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Abnormal perceptual sensitivity in body-focused repetitive behaviors

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Abstract

Objective

Several compulsive grooming habits such as hair pulling, skin picking, and [nail biting](#) are collectively known as body-focused [repetitive behaviors](#) (BFRBs). Although subclinical BFRBs are common and benign, more severe and damaging manifestations exist that are difficult to manage. Researchers have suggested that BFRBs are maintained by various cognitive, affective, and sensory contingencies. Although the involvement of cognitive and [affective processes](#) in BFRBs has been studied, there is a paucity of research on sensory processes.

Methods

The current study tested whether adults with subclinical or clinical BFRBs would report abnormal patterns of [sensory processing](#) as compared to a healthy control sample.

Results

Adults with clinical BFRBs ($n = 26$) reported increased sensory sensitivity as compared to persons with subclinical BFRBs ($n = 48$) and healthy individuals ($n = 33$). Elevations in sensation avoidance differentiated persons with clinical versus subclinical BFRBs. [Sensation seeking](#) patterns were not different between groups. Unexpectedly, BFRB severity was associated with lower registration of [sensory stimuli](#), but this finding may be due to high psychiatric comorbidity rates in the BFRB groups.

Conclusions

These findings suggest that several sensory abnormalities may underlie BFRBs. Implications for the etiology and treatment of BFRBs are discussed.

Keywords

Trichotillomania, Excoriation disorder, Sensory gating, Somatization, Perception

1. Introduction

Several compulsive grooming habits such as hair pulling, skin picking, and [nail biting](#) are collectively known as body-focused [repetitive behaviors](#) (BFRBs) [1]. Despite involving different areas of the body, BFRBs are thought to share functional similarities and may represent different behavioral manifestations of a single latent obsessive-compulsive related disorder. Indeed, BFRBs have similar symptom presentations, [phenomenology](#), age of onset, and courses; co-occur at a high rate [2, 3]; and respond to similar treatments [4, 5, 6].

Occasional engagement in BFRBs is relatively common and benign [7], but more severe manifestations can lead to significant physical and psychosocial consequences such as bleeding, scarring, shame, and depression [4, 8, 9]. Despite these negative [sequelae](#), individuals with clinical BFRBs have difficulty controlling or stopping the behaviors [10], leading researchers to examine variables that maintain symptoms.

Mansueto et al. [11] proposed a comprehensive behavioral model of BFRBs in which symptoms are maintained by cognitive, affective, and sensory contingencies. For instance, individuals may engage in symptoms to remove undesired hairs or blemishes¹, cope with stress, and/or provide [tactile stimulation](#). This model has been supported by research on [emotion regulation](#) in BFRBs. Emotion regulation is a self-regulatory process whereby individuals attend to and respond to internal affective events [12], and maladaptive emotion regulation is thought to involve problems in identifying, managing, and/or regulating emotional experiences [13, 14]. Considerable evidence indicates that BFRBs are associated with maladaptive emotion regulation [15]. Indeed, research shows that aversive affect tends to elicit BFRBs and that BFRBs temporarily attenuate aversive internal events (e.g., anxiety, stress, and tension) [15].

In addition to emotion regulation, researchers have suggested that stimulus regulation is an important function of BFRBs [11, 16]. Stimulus regulation is another self-regulatory process whereby individuals identify and respond to [somatic](#) events [17]. This proposition has some support based on the known phenomenology of BFRBs. For instance, BFRBs are non-violent, self-defacing behaviors that stimulate the skin, nails, and teeth. Rather than being experienced as aversive and painful, symptoms are often perceived as enjoyable [18], supporting the notion that BFRBs are automatically reinforced. Indeed, researchers using functional behavior analytic assessments have found that BFRBs are at least partially reinforced through [self-stimulation](#) [19, 20, 21]. Other studies using retrospective [self-report](#) have found that compulsive hair

pulling and skin picking attenuates aversive sensations (e.g., [itching](#) and tension) and provides automatic sensory reinforcement (e.g., pleasurable sensations) [[18](#), [22](#), [23](#), [24](#)].

Penzel [[16](#)] proposed a model wherein affected persons engage in BFRBs to distract themselves when over-stimulated and arouse themselves when under-stimulated. Penzel argued that BFRBs serve this function because: (a) humans have a large amount of easily accessible hair, skin, teeth, and nails; (b) the areas involved in BFRBs (i.e., [hair follicles](#), skin, [fingertips](#), and gums) are densely populated with nerves and are easy to stimulate; (c) there are many features of hair, skin, gum beds, and nails that are stimulating to [touch](#) (e.g., bumps, rough or hard spots); (d) BFRBs may represent genetic relics of ancient grooming patterns that can be elicited easily; and (e) BFRBs are often reported as pleasurable in persons with clinical presentations [[15](#)]. According to the stimulus regulation model, persons with BFRBs possess deficient neural mechanisms that are unable to balance internal stimulation and achieve [homeostasis](#) [[16](#)]. BFRBs are then seen as efforts to behaviorally regulate the imbalanced internal states that arise from these deficient neural mechanisms.

Unfortunately, little research has examined the validity of the stimulus regulation model, particularly the notion of deficient [self-regulation](#) processes. Extant research has shown that individuals with BFRBs report greater magnitudes of somatic sensations than healthy controls [[25](#), [26](#)], while other studies have found no difference in [pain thresholds](#) between persons with and without BFRBs [[27](#), [28](#)]. A growing body of literature has begun to document sensory abnormalities in some other Obsessive-Compulsive Related Disorders, such as [Obsessive-Compulsive Disorder](#) and Tourette's Disorder. Persons with Tourette's Disorder have reported heightened interoceptive awareness and [hypersensitivity](#) to external stimuli from all five senses [[26](#), [29](#)], and persons with Obsessive-Compulsive Disorder have reported hypersensitivity and intolerance to both external and interoceptive stimuli [[30](#), [31](#), [32](#)]. Additionally, recent studies have found that interoceptive awareness is positively correlated with urges to [tic](#) in persons with Tourette's Disorder [[33](#)] and that persons with self-reported sensory intolerance have a higher lifetime incidence of tics and Obsessive-Compulsive Disorder than those without sensory intolerance [[34](#)]. These findings suggest that some Obsessive-Compulsive Related Disorders may be associated with abnormal [sensory processing](#).

Although existing research on Obsessive-Compulsive Related Disorders points to the existence of several sensory abnormalities, much of the research has presented vague and inconsistent operational definitions of sensory phenomena (e.g., sensory intolerance vs. hypersensitivity). In some cases, researchers seem to be investigating whether individuals with Obsessive-Compulsive Related Disorders are more perceptive of [sensory input](#), which would reflect abnormally low detection thresholds [[26](#), [29](#)]. Other studies seem to be concerned with behavioral responses to stimuli and use terms such as “sensory intolerance” or “sensory over-responsivity” [[30](#), [31](#), [32](#), [35](#)]. This lack of clarity makes it difficult to (a) draw conclusions across studies, (b) discern what specific sensory and perceptual abnormalities are associated with Obsessive-Compulsive Related Disorder psychopathology, and (c) infer clear treatment implications [[35](#)].

Dunn [[36](#)] argued that sensory processing abilities are the product of an interaction between two orthogonal dimensions: neurological thresholds and behavioral responses. Neurological thresholds refer to the ability of individuals to detect stimuli at certain amplitudes or intensities. Low neurological thresholds reflect a low sensory detection threshold (i.e., the ability to detect and respond to low-intensity stimuli), whereas high neurological thresholds reflect a high sensory detection threshold (i.e., a reduced propensity to detect low-intensity stimuli). Behavioral responses describe individuals' propensity to approach (i.e., behavioral accordance) or avoid (i.e., behavioral counteracting) sensory stimuli. [Fig. 1](#) showcases Dunn's four-quadrant model reflecting the interaction between neurological thresholds and behavioral responses. Sensitivity to stimuli reflects a passive discomfort in response to perceptual inundation, but no significant efforts to counteract or avoid this discomfort. Persons who score high on this scale would be expected to have a tendency to become distracted by stimuli, have difficulty focusing on stimuli, and report feeling overwhelmed in high-intensity sensory

environments. Similarly, sensation avoiding reflects a low threshold and tendency to avoid or counteract stimuli, with persons scoring high on this scale reporting that they actively limit their exposure to high-intensity stimuli. On the other end of the neurological threshold continuum, low registration reflects low response to stimulation and a tendency to overlook or fail to recognize stimuli, whereas [sensation seeking](#) reflects a tendency to counteract one's perceived lack of stimulation by pursuing high-intensity stimulation. Utilizing Dunn's model of sensory processing, it is possible to link potential sensory abnormalities in BFRBs to these behavioral profiles. Doing so could provide researchers with increased specificity about the experience of affected individuals as well as insights into possible underlying mechanisms.

Neurological Threshold Continuum	Behavioral Response Continuum	
	Accordance	Counteract
High	<p>LOW REGISTRATION</p> <p>Weak response to stimulation, passive disregard</p>	<p>SENSATION SEEKING</p> <p>Weak response to stimulation, feels need for greater stimulation</p>
Low	<p>SENSORY SENSITIVITY</p> <p>Strong response to stimulation, passive discomfort</p>	<p>SENSATION AVOIDING</p> <p>Strong response to stimulation, works to avoid aversive stimulation</p>

Fig. 1. Dunn's model of [sensory processing](#).

In one study using a self-report measure based on Dunn's model of sensory processing [37] results showed that participants with Obsessive-Compulsive Disorder had increased sensory sensitivity and sensation avoiding, as well as increased low registration and reduced sensation seeking when compared to a [community sample](#). Despite the fact that the authors only predicted the former two results, they reasoned that the increased low registration scores could have been due to comorbidity in the Obsessive-Compulsive Disorder sample and that the decreased sensation seeking scores were consistent with the increased sensation avoiding scores.

Consistent with the growing body of research on sensory abnormalities in Obsessive-Compulsive Related Disorders, the current study sought to supplement preliminary findings in BFRBs by investigating whether affected individuals perceive their sensory environments abnormally. The current study also sought to extend previous research by determining whether sensory abnormalities observed in other Obsessive-Compulsive Related Disorders are also present in BFRBs. As such, we utilized the same measure of Dunn's model of sensory processing as Rieke and Anderson [37] to assess sensory processing in three groups of young adults identified as having either clinical BFRBs, subclinical BFRBs, or no BFRBs. Based on previous research [15, 22, 23, 24, 25, 26, 37], it was hypothesized that individuals with clinical BFRBs would report increased sensitivity to stimuli and increased sensory avoiding. It was also hypothesized that there would be no differences between groups on low registration scores after controlling for psychiatric comorbidity. With regard to stimulus seeking, we expected that because individuals with skin picking report [craving](#) the sensations caused by their symptoms [18], individuals with clinical BFRBs would report elevated scores on this subscale. Finally, because many individuals have non-pathological BFRBs that are non-impairing, and most existing research on BFRBs comes from clinical populations, we conducted exploratory analyses testing whether individuals with subclinical BFRBs could be differentiated from individuals with clinical BFRBs on these sensory processing variables.

	Hair pulling	Skin picking	Nail biting	Cheek biting	Teeth grinding	Skin biting	Other BFRB
n (Clinical)	1 (3.85%)	11 (42.31%)	8 (30.77%)	8 (30.77%)	3 (11.54%)	2 (7.69%)	3 (11.54%)
n (Subclinical)	8 (16.67%)	20 (41.67%)	19 (39.58%)	31 (64.58%)	9 (18.75%)	5 (10.42%)	3 (6.25%)

Table 2. Demographic information and psychiatric comorbidity by group.

	Clinical BFRBs (n = 26)	Subclinical BFRBs (n = 48)	Healthy controls (n = 33)	F, χ^2	p-Value
Gender				0.44	0.80
Female	19 (73.1%)	35 (72.9%)	22 (66.7%)		
Male	7 (26.9%)	13 (27.1%)	12 (33.3%)		
Ethnicity				4.30	0.12
Hispanic	2 (7.7%)	7 (14.6%)	9 (27.3%)		
Non-Hispanic	24 (92.3%)	41 (85.4%)	24 (72.7%)		
Race				6.64	0.58
White	22 (84.6)	38 (79.2%)	26 (78.8%)		
Black	1 (3.8%)	4 (8.3%)	0		
Native American	0	0	1 (3.0%)		
Asian	2 (7.7%)	2 (4.2%)	1 (3.0%)		
“Other”	1 (3.8%)	3 (6.3%)	3 (9.1%)		
Age: M(SD)	18.84 (1.21)	18.83 (1.80)	18.63 (1.01)	0.22	0.80
Current psychiatric Diagnoses	19 (73.1%) ^a	17 (37%) ^b	0 ^c	34.66	<0.001
major depression	2 (7.7%)	0	0		
Bipolar I	2 (7.7%)	0	0		
Bipolar II	2 (7.7%)	0	0		
Bipolar not otherwise specified	0	0	0		
Panic disorder	3 (11.5%)	0	0		
Agoraphobia	9 (34.6%)	7 (14.6%)	0		
Social phobia	7 (26.9%)	3 (6.3%)	0		
Obsessive-compulsive disorder	4 (15.4%)	1 (2.1%)	0		
Posttraumatic stress disorder	0	1 (2.1%)	0		
Alcohol dependence	1 (3.8%)	2 (4.2%)	0		
Alcohol abuse	0	3 (6.3%)	0		
Substance dependence	3 (11.5%)	1 (2.1%)	0		
Substance abuse	0	1 (2.1%)	0		
Psychotic disorder	0	0	0		
Mood disorder with psychotic features	0	0	0		
Anorexia nervosa	0	0	0		
Bulimia nervosa	1 (3.8%)	1 (2.1%)	0		
Binge eating disorder	0	0	0		
Generalized anxiety disorder	12 (46.2%)	4 (8.3%)	0		
Antisocial personality disorder	0	0	0		
Multiple current psychiatric diagnoses	15 (61.5%) ^a	7 (14.6%) ^b	0 ^c	33.17	<0.001

Shared superscripts reflect no differences between groups, whereas different superscripts reflect significant between-group differences.

2.2. Measures

2.2.1. Sensory processing

The Adult/Adolescent Sensory Profile (AASP) [38] is a 60-item [self-report](#) measure of [sensory processing](#). The measure is designed to assess individuals' responses to everyday sensory experiences in six categories: auditory, visual, taste/smell, movement, body position, and [touch](#). Based on Dunn's model of sensory processing [36], the scale consists of four subscales: Low Registration, [Sensation Seeking](#), Sensory Sensitivity, and Sensation Avoiding. Items are endorsed on a 5-point [rating scale](#) ranging from 1 (“Almost Never”) to 5 (“Almost Always”). Each subscale is made up of 15 items, resulting in scores ranging from 15 to 75. The AASP has demonstrated good construct validity by correlating strongly with measures of skin conductance and physiological response to [auditory stimuli](#), and each of the subscales has shown adequate to good internal consistency [38].

2.2.2. Diagnosis

The Habit Disorder Interview (HDI) was developed by the authors for the purpose of the current study (See [Table 3](#) for an example of HDI questions for skin picking). The HDI is a structured, diagnostic assessment consisting of items derived from DSM-5 criteria for BFRBs. After a trained interviewer checked diagnostic criteria for each BFRB, he or she summarized these criteria endorsements into diagnostic decisions (i.e., Clinical BFRB, Subclinical BFRB, or No BFRB). No [psychometric](#) data are available on the HDI, but the interview was constructed based on the Trichotillomania Diagnostic Interview (TDI) [39], which has been used extensively as a Trichotillomania diagnostic instrument. Evidence indicates that the diagnostic criteria assessed with the TDI have strong sensitivity and ability to identify symptoms that distinguish symptoms of clinical psychopathology along the TTM latent dimension [40], hence the TDI likely possesses strong [criterion validity](#).

Table 3. Habit disorder interview - skin picking (excoriation).

Question	Diagnostic criteria	Score
Do you currently pick or scratch at your skin?	A1. Recurrent skin picking...	Yes/no
What areas of your body do you pick from?	n/a	Face chest Arms fingers Shoulders legs Back toes Other: _____
Do you have damage to the skin in the areas you pick?	A2. ...resulting in skin lesions.	0 1 2 3
Have you tried to stop picking your skin?	B. Repeated attempts to decrease or stop skin picking.	0 1 2 3
Does the picking bother you? Does the picking get in the way of your life?	C. The skin picking causes clinically significant distress or impairment in social, occupational, or other important areas of functioning.	0 1 2 3
Do you have any eczema, skin rash, or other skin conditions that may explain picking?	D. The skin picking is not attributable to the physiological effects of a substance (e.g., cocaine) or other medical condition (e.g., scabies).	0 1 2 3
Why are you trying to pick your skin? Are you trying to “fix” your appearance? Do you see things that others cannot? Are you attempting to harm yourself?	E. The skin picking is not better explained by symptoms of another mental disorder (e.g., delusions, body dysmorphia, non-suicidal self-injury)	0 1 2 3
Diagnosis?		
No skin picking	Subclinical skin picking	Clinical skin picking

0 = inadequate information; 1 = absent; 2 = subthreshold; 3 = threshold/true.

The [Mini International Neuropsychiatric Interview](#) (MINI) [41] is a structured diagnostic interview based on the [DSM-IV](#). The MINI was designed to establish both principal and co-occurring DSM-IV diagnoses. MINI validation studies have found that the measure possesses good psychometric properties [[41], [42], [43]].

2.2.3. BFRB severity

Because there are no psychometrically validated measures of nail biting severity, cheek biting severity, teeth grinding severity, skin biting severity, or “other BFRB” severity, a global measure of disorder severity was used across diagnoses. The [Clinical Global Impressions-Severity Scale](#) (CGI-S) [44] is a clinician-rated measure of global disorder severity that is used with various psychological and medical disorders. Scoring on the CGI-S involves a single global rating ranging from 1 (“Normal, Not at all ill”) to 8 (“Extremely ill”). The CGI-S possesses [convergent validity](#) on many symptom severity scales across psychiatric conditions [[45], [46], [47], [48]]. For the purposes of this study, a version of the CGI-S that has been used extensively in TTM studies [49, 50] was adapted for each specific BFRB.

2.3. Procedure

Eligible participants were identified using an online [screening](#) questionnaire (described above) before being invited into the laboratory to complete the study. After providing informed consent, the HDI, CGI-S, and MINI were administered by trained [clinical psychology](#) doctoral students and a masters-level clinician, and all evaluators - trained and supervised by the 4th author - possessed extensive knowledge of BFRBs. Participants then completed the AASP.

3. Results

3.1. Group differences on sensory processing

As can be seen in [Table 2](#), there were no significant differences in gender, ethnicity, or age between the groups. Thus, these variables were not included in covariate analyses. However, because the BFRB groups were more likely to have a comorbid [psychiatric diagnosis](#), the presence or absence of a comorbid condition was introduced into analyses as a dichotomous covariate following the calculation of initial analyses that did not include this covariate.

Differences between groups on the four AASP subscales were examined using a [Multivariate Analysis of Variance](#) (MANOVA) test. Results of this omnibus [MANOVA](#) indicated that the groups reported significant differences on AASP subscales ($F(8, 186) = 5.15, p < 0.001$; Wilk's $\Lambda = 0.67$; $\eta_p^2 = 0.18$). The univariate (ANOVA) and covariate (ANCOVA) analyses that were calculated following the significant MANOVA are described below. Dunnett's C post-hoc tests were used in ANOVA analyses for multiple comparisons due to unequal sample sizes between groups. For [ANCOVA](#) analyses, post-hoc tests were conducted using pairwise comparisons of estimated marginal means with Bonferroni adjustments. Descriptive statistics pertaining to ANCOVA analyses are provided in [Table 4](#).

Table 4. Descriptive statistics for AASP scales between groups.

	Healthy Mean (SD)	Subclinical BFRB Mean (SD)	Clinical BFRB Mean (SD)
Low registration	31.31 (6.08) ^a	34.89 (7.33) ^a	37.38 (7.41) ^a
Sensation seeking	47.25 (7.18) ^a	48.05 (8.02) ^a	44.72 (8.91) ^a
Sensory sensitivity	33.44 (6.68) ^a	35.00 (7.22) ^a	41.24 (6.49) ^b
Sensory avoidance	35.06 (6.80) ^{a,b}	35.21 (8.17) ^a	43.30 (5.83) ^b

Shared superscripts denote a lack of significant difference in [ANCOVA](#) analyses when controlling for comorbid psychopathology.

Consistent with the prediction that there would be significant differences on the Sensory Sensitivity subscale, the univariate ANOVA test for that subscale was significant ($F(2, 96) = 14.18, p < 0.001, \eta_p^2 = 0.23$). Post-hoc comparisons indicated that the clinical BFRB group had higher scores than the other groups (both p -values < 0.05). There were no differences between the healthy control group and the subclinical BFRB group. The overall ANCOVA remained significant when comorbid psychiatric diagnostic status was entered as a covariate ($F(2, 95) = 5.78, p = 0.004, \eta_p^2 = 0.11$), and post-hoc comparisons for this ANCOVA yielded the same pattern of results as those conducted following the ANOVA. As such, individuals with clinical BFRBs appear to have greater sensitivity to [sensory stimulation](#) than individuals with subclinical BFRBs and healthy individuals.

Also consistent with predictions, there were significant differences on the Sensory Avoidance subscale ($F(2, 96) = 16.07, p < 0.001, \eta_p^2 = 0.25$). Post-hoc analyses indicated that the clinical BFRB group had higher scores than the other groups (both p -values < 0.05). There were no differences between the healthy control group and the subclinical BFRB group. The overall ANCOVA remained significant when comorbidity status was entered as a covariate ($F(2, 95) = 6.11, p = 0.003, \eta_p^2 = 0.12$), but post-hoc analyses yielded a different pattern of results. There was still a significant difference between the clinical and subclinical BFRB groups, still no difference between the subclinical BFRB group and the healthy control group, but the difference between the clinical and healthy control groups was no longer significant. This suggests that persons with BFRBs do not differ from healthy controls in terms of sensation avoiding after controlling for comorbid psychopathology, but sensation avoiding may differentiate persons with subclinical from clinical BFRBs.

Inconsistent with predictions, no significant differences between groups were observed on the [Sensation Seeking](#) subscale ($F(2, 99) = 1.33, p = 0.27$), even when psychiatric comorbidity status was entered as a covariate ($F(2, 99) = 0.85, p = 0.43$). This indicates that there are no differences between persons with clinical or subclinical BFRBs and healthy individuals with regard to feeling under-stimulated and seeking out additional stimulation.

We did not predict group differences on the Low Registration subscale, particularly after accounting for comorbid psychopathology. Results were partially consistent with that hypothesis. There were significant differences on the Low Registration subscale in the ANOVA analysis ($F(2, 96) = 6.92, p = 0.002, \eta_p^2 = 0.13$). Dunnett's C post-hoc tests indicated that the clinical BFRB group had higher scores than the healthy control group ($p < 0.05$) but not the subclinical BFRB group. There were no significant differences between the healthy control group and the subclinical BFRB group. When psychiatric comorbidity was entered into the model as a covariate, there was no overall significant difference between groups on the Low Registration subscale ($F(2, 95) = 2.18, p = 0.12$). This suggests that people with clinical BFRBs may experience a reduced propensity to detect and respond to stimuli, but this is likely explained via comorbid diagnoses.

3.2. Relationship between BFRB severity and sensory processing

To further investigate the associations between sensory abnormalities and BFRB severity, Pearson's correlations were calculated between AASP subscales and the highest CGI-S rating that each individual received for a BFRB. Only individuals in the subclinical and clinical BFRB groups were included in this analysis. This correlation matrix is shown in [Table 5](#). Scores on the Low Registration subscale, Sensory Sensitivity subscale, and Sensation Avoiding subscale were positively correlated with BFRB severity. Inconsistent with predictions, scores on the Sensation Seeking subscale were not correlated with BFRB severity.

Table 5. Correlations between BFRB severity and AASP subscales.

	BFRB severity	Low registration	Sensation seeking	Sensory sensitivity
Low registration	0.25*			
Sensation seeking	-0.14	0.04		
Sensory sensitivity	0.51***	0.71***	-0.01	
Sensation avoidance	0.38**	0.42***	-0.30*	0.68***

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

4. Discussion

The current study investigated [sensory processing](#) in persons with BFRBs. Consistent with hypotheses, individuals with clinical BFRBs showed greater sensory sensitivity and sensory avoidance than individuals with subclinical BFRBs and healthy controls, even when controlling for comorbid diagnoses. Also consistent with hypotheses, individuals with clinical BFRBs, subclinical BFRBs, and those without BFRBs did not differ on low registration after controlling for comorbid diagnoses. The lack of significant differences on the [Sensation Seeking](#) subscale was inconsistent with predictions. Finally, consistent with hypotheses, results indicated that increased BFRB severity was associated with increased sensory sensitivity and sensation avoidance. Surprisingly, results also indicated that BFRB severity was associated with low registration, though this relationship could be explained by comorbid psychopathology.

According to Dunn's model of sensory processing [38], our pattern of results indicates that people with clinical BFRBs have low neurological thresholds and tend to engage in sensory avoiding when compared to persons with subclinical BFRBs. These results suggest that the function of clinical BFRBs differs in subtle ways from the function of subclinical BFRBs. It appears that individuals with varying levels of BFRB severity may possess different sensory/perceptual traits. Differences in these traits may be relevant for understanding differences in the frequency with which persons with clinical versus subclinical BFRBs perform their symptoms. In practical terms, it appears that hair pulling, skin picking, and other BFRBs may provide pleasurable automatic sensory reinforcement and allow individuals to distract themselves from aversive sensory states such as stress, tension, or perceptual over-inclusion. Assuming that persons with subclinical BFRBs use BFRBs to regulate sensations, perhaps individuals with subclinical BFRBs do not experience excessive perceptual discomfort regularly. Therefore, such persons may be prompted to perform BFRBs infrequently. Indeed, Dunn [51] argued that persons with low neurological thresholds tend to respond with avoidance to aversive [over-stimulation](#) and that these persons frequently use habitual/ritualistic behaviors to regulate their level of stimulation.

However, the notion that BFRBs function as avoidance mechanisms could be seen as standing in contrast to the fact that BFRBs involve physical [self-stimulation](#) [23] and positive reinforcement [18]. This apparent contradiction may be explained by research on behaviors similar to BFRBs: [non-suicidal self-injury](#). Evidence indicates that the predominant function of non-suicidal self-injury is the attenuation of unpleasant emotion [52], but individuals who engage in self-injurious behavior also report that their symptoms occasionally create positively reinforcing sensations, such as satisfaction [53]. However, the exact hedonic features of non-suicidal self-injury are still largely unknown, and it is difficult to distinguish feelings of satisfaction from similar euphoric feelings that are derived from the removal of aversive stimuli (i.e., pain relief).

Alternatively, this apparent contradiction may be explained by research on [addictive disorders](#). Such research suggests that, as one uses substances more frequently and pathologically, substance use may function less as a positive reinforcer and more so as a negative reinforcer over time [54, 55]. Clinical BFRBs may follow a similar course. That is, persons may initially perform BFRBs to achieve a particular sensation; however, as BFRB performance becomes more frequent, intense, and pathological, reasons for performing BFRBs may shift, such

that persons with clinical BFRBs may be motivated to perform BFRBs to avoid aversive stimuli (e.g., including perceptual experiences) rather than to achieve a particular sensation.

Currently, the behavioral and [neurobiological mechanisms](#) that underlie the abnormal sensory sensitivity reported by those with clinical BFRBs are unclear. One possibility is that individuals with clinical BFRBs possess ineffective sensory processing mechanisms that ultimately allow them to perceive abnormally high amounts of sensory information at any given time. As one example, [sensory gating](#) is an inhibitory process whereby excess sensory information is filtered between peripheral sensory afferents and cortical sensory processing areas [56]. Deficient sensory gating has been linked to abnormal sensory experiences, such as symptoms of [schizophrenia](#) [57]. In addition, several studies have found evidence of reduced sensory gating in persons with Tourette's Disorder and [Obsessive-Compulsive Disorder](#) [[58], [59], [60], [61], [62], [63], [64], [65], [66]], providing support for the notion that this deficit may cut across the Obsessive-Compulsive spectrum and apply to BFRBs.

Another explanation for the current results is that there may be etiological overlap between BFRBs and sensory processing disorders. Sensory processing disorders are characterized by deficits in processing sensory information that often result in [hyper-](#) or [hypo-](#)sensitivity and problems responding to sensory information [67]. However, it should be noted that while sensory processing disorders are often emphasized in the [occupational therapy](#) field, they are not recognized in the psychiatric nomenclature. It is argued that persons with sensory processing disorders typically show heightened sensory sensitivity, [aversion](#) to certain types of stimulation, and poor attention and coordination [68]. Yet, evidence regarding this connection is mixed. As previously mentioned, there appears to be a significant association between sensory processing dysfunction and some Obsessive-Compulsive [spectrum disorders](#) [34], but one study found no evidence for overlap between sensory over-responsivity and childhood [behavior disorders](#), including [tics](#), Obsessive-Compulsive Disorder, and [Trichotillomania](#) [69]. Taken together, the existing research suggests that while persons with BFRBs do not display the debilitating sensory processing deficits seen in some conditions such as [autism](#) [70], there do appear to be some abnormal sensory experiences that cut across the Obsessive-Compulsive spectrum.

The current findings have immediate implications for clinical management of BFRBs. [Cognitive-behavior therapy](#) has the highest level of empirical support for BFRBs [4, 5]. Although effect sizes are high for such treatments [4, 71], complete [remission](#) is infrequent [6, 72] and long-term relapse is common [[73], [74], [75], [76], [77]]. This may not be surprising in light of the current findings. Cognitive-behavior therapy for BFRBs is a multi-component [treatment package](#) that includes habit-reversal training, stimulus control, [emotion regulation](#) skills, and tools for coping with cognitions that trigger symptoms. Little attention is provided to improve stimulus regulation, although some treatment packages do include [mindfulness](#) [78] or [coping strategies](#) for satisfying sensory-related urges to engage in symptoms (i.e., responding to urges to tug at hair by playing with a plush stuffed animal) [73, 79]. Another promising adjunct to traditional cognitive-behavior therapy that may address stimulus regulation has been put forth by O'Connor [80]. Termed cognitive-psychophysiological therapy, this technique targets rising tension and sensorimotor activation prior to symptom performance through a combination of interoceptive awareness training, behavioral restructuring of overactive styles of action, and [cognitive restructuring](#) of beliefs systems linked to tension [81]. Indeed, a recent study found that this treatment was associated with changes in [event-related potentials](#) during a motor inhibition task in sensorimotor and [prefrontal areas](#) [82], suggesting that this form of treatment affects sensory processing on a neural level.

Limitations to the current study include a limited size and college-aged sample. However, given the exploratory nature of this study, the low prevalence of clinical BFRBs, and the medium-to-large effect sizes of our findings, these preliminary results should [spur](#) future research with greater and more representative samples. Another potential limitation of the study concerns the fact that persons with different types of BFRBs were grouped

together, but this grouping was based on an evidence-based conceptualization of high overlap between types of BFRBs [3]. Future research should collect greater samples of each type of BFRB and conduct comparisons between these groups to determine if any meaningful differences in sensory processing exist. These results are also constrained by the limitations of using [self-report](#) methodology, whereas using quantitative sensory approaches may have revealed different results. For instance, one study found that children with Tourette's Disorder reported heightened sensitivity to stimuli from all five senses, but quantitative tests of olfactory and tactile detection thresholds revealed no differences between children with Tourette's Disorder and healthy controls [29]. Findings such as this raise the possibility that individuals with clinical BFRBs may perceive their [sensory inputs](#) as more intense and bothersome than unaffected individuals, but the exact physiological mechanisms accounting for these experiences cannot be directly inferred from self-reports. Despite these limitations, this study represents the first study to utilize a psychometrically validated measure of sensory processing abnormalities in individuals with diagnosable BFRBs. As such, this study should spur future research on sensory abnormalities and inform development of novel treatment approaches.

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¹ If hair pulling or skin picking is performed solely to remove undesired hair or skin, and diagnostic criteria for Body Dysmorphic Disorder (BDD) are met, BDD should be diagnosed rather than Trichotillomania or Excoriation.

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