Considering the peculiar aspects of pain perception in the BPD population, most of the available research focused on the nociceptive modality of the somatosensory system. In a seminal study carried out in accordance with the pain processing model proposed by Melzack and Casey (1968), Schmahl and colleagues (2004) missed to found difference between BPD patients and controls when asked to localize the painful stimuli. On the contrary, data showed that pain thresholds (namely the level at which a certain stimulus is considered as painful) – in terms of subjective ratings in response to laser-evoked pain – were significantly higher in BPD patients compared to healthy controls; in other words, the authors showed

that BPD patients need a higher heat intensity than controls to perceive pain. Similar results have been consistently found across several successive studies which, although employing different protocols, indicated higher pain thresholds in BPD patients (Ludäscher et al., 2007; Schmahl et al., 2006; Schmahl & Baumgärtner, 2015).

One aspect that has been less investigated is basic somatosensory functions. We believe that the possibility of having more knowledge about the functioning of basic tactile modalities could help in understanding the peculiar way of processing painful stimuli observed in BPD patients. In fact, while the focus on more conspicuous phenomena such as the analgesic effect experienced during acts of self-injury is understandable, the absence of data on basic somatosensory submodalities has limited a complete psychophysiological picture of BPD sensory profiles. When we talk about the somatosensory system it is usual to describe it in terms of several submodalities, in accordance with the function they subserve. For instance, Longo and colleagues (2010) have proposed a model in which three main components have been identified: somatosensation, somatoperception and somatorepresentation. Whereas somatoperception describes high-level processes of constructing percepts and experiences of somatic objects, events and of one's own body (e.g., localization of somatic stimuli on the body surface, perceiving the actual posture of the body, and construction and maintenance of a conscious body image) and somatorepresentation refers to abstract knowledge, beliefs, and attitudes related to the body as an object of third-person perception, categorization and cognitive reflection (e.g., structural-topological and lexical-semantic knowledge about bodies, attitudes and emotion towards the body), basic somatosensation refers to peripheral sensations that occur when a specialized mechanoreceptor in the skin is activated by a contact stimulus and encodes for its physical characteristics (e.g., force or direction). A full assessment of higher-order somatosensory components, such as somatoperception and somatorepresentation, would be beyond the aims of the current article; hence, we will focus on basic somatosensation. Historically, two main subcomponents of basic somatosensation have been identified: tactile acuity, the ability to discriminate and differentiate between two spatially close tactile stimuli delivered on the skin surface, and tactile sensitivity, the ability to identify whether an innocuous tactile stimulus is touching one's own skin or not (Mountcastle, 2005;

Weinstein, 1968). Regarding basic somatosensation, only two studies have explored such component in BPD in terms of tactile acuity (Pavony & Lenzenweger, 2013, 2014) showing no differences between BPD patients and healthy controls and suggesting a specific dysfunction in the nociceptive system that does not generalize to basic somatosensation; nevertheless, other somatosensation submodalities such as tactile sensitivity have not been explored in BPD yet.

Recent scientific literature has also highlighted the presence of a specific tactile system subserving the conveyance of social and affective aspects of touch (McGlone et al., 2007, 2014; Olausson et al., 2016). This type of touch has been often referred to as affective touch, a label that defines the subjective, pleasant sensation that is evoked by light, caress-like stimuli, delivered on the skin at slow velocities (i.e. between 1 and 10 cm/s) (Ackerley et al., 2014a; Löken et al., 2009) with temperature similar to the skin surface (Ackerley et al., 2014b) (for a review, see Cruciani et al., 2021). From a physiological standpoint, affective touch seems to be mainly conveyed by specific low-threshold mechanoreceptive afferents, namely C-tactile (CT) fibers (Löken et al., 2009; McGlone et al., 2014; see also Case et al., 2023; Schirmer et al., 2023 for recent studies on the role of other fibers in conveying affective touch). These are activated by slow, caress-like stimuli, and their activity positively correlates with subjective pleasantness of sensations (Ackerley et al., 2014a; Löken et al., 2009; Nordin, 1990). Affective touch perception appears impaired in several psychiatric disorders including anorexia nervosa (Crucianelli et al., 2016, 2020; Davidovic et al., 2018), and bulimia nervosa (Wierenga et al., 2020) as well as in healthy people with insecure (Krahé et al., 2018) and disorganized (Spitoni et al., 2020) attachment pattern, suggesting that abnormal processing of social and interpersonal information may have a modulating role in perceiving affective, pleasant tactile stimuli.

Moreover, the literature has highlighted a link between affective touch and pain perception; in fact, affective touch has a modulator role on nociception, indicating that optimal activation of CT fibers results in a reduction of subjective pain ratings of noxious stimuli (Habig et al., 2017; Krahé et al., 2016; Liljencrantz et al., 2017; von Mohr et al., 2018). Despite this, although unstable interpersonal relationships and abnormal pain perception are two well-established features of BPD, the perception of affective touch in such patients has not been explored extensively.

For these reasons, the current study aims to systematically measure different submodalities of the somatosensory system in BPD patients compared to healthy controls. In particular, established psychophysical tests have been employed in the assessment of pain perception (i.e., warm, cold and mechanical) as well as of basic somatosensation (i.e., tactile acuity and tactile sensitivity). In addition, an extensively used, specific protocol for the evaluation of affective touch perception has been included in the tactile battery. Consistent with previous literature, we hypothesized that BPD patients would display an altered pain perception with respect to healthy controls. Concerning somatosensation and affective touch, given the scarcity of available data on BPD patients, no directional hypotheses can be drawn; rather, we aimed at exploring BPD performance in somatosensation and affective touch domains.

2. Methods

2.1. Participants

35 BPD patients were recruited from a neuropsychiatric hospital (Villa Von Siebenthal intensive and extensive services). Diagnosis of BPD was defined by a psychiatric interview made by the clinicians and in accordance with the Diagnostic and Statistical Manual of Mental Disorders - Fifth Edition (DSM-5) criteria (APA, 2013). Exclusion criteria for BPD participants were: lifetime diagnosis of bipolar type I or II disorder, psychotic disorders, neurological diseases, and other serious medical conditions; patients were also excluded in case of current abuse or addiction disorders and/or of major depression. Since 3 of the patients were excluded according to exclusion criteria, and 2 other patients did not complete the experimental procedure, a final sample of 30 BPD patients (16 females, mean age = 32.8 ± 11.18, all right-handed) was used for data analysis. Of these, nine patients additionally fulfilled the DSM-5 lifetime-criteria for substance related disorders, and eight patients reported lifetime major depressive or dysthymic disorders. All patients were on stable medication for 2 weeks prior to the experiment.

30 age- and sex- matched healthy participants (16 females, mean age = 32.1 ± 10.74, all right-handed) were recruited from the general population by word of mouth and using flyers distributed in a commercial area of downtown and participated as a control group. All control participants reported no

history of neurological or psychiatric diseases, were in good health and were not on any medication. To exclude any possible BPD patient from the control group, healthy participants were evaluated using the specific BPD module from the Structured Clinical Interview for DSM-5 - Personality Disorders (SCID-5-PD; First et al., 2016; Italian version by Fossati & Borroni, 2017).

All participants also underwent clinical assessment via the Symptom Checklist-90-Revised (SCL-90-R; Derogatis, 1994), a self-report questionnaire composed of 90 items exploring the frequency of several psychological symptoms in the last week across nine clinical subscales (Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Phobic Anxiety, Psychoticism, Paranoid Ideation, and Hostility) and a Global Severity Index (GSI). SCL-90-R was used to exclude possible cases of clinically relevant psychological distress in the control group.

2.2. Procedure

The present research was approved by the ethics committee of the Department of Dynamic and Clinical Psychology, and Health Studies, Sapienza University of Rome, and conforms to the World Medical Association Declaration of Helsinki of 1975, as revised in 2008. All participants provided written informed consent prior to the experiment and were free to withdraw from the study at any time.

Each participant was tested individually in a quiet room and the experimental session took approximately 45 minutes. All participants completed the SCL-90-R, and control participants were interviewed via SCID-5-PD. Afterward, participants underwent a somatosensory assessment battery made up of 8 separate tests, delivered in the following order: affective touch perception, tactile acuity, tactile sensitivity, mechanical pain perception, warm detection threshold, warm pain threshold, cold pain threshold, and cold tolerance. All participants were tested in the same fixed order: this was necessary to avoid possible interactions between specific submodalities of touch, such as mechanical pain sensitivity phenomena following thermal stimulations (Gröne et al., 2012). Participants were all stimulated on the right forearm/hand.

2.3. Measures

2.3.1. Affective touch

- *Affective touch protocol.* Participants sat at a table with their dominant forearm resting palm-down. Participants were instructed to sit still with their eyes closed during the procedure and to focus on the tactile sensation. As in previous studies (Keizer et al., 2019; Pawling et al., 2017; Sailer & Ackerley, 2019; Spitoni et al., 2020; Zingaretti et al., 2019), tactile stimulation of the participants' dorsal forearm was delivered manually by the same experimenter, who was trained to apply stroking in a proximo-distal direction with constant pressure and velocity using a soft goat's hairbrush. Stroking was delivered at two velocities: 3 cm/s (CT-optimal) and 30 cm/s (non-CT-optimal). The terms CT-optimal and non-CT-optimal refer to velocities that have been shown to optimally or suboptimally elicit CT fibers firing respectively (Ackerley et al., 2014a; Löken et al., 2009). To guide the experimenter during the stimulation, a 15 cm of length and 4 cm of height grid was drawn on the long axis of participants' forearm; to minimize CT habituation, four different areas were delimitated by the grid (two laterals and two medials) and were stimulated in alternate way. 10 CT-optimal and 20 non-CT-optimal stimuli were delivered in a pseudorandomized order to each participant. After each stimulation, subjects were asked to rate their subjective perception of pleasantness using a 100mm VAS with "not pleasant at all" (sad face) and "extremely pleasant" (smiley face) as endpoints. For each participant, individuals' affective touch index was calculated as well. The affective touch Index reflects the individual preference towards CT-optimal or non-CT-optimal stimulations and it is defined as the individual difference in pleasantness rating between the CT-optimal (i.e., 3 cm/s) and non-CT-optimal stroking velocities (i.e., 30 cm/s), weighted by the overall pleasantness of the touch (Croy et al., 2019). Positive values for the affective touch index indicate a preference for slower over faster stroking, whereas negative values suggest a preference towards faster over slower stimulations.

2.3.2. Somatosensation

- *Von Frey's monofilaments test (von Frey et al., 1896).* This test was used to assess tactile sensitivity thresholds as it is a classical measure of sensitivity to tactile pressure that is used for diagnostic

and research purposes (North Coast Medical, Inc., Morgan Hill, CA, USA). The tip of a fiber with a specific force rating (from 0.008 to 300 gf) is pressed against the skin of the participants' dorsal forearm at right angles for about 1 second. The force of application increases as the researcher advances the probe until the fiber bends. Participants were instructed to sit still with their eyes closed and focus on the tactile sensation. The procedure was repeated using various fiber force ratings, forming an ascending staircase in which monofilament thickness increased, as well as the force of application to bend the fiber. At each level of the staircase, meaning for each monofilament, 6 actual stimulations and 4 catch trials (a total of 10 stimulations) were presented. For each stimulation, the experimenter asked the participants whether they felt the stimulus, to which they had to respond verbally. The threshold was established at the level when the subjects reported 7 out of 10 stimuli correctly and was expressed in gramme force (gf).

- *Two Point Discrimination test (2PD – Weber, 1978).* 2PD was employed to assess tactile acuity thresholds. Stimuli were delivered manually to the dominant forearm using an adjustable aesthesiometer (Med Core, St. Louis, MO, USA) with two separate blunted tips. Participants were instructed to sit still with their eyes closed and to discriminate between single and double taps, responding verbally. Double or single taps were administered randomly to minimize attention effects. Only double taps were used to calculate the threshold. Stimuli were applied with approximately two seconds allowed between each application. For this type of sensory testing, pressure that depresses the skin no more than 1 mm is appropriate; additional pressure may be perceived as pain rather than light touch and would bias the results. All the stimuli were delivered parallel to the long axis of the forearm (Nolan, 1982). The separation between the two starting points was 1 cm. When an error was made, the separation rose by 0.5 cm. The separation was then decreased by 0.5 cm after each correct response. The participants' threshold was derived from the minimum distance that was correctly perceived between the two points 5 times consecutively and was expressed in cm.

2.3.3. Pain

- *Mechanical pain perception task.* Mechanical pain perception was investigated using a Wartenberg pinwheel, an instrument widely used in clinical and research practice for the assessment of sensitivity and pain perception (Bock et al., 2005; Caro & Winter, 2014; Wartenberg, 1937). As recommended by the guidelines for the use of this clinical tool, the pinwheel was moved with constant moderate velocity and pressure across a section of around 15 cm of length on the dominant dorsal forearm. After each trial, participants were asked to rate the perceived pain using a 100mm visual analog scale (VAS) ranging from 0 ("not painful at all") to 100 ("extremely painful"). Three trials were delivered with an interstimulus interval of 20s and then averaged to obtain the mean of perceived mechanical pain for each participant (expressed in mm).

- *Warm detection threshold test.* Warm thresholds were collected using a TSA II device (MEDOC Inc., Ramat Ishai, Israel). A warming cylinder with 1.5 cm of diameter was placed on the dorsum of the right hand and warm detection threshold was estimated by the method of limits (Yarnitsky et al., 1995). The probe temperature was fixed at a basal level of 32°C and then ramped up by 1°C/s; to avoid any tissue damage, maximum temperature was set at 50°C. Participants were asked to report verbally as soon as they perceived any change in the temperature and then report the direction of temperature change. To avoid distorted responses, participants were told that temperature could either became warmer or cooler, although it was actually only ramped up. Three trials were delivered, with an interstimulus interval of 20s. The trials were then averaged to obtain an individual warm detection threshold, expressed in °C.

- *Warm pain threshold test.* A similar procedure as described above was used in this test. In this case, participants were asked to report verbally as soon as the heat became intolerable. Three trials were delivered and then averaged to obtain an individual warm pain threshold, expressed in °C.

- *Cold Pressor Test.* Participants were asked to immerse their hand up to the wrist in a compartment containing cold water at 1°C. To avoid any tissue damage, maximum time of immersion was set at 4 minutes and participants were told that they could remove their hand at any time. Two outcomes were collected in one single session: cold pain thresholds and cold tolerance. For cold pain threshold,

participants were asked to keep their hand submerged in the water and verbally report as soon as the cold became painful; cold pain threshold was expressed in seconds from the moment participants immersed their hand to when they reported a painful sensation. For cold tolerance, participants were asked to resist as long as possible with their hand submerged in the cold water; cold tolerance was measured in seconds from the moment participants inserted their hand in water to when they removed it from the compartment.

2.4. Statistical analyses

Data processing was performed using IBM SPSS Statistics software version 25.

To evaluate group differences in demographic and clinical variables of the study, two sample *t*-tests were computed on age and SCL-90-R subscales. Chi-square comparison was run to test for group differences in sex distribution.

To assess differences between BPD patients and healthy controls in the submodalities of touch, data were first checked for normality of distribution using one-sample Kolmogorov-Smirnov tests. These showed that data on 2PD, Von Frey's monofilaments test, mechanical pain perception task, warm thresholds tests and the affective touch index were not normally distributed. Therefore, groups were compared running both nonparametric (Mann-Whitney *U*) and parametric (two sample *t*-test) statistics. Cohen's *d* was calculated to quantify the effect sizes of comparisons.

To examine group differences in the perception of affective touch, a mixed factorial 2x2 ANOVA was run, with Group (BPD vs. controls) as between subjects factor, Velocity of stimulation (3 cm/s vs. 30 cm/s) as within subjects factor, and subjective pleasantness ratings as dependent variable. Partial eta-squared and observed power were calculated.

3. Results

The dataset had no missing data. Given the absence of significant age (BPD mean = 32.8 ± 11.18; Controls mean = 32.1 ± 10.74; $t_{(58)} = 0.247$; $p = 0.806$) and sex distribution ($\chi^2 = 0.000$; $p = 1.000$) group

differences, they were not included as a covariate in the statistical analyses. Group differences in the subscales of SCL-90-R are summarized in Table 1.

[Insert Table 1 about here]

Group comparisons for all the somatosensory measures are reported in Table 2 and individual data points are displayed in Figure 1. When BPD patients were compared with healthy controls, group differences emerged. Specifically, we found higher tactile sensitivity thresholds in the BPD group in the Von Frey's monofilaments test; lower subjective pain ratings in the BPD group in the mechanical pain perception; lower sensitivity to temperature change in the BPD group in the warm detection threshold; higher thresholds in the BPD group in the warm pain threshold. No group differences were found neither for tactile acuity nor for cold pain thresholds, cold tolerance, or for the affective touch index.

[Insert Table 2 about here]

[Insert Figure 1 about here]

Regarding affective touch perception, the ANOVA revealed a significant main effect of Velocity of stimulation ($F_{1,58}$ = 45.988; p < 0.001; Partial eta-squared = 0.442; Observed power = 1.000), with higher pleasantness ratings for stimulations at 3cm/s compared with 30cm/s. Neither a significant main effect of Group ($F_{1,58}$ = 0.000; p = 0.996; Partial eta-squared = 0.000; Observed power = 0.050) nor Velocity x Group interaction ($F_{1,58}$ = 0.081; p = 0.777; Partial eta-squared = 0.001; Observed power = 0.059) emerged (Figure 1).

[Insert Figure **2** about here]

4. Discussion

The aim of the current study was to provide a detailed description on the functioning of different tactile modalities in patients with BPD. To this end, a battery of tactile measures was created to evaluate somatosensation, pain and affective touch. We extended previous studies measuring specific functions of the tactile modalities. Somatosensation was measured through the assessment of tactile sensitivity and

tactile acuity. With respect to pain, we assessed mechanical and thermal pain; this latter was measured by detection and thresholds of pain perception produced by warm and cold stimulation. Finally, affective touch was studied using a protocol able of eliciting CT-optimal and CT non-optimal stimulations. Patients' performance was compared with that of a control group paired by demographic characteristics.

4.1. Somatosensation

When compared with the control group, it was found that the sensitivity thresholds shown by the BPD patients were significantly higher. Specifically, patients needed about 96 gramme force more to identify the presence of a tactile stimulus touching the skin. In other words, in order to perceive a stimulus on the skin, BPD patients must be touched with a thicker and stiffer filament. As mentioned earlier, the Von Frey test is recognized as the gold standard measure for assessing mechanical sensitivity in the clinical setting (Kang et al., 2022). Obviously, the nature of our study does not allow us to make inferences about the state of functioning of mechanoreceptors stimulated by Von Frey filaments; what we can do, however, is to recognize that BPD patients seem to need more intense mechanical stimulation than controls. This observation seems in line with a peculiar hallmark of these patients, namely, the constant search for intense sensory experiences as a means of "feeling and experiencing sensations" that they are otherwise unable to have. Marsha Linehan, creator of the Dialectical Behavior Therapy, argues that BPD patients seem to have “no emotional skin” (Linehan, 1993). The literature suggests that this state is not innate, but rather the result of a psychological process activated and maintained by patients to avoid being hurt even by stimuli that, for healthy subjects, are harmless. A kind of psychological thickening of the emotional skin. Within this framework, the data on reduced tactile sensitivity to Von Frey, could provide an additional component in understanding the phenomenon.

Regarding tactile acuity, we observed no differences between groups; this finding is in line with and confirms previous studies (Pavony et al., 2013, 2014). Unlike tactile sensitivity, which refers to the force applied by a stimulus to be perceived, tactile acuity simply encodes for the spatial qualities of the stimulus.

Thus, it is reasonable that BPD patients do not show alterations in processing the spatial properties of tactile stimuli.

4.2. Pain

Three nociceptive submodalities have been studied, namely mechanical, thermal warm and thermal cold.

Mechanical pain was delivered by the Wartenberg pinwheel, a tool widely used in clinical assessment of tactile sensitivity and pain perception (Bock et al., 2005; Caro & Winter, 2014; Wartenberg, 1937). Compared with the control group, patients showed almost no painful perception; while healthy subjects perceive the pinwheel stimulation as painful (VAS = 63.46 units) patients indicate that the same stimulation produces half as much pain (VAS = 34.5 units). This finding appears to us to be consistent with that of sensitivity; in fact, even in the case of pain, patients exhibit lower sensitivity to nociceptive stimulation supporting, therefore, a hypothesis of psychological thickening of the emotional skin.

The finding on lower mechanical pain perception has also been used as a possible explanation for the self-harm behaviours that occurred in BPD patients. Schmahl and Baumgärtner (2015) have proposed a stress-induced analgesia model to address self-injurious behaviors in BPD patients as a way to reduce aversive inner tension. Particularly, the authors suggest two possible underlying mechanisms, in which either stress decreases following injury through autonomic-limbic pathways in a direct paradoxical feedback mechanism, or the pain experience associated with the injury leads to a decrease in stress via paradoxical feedback involving the nociceptive and limbic-behavioral networks. In either case, such behaviors are associated to habituation, leading to alterations in the nociceptive pathways. In fact, it was observed that repeated self-injury in BPD patients may lead to a reduction of pain sensitivity in response to mechanical noxious stimuli (Magerl et al., 2012).

An additional data confirming this pattern was observed in the perception of thermal warm pain; compared with control participants indeed, BPD patients showed a higher threshold of perception of warm pain. In other words, and in agreement with literature, BPD patients need higher temperatures to perceive

noxious sensations (Bohus et al., 2000; Russ et al., 1992; Schmahl et al., 2004). Consistent with this latter finding, we also found higher warm detection thresholds in BPD, indicating that, compared with controls (35.04°), patients need a higher temperature change (37.13°) to detect modifications in thermal stimuli. Whereas higher pain thresholds reflect hypoalgesic phenomena, the increased warm detection thresholds refer to hypoesthesia, that is, reduced thermal sensitivity. It is worth mentioning that literature on reduced sensitivity to innocuous warm stimuli in BPD are inconsistent, reporting whether no differences between patients and controls (Bekrater-Bodmann et al., 2015; Ludäscher et al., 2007) or lower thermal sensitivity in BPD individuals (Defrin et al., 2020; Schmahl et al., 2004). Similar inconsistencies could be observed also in the assessment of cold perception in BPD using the cold pressor test. In fact, a few articles reported lower pain ratings during the cold pressor test in BPD with respect to healthy controls (e.g., Bohus et al., 2000); however, other studies showed either no group differences (McCown et al., 1993) or higher cold tolerance but similar cold pain thresholds in BPD patients with respect to healthy participants (Pavony et al., 2014). Our results did not show significant differences in any of the cold pressor test outcome (i.e., cold pain thresholds and cold tolerance) between BPD patients and controls. The latter data seems to deflect the interpretation on the possible alteration of psychological thickness of emotional skin, nevertheless, the raw data showed a large difference to cold pain tolerance.

Since the inferential statistics did not show significance, we cannot treat this finding as an actual difference between the two groups. However, it is interesting to note that the values observed in patients (cold pain = 19. 38 and cold tolerance = 78.28) are significantly larger than those found in controls (cold pain = 10.28 and cold tolerance = 56.01) suggesting that patients seem to show higher tolerance to pain caused by cold. Perhaps, the high variability of these measures, may have had an influence on the lack of a significant statistic; for this reason, it is essential to further investigate the data with ad hoc studies.

4.3. Affective touch

All study participants were evaluated with a comprehensive affective touch protocol, consisting of affective (CT-optimal) and non-affective (non-CT-optimal) stimulations on the right forearm. Unexpectedly, we found

no differences between patients and healthy controls in the evaluation of either affective or non-affective stimuli. Both groups rated affective stimulations more pleasant than non-affective stimulations missing to confirm the few previous studies on the evaluation of affective touch in borderline patients. Although at first sight this finding may seem surprising, a close comparison with previous studies reveals numerous methodological differences that range from the type of patients studied, the specific stimulation technique and the body district stimulated. For example, Croy et al. (2016) found that patients with personality disorders rated pleasant touch as less pleasant compared to controls; however, authors did not report results for different kind of personality disorders leaving the specific BPD alterations unknown. More recently, an elegant study on the relationship between pleasant touch perception and disturbed body representation in BPD (Löffler et al., 2022), authors found that compared to controls, BPD perceived pleasant touch as less pleasant and less intense. The reason why this latter evidence appears inconsistent with the data from our study, could be methodological as the two studies differ significantly. The first difference concerns the sample. In the study by Löffler et al. (2022), only females were studied while in our study the sample was equally divided between males and females. This finding needs to be taken into account in light of a meta-analysis that showed sex differences in the perception of affective touch (Russo et al., 2019). A second difference between the two studies, concerns the stimulated body part and the stimulation technique that was used. In our study, we manually stimulated the right forearm since it is the body district most affected by self-injury. In the study by Löffler and collegues (2022), stimulations were given on the back of the left hand using a custom apparatus which applied touch without social interaction. This second difference could be partially explained by the so called “touch hunger” hypothesis which postulates that deficiency of early tactile social experiences, such in case of neglecting parenting characterizing BPD, may result in a need for social touch (Field, 2010, 2014). In these terms, the presence of an experimenter may have influenced the experience of stimulation through an interaction between the actual tactile stimulation and the fact that it was delivered by a human being. At present, the limited number of specific studies on affective touch in BPD patients does not allow for more solid interpretations; therefore, we share the need to increase experimental studies on this topic.

4.4. Limitations

This study presents several limitations. The most conspicuous limitation is the absence of a direct comparison between BPD patients who self-harm and patients who do not. At the time of data collection, access to psychiatric hospitals was severely limited by pandemic procedures. This status did not allow the collection of larger numbers of patients to create two balanced groups. Moreover, self-harming behaviors have not been extensively explored, although all healthy controls reported no self-injurious behaviors when screened with the SCID-5-PD. Future studies should better address these issues, with particular regard to the relation with affective touch perception.

Secondly, although current comorbidity with other psychopathologies was excluded, BPD patients reported higher clinical symptomatology as assessed via SCL-90-R; further research is mandatory to explore how psychopathological symptomatology may affect tactile perception in BPD patients, with particular regards to traumatic experiences and levels of dissociations: these clinical features have been in fact linked to BPD but also to anorexia and bulimia nervosa, as well as to disorganized attachment, and could play a role in modulating tactile functions. Similarly, we could not clinically assess all relevant comorbidities (e.g., eating disorders, dissociative disorders) in the control group, although self-report screening procedure did exclude history of any psychiatric or neurologic disorders and current clinical symptomatology.

Another limitation regards the psychophysical methods for the assessment of the warmth detection threshold. When someone displays an elevated warmth detection threshold in the test used here, we cannot be sure whether this is reflects poor sensitivity (their percept does not strongly track the actual stimulus temperature) or because they have a bias against saying “warm”. In other words, we cannot distinguish between sensitivity and an unusual response bias. Future studies should address this issue by investigating a possible response bias in participants’ performance, for instance by analyzing data using point of subjective equality and just noticeable difference approaches or including additional implicit measures (e.g., neuroimaging, heart rate variability, skin conductance).

A last limitation concerns a mandatory differentiation between the physiological encoding (detection) and the perception of a tactile stimulus. Detection can provide us with clear results, as it is a specific threshold, whereas other perceptions, including pain, are more individual and variable. In this framework, it is pivotal to study the contribution of peripheral and central processes to detection and perception of these tactile stimuli combining, for instance, microneurography, psychophysical and psychophysiological experiments and collecting and analysing data following the Signal Detection Theory (Green & Swets, 1966; Macmillan & Creelman, 2005).

4.5. Conclusions

Limitations notwithstanding, the present work provides an extensive assessment of all principal subdimensions of touch using well-established psychophysical tests, exploring for the first time also tactile sensitivity and affective touch perception in BPD patients. Overall, the current study provides evidence pointing to a deficit in nociception, as previously reported, as well as in tactile sensitivity in BPD individuals, compared to healthy controls. Future studies are needed to better address whether such impairment could be due to peripheral deficit or to central mechanisms involving clinical, psychological and interpersonal factors.

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Conflict of interest. None

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Tables and Figures

Table 1. Descriptives and statistics of pre-existing group differences in the SCL-90-R subscales.

Subscale	**Mean ± SD Borderline**	**Mean ± SD Controls**	***t***	***p***	**Cohen's *d***
Somatization	61.12 ± 11.78	45.93 ± 5.19	5.967	<.001	1.714
Obsessive-compulsive	61.72 ± 10.94	46.55 ± 6.94	5.974	<.001	1.684
Interpersonal sensitivity	60.88 ± 11.80	46.52 ± 6.47	5.422	<.001	1.541
Depression	66.60 ± 9.57	47.03 ± 6.49	8.652	<.001	2.428
Anxiety	66.52 ± 11.15	47.03 ± 6.49	7.420	<.001	2.102
Hostility	57.04 ± 12.46	45.79 ± 6.17	4.102	<.001	1.172
Phobic anxiety	63.60 ± 11.32	45.72 ± 3.92	7.516	<.001	2.177
Paranoid ideation	60.16 ± 13.32	46.31 ± 6.21	4.773	<.001	1.368
Psychoticism	66.36 ± 11.04	48.48 ± 8.03	6.866	<.001	1.874
Global Severity Index	66.24 ± 11.27	46.83 ± 7.30	7.383	<.001	2.078

Table 2. The table summarizes the main features of measures included in the somatosensory asssessment. For each measure, group comparisons descriptives and statistics are provided.

Measure	**Function (unit)**	**Question**	**Mean ± SD Borderline**	**Mean ± SD Controls**	**Mann-Whitney *U***	***p***	**Student's *t***	***p***	**Cohen's *d***
Von Frey's Monofilament	Tactile sensitivity (gramme force)	Did you feel the stimulus?	3.06 ± 0.50	2.64 ± 0.63	283	.013	2.845	.006	0.739
Two point discrimination	Tactile acuity (centimeters)	Did you feel one or two taps?	4.22 ± 1.28	3.01 ± 0.89	448	.982	0.702	.486	1.098
Mechanical pain perception	Mechanical pain (VAS)	How painful was the stimulation?	34.50 ± 22.55	63.46 ± 20.33	149	<.001	-5.143	<.001	1.349
Warm detection threshold	Warm sensitivity (°C)	When does the temperature change?	37.13 ± 3.52	35.04 ± 1.59	269	.007	2.969	.004	0.765
Warm pain threshold	Warm pain (°C)	When does it feel painful?	45.58 ± 3.15	42.54 ± 3.49	224	<.001	3.540	.001	0.915
Cold pressor test	Cold pain (seconds)	When does it feel painful?	19.38 ± 26.16	10.28 ± 9.30	337	.139	1.768	.082	0.464
Cold pressor test	Cold tolerance (seconds)	How long can you resist?	78.28 ± 76.29	56.01 ± 52.16	383	.435	1.305	.197	0.341
Affective touch index	Affective touch (VAS)	How pleasant was the stimulation?	0.51 ± 0.70	0.48 ± 0.51	431	.786	0.212	0.833	0.055

Figure 1.

Plots of individual data points for measures included in the somatosensory assessment.

[NO COLORS]

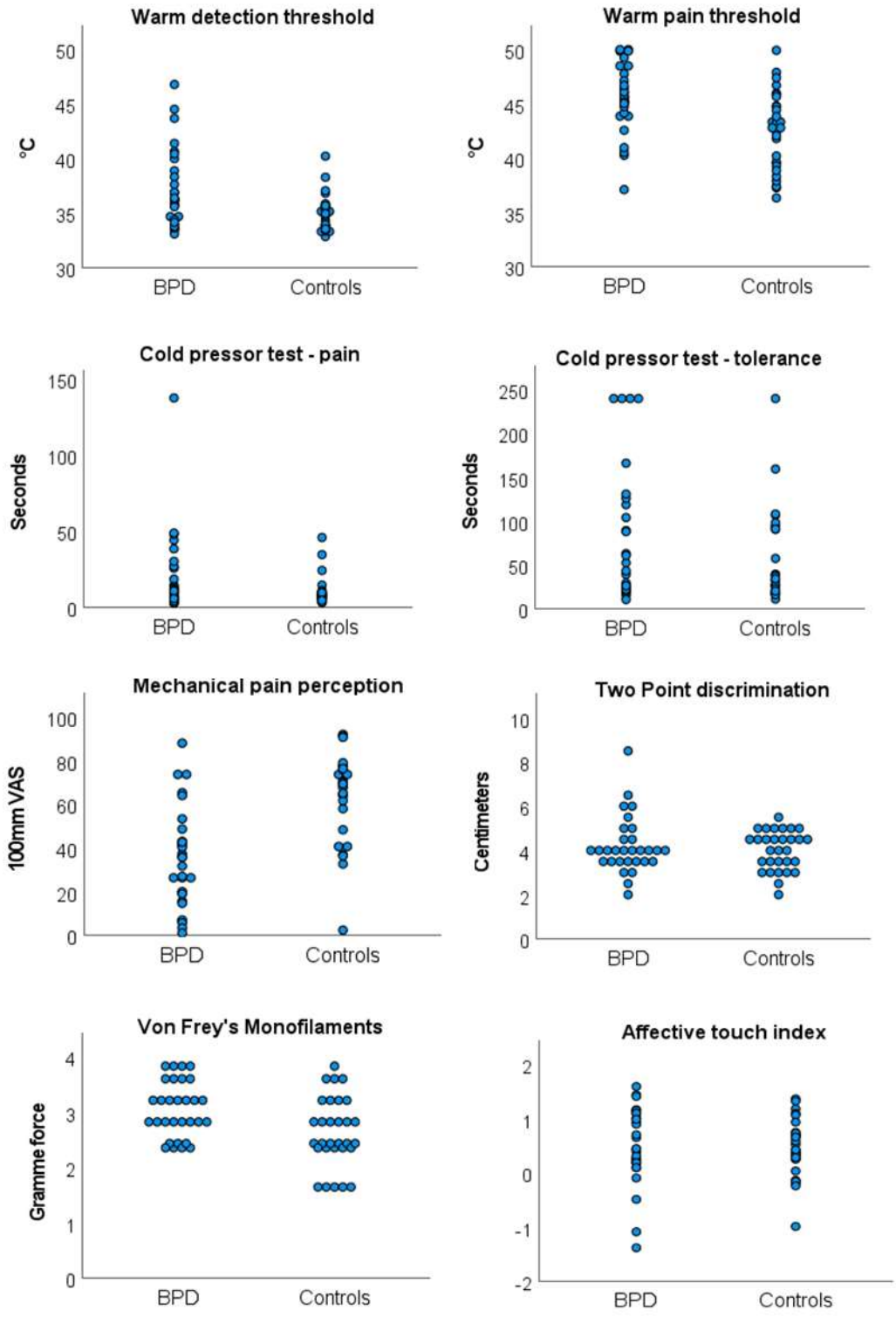

Figure 2.

Group comparison between BPD patients and healthy controls on ratings of CT-optimal (3 cm/s) and non-CT-optimal (30 cm/s) stimulations. Y-axis depicts pleasantness ratings in response to CT-optimal and non-CT-Optimal stimulations on a 100mm VAS scale with anchors 0 = “not pleasant at all” and 100 = “extremely pleasant”.

[NO COLORS]