Neurological Underpinnings of Psychological Factors Distinguishing Obsessive-Compulsive Disorder From Misophonia

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ABSTRACT

Several studies have suggested that misophonia should be categorized as an obsessive-compulsive disorder (OCD) due to similar neural manifestations, such as impairments in limbic structures, and psychological features, such as perfectionism and disgust sensitivity. However, the two disorders may differ in the domains of disgust sensitivity. In OCD, the domain of pathogen disgust has been studied extensively as per the contamination subtype. In misophonia, pathogen disgust has not been reported. We hypothesized that moral disgust may better characterize individuals with misophonia, as studies indicate that people with misophonia view their triggers as morally unacceptable. Furthermore, neuroimaging has shown anterior cingulate cortex (ACC) activation particularly during exposure to misophonic triggers, which is an area associated with moral assessment of stimuli. Another psychological factor that may point to the two disorders being discrete is intolerance of uncertainty (IU), an aversion to undetermined events. IU has been well documented in OCD: It has been found to be positively associated with striatal volume and dysfunction in the ACC—both of which are common findings in OCD. We expected people with misophonia not to exhibit IU since they experience distress in response to specific triggers and, unlike individuals with OCD, do not experience preemptive anxiety. Multivariate logistic regression analysis run on survey-gathered data revealed IU as a significant predictor of OCD symptoms and moral disgust as a significant predictor of misophonia. Consistent with our hypotheses, our findings suggest that IU and moral disgust and the associated neural underpinnings differentiate misophonia from OCD. **[*Psychiatr Ann*. 2023;53(12):570-580.]**

Obsessive-compulsive disorder (OCD) is a psychiatric disorder marked by disturbing, intrusive patterns of thought (obsessions) and repetitive actions or behaviors done in response to obsessions to decrease anxiety (compulsions such as checking, counting, touching, and arranging).[1] Functional and structural abnormalities have been investigated, with the literature widely implicating the cortico-striato-thalamo-cortical (CSTC) circuit,[2] which is associated with behavioral self-regulation, habit learning, and reward-based learning,[3,4] in OCD pathophysiology. The CSTC circuit can be viewed in two pathways: 1) the direct pathway (ie, projections from the orbitofrontal cortex-striatum-internal globus pallidus-thalamus-cortical), which is thought to be excitatory (positive-feedback loop,

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activation of actions) and 2) the indirect pathway (ie, projections from the dorsolateral prefrontal cortex-striatum-external globus pallidus-subthalamic nucleus-thalamus-cortical), which is inhibitory (negative feedback loop, inhibition of actions).[4] The imbalance of both pathways is thought to result in a hyperactivated CSTC circuit, where the inhibitory path is unable to properly execute proper inhibitory control.[5] The following have also been reported as key players in OCD pathophysiology:

- The insula, which is involved in self-awareness, autonomic functions, and emotional processing;[6]
- Amygdala, which is also involved in emotional processing;
- The anterior cingulate cortex (ACC), a region of the cingulate cortex responsible for emotional and conflict processing as well as error recognition;[7]
- Ventromedial prefrontal cortex (vmPFC) and dorsolateral prefrontal cortex (DLPFC), which are involved in flexible behavior and safety signaling;[8,9]
- Orbitofrontal cortex (OFC), which has been implicated in reward-guided learning and symptom severity;[10,11]
- Striatum activation and volume.[12]

Gathered from neuroimaging data, individuals with OCD tend to exhibit impairments in executive functioning, emotional processing, and flexibility.[13,14]

Misophonia is a neurophysiological disorder characterized by a disproportionate negative emotional response to common sounds such as chewing, slurping, tapping, and pen clicking.[15,16] Autonomic response tends to accompany emotional reactions, as exposure to triggering stimuli promotes increased sympathetic nervous system arousal.[16,17] Initially conceptualized by Jastreboff and Jastreboff, the term misophonia stemmed from early studies surrounding tinnitus and hyperacusis.[18-20] Tinnitus describes one's perception of auditory stimuli despite the absence of actual auditory stimuli, where one may experience ringing in one or both ears, usually as the result of hearing loss.[21] Hyperacusis is used to refer to a heightened sensitivity to noise, leading one to believe that noises are much louder than they are.[22] Yet, increasing neuroscientific studies point to the idea that misophonia is not guided by auditory track abnormalities, but rather by emotional neural networks, as indicated by the involvement of the insula, ACC, amygdala, and prefrontal cortical regions in the presentation of the disorder.[23]

Due to the resemblance in symptomatology and neural manifestations between misophonia and OCD, some studies argue that misophonia should not be classed separately from OCD. The findings of Cusack et al. support the link between misophonia and OCD,[24] with the authors suggesting misophonia carries more of the obsessive than compulsive traits of OCD. When assessing three individuals with misophonia, Natalini et al.[25] found that levels of perfectionism were elevated, consistent with an obsessive-compulsive personality disorder. In the same vein, Jager et al.[26] reported that 26% of the a misophonic sample presented with obsessive-compulsive personality traits, speculating that there is some connection between misophonia and obsessive-compulsive symptoms. Neurologically speaking, some researchers believe misophonia and OCD may share related neurocircuitry, that is, impairments in limbic structures such as the amygdala and basal ganglia,[10] whereas others believe the overlap between the two disorders is due to dysfunction of the serotonergic and dopaminergic neural systems.[27] Specifically, both OCD and misophonia exhibit hyperactivity in the insula and amygdala when exposed to triggers.[23] Hyperactivity in the ACC has also been implicated in both OCD and misophonia, specifically in an error-processing task and trigger sound exposure, respectively.[23]

Although the findings of these studies point out overlapping features, hallmark traits of OCD, such as compulsions and transdiagnostic factors, such as disgust sensitivity and intolerance of uncertainty (IU), have not been observed to be significantly associated with misophonia. Further, recent neuroimaging studies confirm the unique profile of misophonia, further supporting the distinction between OCD and misophonia. Activation of the midcingulate cortex (MCC) and the supplementary motor area (SMA) differs between the disorders. More specifically, the MCC, involved in motor and cognitive control,[28] has been found to be hyperactive in the presence of triggers in misophonia, as misophonic response to triggers is autonomically driven, which may translate to reactionary behaviors.[29] Conversely, in OCD, hypoactivity in the MCC was observed during symptom provocation, which some researchers speculate occurs as a way to decrease anxiety.[12] Differences have also been observed in the SMA, which is associated with motor initiation/planning and inhibitory control.[30] While hyperactivation has been reported in misophonia upon subjection to triggers,[29] hypoactivation has been found in OCD during error-processing tasks.[23] Therefore, while misophonia shares common psychological and neurological traits with OCD, there are substantial differences that warrant the distinction between the two.

Disgust sensitivity has been reported in both OCD[31,32] and misophonia.[33,34] Defined as a negative emotion that leads to repulsion and/or behavior avoidance,[35] disgust has come to be understood in the context of three domains: (1) pathogen-based disgust (aversion toward pathogens/contaminants), (2) moral disgust (aversion toward moral offenses), and (3) sexual disgust (aversion toward inappropriate sexual behaviors).[36] While,

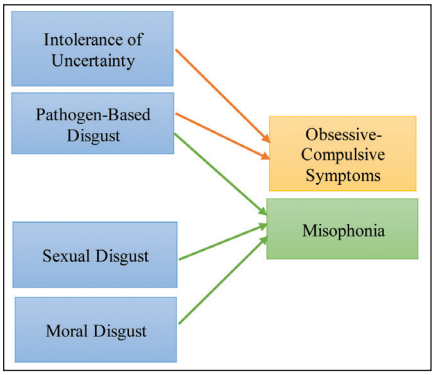

Figure 1. Hypothesized model for the differential prediction of obsessive-compulsive and misophonia symptoms based on intolerance of uncertainty and types of disgust.

generally, disgust has been implicated in both disorders, the domain of disgust may differ. Pathogen-based disgust has long been studied in OPD;[37,38] however, moral disgust and sexual disgust have been understudied. In terms of misophonia, although disgust sensitivity was found to be associated with emotional reactivity, no relation was found with pathogen-based disgust.[33] The domains of moral or sexual disgust may be associated with misophonia due to the potential association with mental contamination. As such, the domains of disgust may serve as a way to differentiate the two disorders.

Intolerance of uncertainty may also serve as a way to distinguish misophonia from OCD. IU refers to the aversion to uncertain situations that are characterized by negative emotional, cognitive, and behavioral reactions.[39] IU has been implicated in various anxiety disorders such as social and general anxiety,[40] as well as mood disorders such as depression.[41] In the context of OCD, IU is considered the predictor of OC symptoms[42] and influences symptom severity,[43] making it an important factor to consider when discussing OCD traits. IU has yet to be explored in misophonia, but we do not anticipate those with misophonia to exhibit IU as strongly as do individuals with OCD because, although people with misophonia may experience immediate distress in response to specific triggers, this distress would not be marked by preemptive anxiety or worry, as experienced by individuals with OCD. Thus, aversion would occur upon realizing the trigger, rather than anticipating one.

STUDY OBJECTIVE AND HYPOTHESES

With consideration of the findings mentioned, we aimed to determine which factors could help differentiate misophonia from OCD. We hypothesized that IU and disgust sensitivity (pathogen, sexual, moral) would be differentially associated with and predict OCD and misophonia symptoms. We also hypothesized that pathogen-based disgust and IU would be predictive of symptoms of OCD and that sexual and moral disgust would be predictive of symptoms of misophonia. Our model of the hypothesized relationships is shown in **Figure 1.**

METHOD

Participants

We recruited our sample from social media and crowdsourcing platforms. Inclusion criteria required participants to be at least 18 years of age and fluent in English. Those over the age of 65 and those not fluent in English were excluded.

Measures

Three-Domains of Disgust Scale. The Three-Domains of Disgust Scale (TDDS) is a 21-item self-report measure used to assess disgust sensitivity over three dimensions: pathogen, sexual, and moral.[44] Sensitivity to each of the three dimensions is gauged by seven statements. Pathogen-based disgust is characterized by statements such as "Standing close to a person who has body odor." Sexual disgust is characterized by statements such as "Bringing someone you just met back to your room to have sex." Moral disgust is characterized by statements such as "Forging someone's signature on a legal document." Participants were asked to respond on a seven-point Likert scale ranging from 0 = not at all disgusting to 6 = extremely disgusting. The TDDS was found to have acceptable reliability.[44] In the current study, the Cronbach's α for pathogen-based disgust, sexual disgust, and moral disgust were found to be 0.77, 0.80, and 0.86, respectively.

Intolerance of Uncertainty Scale. The Intolerance of Uncertainty Scale (IUS) is a 27-item self-report measure used to measure behavioral, emotional, and cognitive responses to undetermined situations.[45] Participants were asked to indicate how they aligned with each statement (eg, "Uncertainty makes me uneasy, anxious, or stressed"), and their responses were based on a five-point Likert scale ranging from 0 = not at all characteristic of me to 4 = entirely characteristic of me. Ratings of items are summed, with higher scores corresponding to greater IU. The English adaptation of the IUS demonstrated high internal consistency, with a Cronbach's α of 0.94.[46] In the current study, the Cronbach's α was 0.95, which also demonstrates excellent internal consistency.

Obsessive-Compulsive Inventory-Revised. The Obsessive-Compulsive Inventory-Revised (OCI-R)[47] is a revision of the 42-item Obsessive-Compulsive Inventory,[48] which consists of 18 items assessing symptoms of OCD. OCI-R items are divided into six factors: (1) washing (eg, "I find it difficult to touch an object when I know it has been touched by strangers or certain people"); (2) obsessing (eg, "I find it difficult to control my own thoughts"); (3) hoarding (eg, "I have saved up so many things that they get in the way"); (4) ordering (eg, "I get upset if objects are not arranged properly"); (5) checking (eg, "I check things more often than necessary"); and (6) neutralizing (eg, "I feel compelled to

count while I am doing things"), with three items in each factor. Participants are asked to respond on a five-point Likert scale ranging from 0 = not at all to 4 = extremely. Rating of items are summed, with scores of 21 or higher indicating presence of OCD. The subscales alongside the full scale have shown acceptable internal consistency, ranging from 0.81 to 0.90 in a sample of patients seeking treatment for OCD symptoms. In the current study, Cronbach's α was 0.95, indicating excellent reliability.

New York Misophonia Scale. The New York Misophonia Scale (NYMS) is composed of two parts—the first assessing emotional distress to misophonic triggers, and the second assessing aggressive and nonaggressive responses to triggers.[33] The first part consists of 25 misophonic triggers (eg, chewing loudly), and participants are asked to indicate how aversive each trigger is using a five-point Likert scale ranging from 0 = doesn't bother me to 4 = disgusting. The second part consists of 13 behavior-based reactions (eg, I cover my ears). Using a five-point Likert scale, ranging from 0 = never to 4 = always, participants are asked to record how often they would respond with the behavior indicated to the triggers in the first part of the NYMS. Participants with scores two SDs above the mean were considered as having "high" misophonia, those with scores two SDs below the mean were categorized as "low," and those falling between ±1 SD were considered "average." In the current study, only those with high scores were considered. Cronbach's α of the NYMS ranged from 0.85 to 0.94 for the total scale and its subscales, indicating good internal consistency. In the current study, the full scale reliability was found to be 0.94.

Table 1

Demographic Characteristics of the Sample (*n* = 264)

Variable	*n*	%
Sex		
Female	157	59.4
Male	87	33.0
Nonbinary	20	7.6
Marital status		
Single, never married	130	49.2
Married or in a relationship	124	47.0
Divorced or separated	9	3.4
Missing data	1	0.38
Educational level		
Less than high school diploma	8	3.0
High school or equivalent	52	19.7
Some college but no degree	45	17.0
Associate's degree	17	6.4
Bachelor's degree	97	36.7
Graduate degree	45	17.0
Race		
Asian	25	9.5
Black or African American	9	3.4
Hispanic or Latino	11	4.2
Multiple races	17	6.4
Race other than those listed	8	3.0
White	194	73.5
Perceived socioeconomic status		
Lower class	28	10.6
Lower middle class	65	24.6
Middle class	124	47.0
Upper middle class	24	9.1
Prefer not to say	23	8.7

Procedure

The current study received approval from the Institutional Review Board of the City University of New York. The scales assessing the study variables, a consent form detailing the purpose of the study, and a demographic form were compiled in Microsoft Forms. The link to the survey was shared on crowdsourcing platforms, namely social media websites

Table 2

Means, Standard Deviations, and Correlations of Predictors and Criterion Variables (n = 264)

Variable	Mean (SD)	Misophonia	Obsessive-compulsive symptoms
Intolerance of uncertainty	69.66 (21.47)	0.386***	0.615***
Pathogen-based disgust	20.29 (8.22)	0.382***	0.371***
Sexual disgust	15.29 (8.98)	0.379***	0.245***
Moral disgust	22.57 (9.34)	0.264***	0.133**
Mean		20.60	63.30
SD		13.43	31.28

*** $P < 0.001$.

such as Facebook, Instagram, and Reddit, as well as survey-sharing platforms such as PollPool, SurveySwap, and SurveyTandem. Upon clicking the survey invitation link, participants were directed to Microsoft Forms, where they were presented with an overview of the study and the consent form. After consenting, participants were guided to the survey. The completed form consisted of 162 statements divided into 5 sections and took approximately 15 minutes to complete. Data collection began in November 2021 and concluded in February 2022.

Data Analysis

SPSS version 27.0 for Windows was used to conduct the data analysis on the collected responses. Beginning with the analysis, the means and SDs for all scales were calculated. The data were then assessed for multivariate outliers using Mahalanobis distance, Cook's distance, and Leverage, with one outlier emerging, which was discarded. Assumptions of additivity, normality, linearity, and homogeneity/homoscedasticity were also examined without violations emerging. All predictor variables were significantly correlated, and correlations were all under 0.5. The 95% CI was calculated for all regression coefficients, and bootstrapping with 5,000 bootstrapped samples within 95% of the CI was performed to assess the relevance of the indirect effects. The results were verified using binomial regression analysis.

RESULTS

Participants

A sample of 264 (59.5% female, 33.0% male, 7.6% nonbinary) individuals between 18 and 65 years of age (mean = 28.6, SD = 9.5 years) was recruited. Most participants reported their race as white (73.5%), followed by Asian (9.5%), black or African American (3.4%), Hispanic or Latino (4.2%), and multiple races (6.4%). The majority (60.1%) of participants had obtained an associate's degree, a bachelor's degree, or a graduate degree. Most participants were either single and never married (49.2%) or married or in a relationship (47.0%), with the rest of the participants divorced or separated (3.4%). All demographic characteristics are displayed in **Table 1.**

Correlations

IU (r = 0.61, P < 0.001), pathogen-based disgust (r = 0.37, P < 0.001), sexual disgust (r = 0.24, P < 0.001), and moral disgust (r = 0.13, P < 0.05) correlated positively and significantly with OCD symptoms. Correlations were also found between IU (r = 0.39, P < 0.001), pathogen-based disgust (r = 0.38, P < 0.001), sexual disgust (r = 0.38, P < 0.001), and moral disgust (r = 0.26, P < 0.001) and symptoms of misophonia **(Table 2)**.

Logistic Regression

Using cut-off scores for the OCI-R and NYMS, 59 participants were used in the logistic regression analysis. Respondents with high levels of OCD symptoms and average or below average misophonia symptoms (n = 31) and those with high levels of misophonia and average or below average OCD symptoms (n = 28) were placed in separate groups. Both groups were contrasted, with a multivariate analysis of variance revealing that the two groups differed significantly on IU (P < 0.01) and moral disgust (P < 0.01) **(Table 3)**.

A bivariate logistic regression was performed to determine the contributions of IU, pathogen-based disgust, sexual disgust, and moral disgust to the likelihood of identifying the individual as having OCD. Each predictor variable was tested to verify that the assumption of linearity of the logit was not violated. The predictor variables IU and moral disgust were found to make significant contributions to the model. The logistic regression model was statistically significant, $\chi^2(4, n = 59) = 18.77$, P < 0.001. The Hosmer-Lemeshow test ($\chi^2(8, n = 59) = 6.63$, $P > 0.05$) was not significant, further confirming the fit of the model. The model explained 36.4% (Nagelkerke r^2) of the variance in OCD, and the percentage accuracy of classification was 71.2%. Greater IU was associated with an increased like-

lihood of reporting OCD symptoms, but higher moral disgust was associated with reduced likelihood of having OCD. The odds ratios of the predictors are displayed in **Table 4.**

Table 3

Results of Multivariate Analysis of Variance Comparing the High Obsessive-Compulsive (n = 31) and High Misophonia Groups (n = 28) on the Study Variables

	Misophonia	Obsessive-compulsive	
Variable	Mean (SD)	Mean (SD)	F
Intolerance of uncertainty	70.75 (20.31)	85.71 (15.33)	10.321**
Pathogen-based disgust	21.82 (7.05)	23.16 (6.59)	0.569
Sexual disgust	19.28 (9.42)	17.87 (7.36)	0.417
Moral disgust	25.89 (6.71)	21.64 (5.98)	6.608

** *P* < 0.01.

DISCUSSION

Consistent with our hypotheses, IU and moral disgust scores were able to predict OCD and misophonia, respectively. Our findings support the distinction between these disorders while lending credence to existing neuroscientific literature underpinning the processes that characterize IU and moral disgust. IU, initially thought to be a defining feature of generalized anxiety disorder,[49] has since been found to play a role in various anxiety disorders, including OCD[40,50,51] and posttraumatic stress disorder.[52,53] Of the studies examining the neural correlates of IU, there seems to be a pattern in brain area involvement, with literature implicating the insula, amygdala, OFC, ACC, vmPFC, and DLPFC in IU. Interestingly, significant overlap exists between the areas implicated in IU and in OCD, providing a neurological backing to the existing body of psychological literature supporting the relationship between IU and OCD. Further, IU has been found to positively correlate with striatal volume, particularly in the putamen,[54] as found in OCD,[55] suggesting there is a link on not only a functional level but a structural level as well. IU has been especially noted in compulsions or ritualistic behavior,[50,51,56] as heightened connectivity of the vmPFC and DLPFC results in impaired safety signaling, thus exacerbating compensatory behaviors. If a person fears they forgot to lock their front door before going to sleep, they may repeatedly check to make sure the door is locked. Thus, they respond to their fear of the uncertain (ie, whether the door is locked) by carrying out a compulsion, in this case the repeated checking of the lock, in an attempt to mitigate the anxiety and promote feelings of safety. Through this logic, IU has been found to predict OCD symptom severity.[57]

As for misophonia, our belief that IU would not predict misophonia was supported by our results. This may be accounted for by recognizing just when anxiety is experienced by those with

Table 4

Odds Ratios and 95% CIs of Factors Predictive of Obsessive-Compulsive Symptoms Versus Misophonia in a Logistic Regression Model

Predictor Variable	B	SE	Wald	df	Sig.	Exp(B)	95% CI for Exp(B)
Intolerance of uncertainty	0.053	0.019	8.128	1	0.004	1.055	1.017 to 1.094
Pathogen-based disgust	0.061	0.053	1.322	1	0.250	1.063	0.958 to 1.179
Sexual disgust	–0.038	0.043	0.778	1	0.378	0.963	0.885 to 1.047
Moral disgust	–0.136	0.055	6.051	1	0.014	0.873	0.784 to 0.973
Constant	–1.509	1.917	0.620	1	0.431	0.221	

SE = standard error; df = degree of freedom; Sig. = significance; Exp(B) = exponentiation of the B coefficient.

misophonia compared to individuals with OCD. As mentioned, we believed people with misophonia would not experience distress prior to encountering their triggers. This belief was supported by neuroimaging studies showing ACC activation only in the presence of triggers. Because the ACC deals with anticipating aversive events,[58,59] ACC activation exclusively in the presence of specific misophonic triggers[23] is not at all consistent with OCD, as there is no anticipation of the triggers or hyperactive resting state, as found in OCD.[60]

Disgust sensitivity is another factor that emerged as significant when attempting to distinguish the two disorders. The three domains of disgust are extremely understudied in neuroscientific literature, and thus, literature surrounding the distinct neural regions each domain activates is scarce. However, the research that does exist suggests that pathogen disgust and moral disgust have distinct neural activation. In a study conducted by Schaich Borg et al., when processing pathogen-based disgust stimuli, the main areas of activation included the left amygdala and the ventral orbito-frontal cortex.[61] Because both areas have been thought of as central players in OCD pathophysiology, the neural correlates of disgust line up with those found in OCD. Additionally, as contamination OCD is one of the more prevalent OCD subtypes, it is reasonable that pathogen disgust emerged as significant, since the fear/avoidance of pathogens defines the subtype.[62,63] Another explanation for OCD response to pathogen disgust may be derived from the concept of overestimation of threat, which is a key cognitive process in OCD in which individuals with OCD overestimate the potential for danger.[64,65] As a result, when these individuals are faced with situations such as stepping in dog feces, they may believe they have somehow exposed themselves to contamination, thus cycling into compulsions to offset the anxiety associated with the contamination-based obsession. People with misophonia do not exhibit the same overestimation of threat tendencies or worry-oriented mindsets that individuals with OCD do, perhaps explaining why pathogen disgust did not emerge as a significant predictor of misophonia. That is, misophonic triggers do not center around the potential danger posed to the individual but rather around the anger felt toward the perpetrator of the action, as anger is a defining characteristic of misophonia.[66]

When disgust stimuli of moral content were processed, significant areas of activation included the medial prefrontal cortex and the areas around the temporo-partial junction, which are regions involved in the processing of moral stimuli[61,67,68] and in the pathophysiology of misophonia.[69] While there has not been a proposed neurological link between moral disgust and misophonia, we speculate that the feeling of disgust in those with misophonia may stem from anger, rather than worry, as observed in OCD. Participants in Edelstein et al.'s study reported that their triggers did not make them feel anxious; however, they did report they felt offended by triggering sounds, which would give rise to sentiments such as "I hate this person."[16] In this way, it is probable that moral disgust emerged as significant since misophonic responses to triggers include negative feelings toward the source of the trigger, rather than toward the trigger itself.

Although moral disgust has been observed to play a role in OCD (mental contamination),[70] we speculate it is not as significant a predictor as pathogen disgust since morality in OCD generally relates to the experience of the individual, rather than the judgment of others, where the individual often casts doubt on their own morality instead of passing judgment on the actions of others—an important defining characteristic between OCD and misophonia. It may also be that morality underscores the pathogen-based and sexual domains in misophonia as well, since the nature of the triggers may fall under a pathogenic or sexual label; however, the overall reaction has less to do with the stimuli and more to do with the perceived morality of the source of the trigger.

CONCLUSION AND RECOMMENDATIONS

The findings of the current study call attention to several issues. First, the data collected from participants was self-reported. Although screening was implemented to reach the target demographic, self-report measures are not sufficient to conclude the distinction between these disorders. The sample of this study was small, meaning more participants are needed to confirm the relationship between IU, disgust sensitivity, OCD, and misophonia. Additionally, studies of the three domains of disgust and misophonia are few, especially in the field of neuroscience, suggesting a need for more research on the subjects.

Future research may attempt to further describe the relationship between OCD and misophonia, so the classification of misophonia may be solidified. It is also worth noting that use of the TDDS limited our scope of pathogen, moral, and sexual disgust. Specifically, the statements describing moral disgust were limited to the immorality of others, leaving us unable to explore the possibility of mental contamination in OCD. As such, a different direction to explore may examining OCD in the context of self-morality and misophonia in the context of the morality of others.

The neuroscience themes described in this article inform treatment planning for patients with OCD. The study results support recent literature[71,72] detailing treatment possibilities for OCD that stray away from the conventional drug and behavioral treatment routes and move in the direction of translating ad-

vances in neuroscience research to effective OCD neurotherapeutics that target the neurobiological alterations involved in psychiatric symptoms. Evidence of this can be found in studies where researchers report positive results when administering high-frequency brain stimulation (reduced OFC, PFC, and ACC activation)[73] and transcranial magnetic stimulation (reduced PFC and ACC activation.)[74] Such findings indicate that addressing the hyperactive CSTC circuit, as well as the neural correlates of IU, may mitigate OCD symptom severity.

As for misophonia, existing treatment methods are especially limited due to the narrow scope of research on the topic. Treatment of misophonia predominately involves psychotherapy.[75] Findings of this study suggest there are key brain regions that influence the presence and severity of misophonia symptoms; these must be further studied to develop new treatment options. Viewing disgust through the lens of anger in those with misophonia, rather than worry as typically expressed in individuals with OCD, may also be beneficial in psychotherapeutic and pharmacological spheres.

REFERENCES

1. *Diagnostic and Statistical Manual Of Mental Disorders.* Fifth edition. American Psychiatric Association; 2013.
2. Saxena S, Brody AL, Schwartz JM, Baxter LR. Neuroimaging and frontal-subcortical circuitry in obsessive-compulsive disorder. *Br J Psychiatry Suppl.* 1998;173(35):26-37. https://doi.org/10.1192/S0007125000297870 PMID:9829024
3. Fitzgerald KD, Stern ER, Angstadt M, et al. Altered function and connectivity of the medial frontal cortex in pediatric obsessive-compulsive disorder. *Biological Psychiatry*. 2010;68(11):1039-1047. https://doi.org/10.1016/j.biopsych.2010.08.018
4. Saxena S, Rauch SL. Functional neuroimaging and the neuroanatomy of obsessive-compulsive disorder. *Psychiatr Clin North Am*. 2000;23(3):563-586. https://doi.org/10.1016/S0193-953X(05)70181-7 PMID:10986728
5. Calzà J, Gürsel DA, Schmitz-Koep B, et al. Altered cortico-striatal functional connectivity during resting state in obsessive-compulsive disorder. *Front Psychiatry*. 2019;10:319-319. https://doi.org/10.3389/fpsyt.2019.00319 PMID:31133898
6. Gu X, Hof PR, Friston KJ, Fan J. Anterior insular cortex and emotional awareness. *J. Comparative Neurology.* 2013;521(15):3371-3388. https://doi.org/10.1002/cne.23368
7. Holroyd CB, Yeung N. An integrative theory of anterior cingulate cortex function: option selection in hierarchical reinforcement learning. In: Mars RB, Sallet J, Rushworth MFS, Yeung N, eds., *Neural Basis of Motivational and Cognitive Control*. The MIT Press; 2011. https://doi.org/10.7551/mitpress/8791.003.0024
8. Apergis-Schoute AM, Gillan CM, Fineberg NA, Fernandez-Egea E, Sahakian BJ, Robbins TW. Neural basis of impaired safety signaling in obsessive compulsive disorder. *Pro. Nat Acad Sciences.* 2017;114(12):3216-3221. https://doi.org/10.1073/pnas.1609194114
9. Ahmari SE, Rauch SL. The prefrontal cortex and OCD. *Neuropsychopharmacology*. 2022;47(1):211-224. https://doi.org/10.1038/s41386-021-01130-2 PMID:34400778
10. DeLong MR, Wichmann T. Circuits and circuit disorders of the basal ganglia. *Arch Neurology.* 2007;64(1):20-24. https://doi.org/10.1001/archneur.64.1.20
11. Beucke JC, Sepulcre J, Talukdar T, et al. Abnormally high degree connectivity of the orbitofrontal cortex in obsessive-compulsive disorder. *JAMA Psychiatry.* 2013;70(6):1-11. https://doi.org/10.1001/jamapsychiatry.2013.173
12. Yu J, Zhou P, Yuan S, et al. Symptom provocation in obsessive-compulsive disorder: A voxel-based meta-analysis and meta-analytic connectivity modeling. *J Psychiatr Res*. 2022;146:125-134. https://doi.org/10.1016/j.jpsychires.2021.12.029 PMID:34971910
13. Snyder HR, Kaiser RH, Warren SL, Heller W. Obsessive-compulsive disorder is associated with broad impairments in executive function: A meta-analysis. *Clin Psychol Sci*. 2015;3(2):301-330. https://doi.org/10.1177/2167702614534210 PMID:25755918
14. Thorsen AL, Hagland P, Radua J, et al. Emotional processing in obsessive-compulsive disorder: a systematic review and meta-analysis of 25 functional neuroimaging studies. *Biol Psychiatry Cogn Neurosci Neuroimaging*. 2018;3(6):563-571. https://doi.org/10.1016/j.bpsc.2018.01.009 PMID:29550459
15. Schröder A, Vulink N, Denys D. Misophonia: diagnostic criteria for a new psychiatric disorder. *PLoS One*. 2013;8(1):e54706-e54706. https://doi.org/10.1371/journal.pone.0054706 PMID:23372758
16. Edelstein M, Brang D, Rouw R, Ramachandran VS. Misophonia: physiological investigations and case descriptions. *Front Hum Neurosci*. 2013;7:296-296. https://doi.org/10.3389/fnhum.2013.00296 PMID:23805089
17. Erfanian M, Kartsonaki C, Keshavarz A. Misophonia and comorbid psychiatric symptoms: a preliminary study of clinical findings. *Nord J Psychiatry*. 2019;73(4-5):219-228. https://doi.org/10.1080/08039488.2019.1609086 PMID:31066600
18. Jastreboff MM, Jastreboff PJ. Components of decreased sound tolerance: hyperacusis, misophonia, phonophobia. Tinnitus.org; 2001. https://www.tinnitus.org/DST_NL2_PJMJ.pdf
19. Jastreboff PJ, Gray WC, Gold SL. Neurophysiological approach to tinnitus patients. *American J Otology.* 1996;17(2):236-240.
20. Jastreboff PJ, Jastreboff MM. Treatments for decreased sound tolerance (hyperacusis and misophonia). *Semin Hear*. 2014;35(2):105-120. https://doi.org/10.1055/s-0034-1372527
21. Baguley D, McFerran D, Hall D. Tinnitus. *Lancet*. 2013;382(9904):1600-1607. https://doi.org/10.1016/S0140-6736(13)60142-7 PMID:23827090
22. Brout JJ, Edelstein M, Erfanian M, et al. Investigating misophonia: a review of the empirical literature, clinical implications, and a research agenda. *Front Neurosci*. 2018;12:36-36. https://doi.org/10.3389/fnins.2018.00036 PMID:29467604
23. Neacsiu AD, Szymkiewicz V, Galla JT, Li B, Kulkarni Y, Spector CW. The neurobiology of misophonia and implications for

novel, neuroscience-driven interventions. *Front Neurosci*. 2022;16:893903-893903. https://doi.org/10.3389/fnins.2022.893903 PMID:35958984

24. Cusack SE, Cash TV, Vrana SR. An examination of the relationship between misophonia, anxiety sensitivity, and obsessive-compulsive symptoms. *J Obsessive Compuls Relat Disord*. 2018;18:67-72. https://doi.org/10.1016/j.jocrd.2018.06.004
25. Natalini E, Dimaggio G, Varakliotis T, Fioretti A, Eibenstein A. Misophonia, maladaptive schemas and personality disorders: a report of three cases. *J Contemp Psychother*. 2020;50(1):29-35. https://doi.org/10.1007/s10879-019-09438-3
26. Jager I, de Koning P, Bost T, Denys D, Vulink N. Misophonia: Phenomenology, comorbidity and demographics in a large sample. *PLoS One*. 2020;15(4):e0231390-e0231390. https://doi.org/10.1371/journal.pone.0231390 PMID:32294104
27. Webber TABA, Johnson PLBA, Storch EAPD. Pediatric misophonia with comorbid obsessive-compulsive spectrum disorders. *Gen Hosp Psychiatry*. 2014;36(2):231.e1-231.e2. https://doi.org/10.1016/j.genhosppsych.2013.10.018 PMID:24333158
28. Stevens FL, Hurley RA, Taber KH. Anterior cingulate cortex: unique role in cognition and emotion. *J Neuropsychiatry Clin Neurosci*. 2011;23(2):121-125. https://doi.org/10.1176/jnp.23.2.jnp121 PMID:21677237
29. Cerliani L, Rouw R. Increased orbitofrontal connectivity in misophonia (preprint). Cold Spring Harbor Laboratory Press; 2020. https://doi.org/10.1101/2020.10.29.346650
30. Nachev P, Kennard C, Husain M. Functional role of the supplementary and pre-supplementary motor areas. *Nat Rev Neuroscience* 2008;9(11):856-869. https://doi.org/10.1038/nrn2478 PMID:18843271
31. Bhikram T, Abi-Jaoude E, Sandor P. OCD: obsessive-compulsive … disgust? The role of disgust in obsessive-compulsive disorder. *J Psychiatry Neuroscience* 2017;42(5):300-306. https://doi.org/10.1503/jpn.160079 PMID:28375077
32. Salvo G, Provenzano S, Di Bello M, D'Olimpio F, Ottaviani C, Mancini F. Filthiness of immorality: manipulating disgust and moral rigidity through noninvasive brain stimulation as a promising therapeutic tool for obsessive compulsive disorder. *Clin Psychol Science*. 2022;10(1):127-140. https://doi.org/10.1177/21677026211009508
33. Barahmand U, Stalias-Mantzikos ME, Rotlevi E, et al. Disgust and emotion dysregulation in misophonia: a case for mental contamination? *Int J Ment Health Addiction*. 2023;21:1550–1569. https://doi.org/10.1007/s11469-021-00677-x
34. Taylor S. Misophonia: A new mental disorder? *Med Hypotheses*. 2017;103:109-117. https://doi.org/10.1016/j.mehy.2017.05.003 PMID:28571795
35. Olatunji BO, Sawchuk CN. Disgust: characteristic features, social manifestations, and clinical implications. *J Soc Clin Psychol*. 2005;24(7):932-962. https://doi.org/10.1521/jscp.2005.24.7.932
36. Tybur JM, Lieberman D, Kurzban R, DeScioli P. Disgust: evolved function and structure. *Psychol Rev*. 2013;120(1):65-84. https://doi.org/10.1037/a0030778 PMID:23205888
37. Eyal T, Dar R, Liberman N. Is disgust in obsessive-compulsive disorder mediated by fear of pathogens? *J Anxiety Disord*. 2021;77:102340-102340. https://doi.org/10.1016/j.janxdis.2020.102340 PMID:33302175
38. Rickelt J, de Wit SJ, van der Werf YD, et al. Emotional processing and disgust sensitivity in OCD patients with and without contamination-type obsessive-compulsive symptoms – An fMRI study. *J Obsessive Compuls Relat Disord*. 2019;22:100443. https://doi.org/10.1016/j.jocrd.2019.100443
39. Buhr K, Dugas MJ. The role of fear of anxiety and intolerance of uncertainty in worry: an experimental manipulation. *Behav Res Ther*. 2009;47(3):215-223. https://doi.org/10.1016/j.brat.2008.12.004 PMID:19159867
40. Penney AM, Rachor GS, Deleurme KA. Differentiating the roles of intolerance of uncertainty and negative beliefs about worry across emotional disorders. *J Exp Psychopathol*. 2020;11(4). https://doi.org/10.1177/2043808720970072
41. Saulnier KG, Allan NP, Raines AM, Schmidt NB. Depression and intolerance of uncertainty: relations between uncertainty subfactors and depression dimensions. *Psychiatry*. 2019;82(1):72-79. https://doi.org/10.1080/00332747.2018.1560583 PMID:30730786
42. Pinciotti CM, Riemann BC, Abramowitz JS. Intolerance of uncertainty and obsessive-compulsive disorder dimensions. *J Anxiety Disord*. 2021;81:102417-102417. https://doi.org/10.1016/j.janxdis.2021.102417 PMID:33991818
43. Geok E-T, Lee KYC, Sündermann O. An experimental investigation of intolerance of uncertainty and its impact on sub-clinical psychopathology. *J Behav Ther Exp Psychiatry*. 2022;75:101718-101718. https://doi.org/10.1016/j.jbtep.2021.101718 PMID:35081482
44. Tybur JM, Lieberman D, Griskevicius V. Microbes, mating, and morality: individual differences in three functional domains of disgust. *J Pers Soc Psychol*. 2009;97(1):103-122. https://doi.org/10.1037/a0015474 PMID:19586243
45. Freeston MH, Rhéaume J, Letarte H, Dugas MJ, Ladouceur R. Why do people worry? *Pers Individ Dif*. 1994;17(6):791-802. https://doi.org/10.1016/0191-8869(94)90048-5
46. Buhr K, Dugas MJ. The Intolerance of Uncertainty Scale: psychometric properties of the English version. *Behav Res Ther*. 2002;40(8):931-945. https://doi.org/10.1016/S0005-7967(01)00092-4 PMID:12186356
47. Foa EB, Huppert JD, Leiberg S, et al. The Obsessive-Compulsive Inventory: development and validation of a short version. *Psychol Assess*. 2002;14(4):485-496. https://doi.org/10.1037/1040-3590.14.4.485 PMID:12501574
48. Foa EB, Kozak MJ, Salkovskis PM, Coles ME, Amir N. The validation of a new obsessive-compulsive disorder scale: The Obsessive-Compulsive Inventory. *Psychol Assess*. 1998;10(3):206-214. https://doi.org/10.1037/1040-3590.10.3.206
49. Dugas MJ, Gagnon F, Ladouceur R, Freeston MH. Generalized anxiety disorder: a preliminary test of a conceptual model. *Behav Res Ther*. 1998;36(2):215-226. https://doi.org/10.1016/S0005-7967(97)00070-3 PMID:9613027

50. Sarawgi S, Oglesby ME, Cougle JR. Intolerance of uncertainty and obsessive-compulsive symptom expression. *J Behav Ther Exp Psychiatry*. 2013;44(4):456-462. https://doi.org/10.1016/j.jbtep.2013.06.001 PMID:23832229
51. Tolin DF, Abramowitz JS, Brigidi BD, Foa EB. Intolerance of uncertainty in obsessive-compulsive disorder. *J Anxiety Disord*. 2003;17(2):233-242. https://doi.org/10.1016/S0887-6185(02)00182-2 PMID:12614665
52. Oglesby ME, Boffa JW, Short NA, Raines AM, Schmidt NB. Intolerance of uncertainty as a predictor of post-traumatic stress symptoms following a traumatic event. *J Anxiety Disord*. 2016;41:82-87. https://doi.org/10.1016/j.janxdis.2016.01.005 PMID:26803928
53. Raines AM, Oglesby ME, Walton JL, True G, Franklin CL. Intolerance of uncertainty and DSM-5 PTSD symptoms: associations among a treatment seeking veteran sample. *J Anxiety Disord*. 2019;62:61-67. https://doi.org/10.1016/j.janxdis.2018.12.002 PMID:30572246
54. Kim MJ, Shin J, Taylor JM, Mattek AM, Chavez SJ, Whalen PJ. Intolerance of uncertainty predicts increased striatal volume. *Emotion*. 2017;17(6):895-899. https://doi.org/10.1037/emo0000331 PMID:28517947
55. Radua J, van den Heuvel OA, Surguladze S, Mataix-Cols D. Meta-analytical comparison of voxel-based morphometry studies in obsessive-compulsive disorder vs other anxiety disorders. *Arch Gen Psychiatry*. 2010;67(7):701–711. https://doi.org/10.1001/archgenpsychiatry.2010.70
56. Abramowitz JS, Wheaton MG, Storch EA. The status of hoarding as a symptom of obsessive-compulsive disorder. *Behav Res Ther*. 2008;46(9):1026-1033. https://doi.org/10.1016/j.brat.2008.05.006 PMID:18684434
57. Calleo JS, Hart J, Björgvinsson T, Stanley MA. Obsessions and worry beliefs in an inpatient OCD population. *J Anxiety Disord*. 2010;24(8):903-908. https://doi.org/10.1016/j.janxdis.2010.06.015 PMID:20627225
58. Critchley HD, Mathias CJ, Dolan RJ. Neural activity in the human brain relating to uncertainty and arousal during anticipation. *Neuron*. 2001;29(2):537-545. https://doi.org/10.1016/S0896-6273(01)00225-2 PMID:11239442
59. Sarinopoulos I, Grupe DW, Mackiewicz KL, et al. Uncertainty during anticipation modulates neural responses to aversion in human insula and amygdala. *Cerebral Cortex*. 2010;20(4):929-940. https://doi.org/10.1093/cercor/bhp155
60. Ursu S, Stenger VA, Shear MK, Jones MR, Carter CS. Overactive action monitoring in obsessive-compulsive disorder: evidence from functional magnetic resonance imaging. *Psychol Sci*. 2003;14(4):347-353. https://doi.org/10.1111/1467-9280.24411 PMID:12807408
61. Schaich Borg J, Lieberman D, Kiehl KA. Infection, incest, and iniquity: investigating the neural correlates of disgust and morality. *J Cogn Neurosci*. 2008;20(9):1529-1546. https://doi.org/10.1162/jocn.2008.20109 PMID:18345982
62. Olatunji BO, Armstrong T, Elwood L. Is disgust proneness associated with anxiety and related disorders? A qualitative review and meta-analysis of group comparison and correlational studies. *Perspect Psychol Sci*. 2017;12(4):613-648. https://doi.org/10.1177/1745691616688879 PMID:28651058
63. Husted DS, Shapira NA, Goodman WK. The neurocircuitry of obsessive-compulsive disorder and disgust. *Prog Neuropsychopharmacol Biol Psychiatry*. 2006;30(3):389-399. https://doi.org/10.1016/j.pnpbp.2005.11.024 PMID:16443315
64. Abramowitz JS, Blakey SM. Overestimation of threat. In: Abramowitz JS, Blakey SM, eds., *Clinical Handbook of Fear and Anxiety: Maintenance Processes and Treatment Mechanisms*, pp. 7–25. American Psychological Association; 2020. https://doi.org/10.1037/0000150-001
65. Steketee G, Frost R, Amir N, et al; Obsessive Compulsive Cognitions Working Group. Development and initial validation of the obsessive beliefs questionnaire and the interpretation of intrusions inventory. *Behav Res Ther*. 2001;39(8):987-1006. https://doi.org/10.1016/S0005-7967(00)00085-1 PMID:11480839
66. Rouw R, Erfanian M. A large-scale study of misophonia. *J Clin Psychol*. 2018;74(3):453-479. https://doi.org/10.1002/jclp.22500 PMID:28561277
67. Liu J, Yuan B, Luo YJ, Cui F. Intrinsic functional connectivity of medial prefrontal cortex predicts the individual moral bias in economic valuation partially through the moral sensitivity trait. *Brain Imaging Behav*. 2020;14(5):2024-2036. https://doi.org/10.1007/s11682-019-00152-1 PMID:31250264
68. Filley CM, Kletenik I, Churchland PS. Morality and the brain: the right hemisphere and doing right. *Cogn Behav Neurol*. 2020;33(4):304-307. https://doi.org/10.1097/WNN.0000000000000253 PMID:33264160
69. Eijsker N, Schröder A, Smit DJA, van Wingen G, Denys D. Structural and functional brain abnormalities in misophonia. *Eur Neuropsychopharmacol*. 2021;52:62-71. https://doi.org/10.1016/j.euroneuro.2021.05.013 PMID:34273684
70. Jacoby RJ, Blakey SM, Reuman L, Abramowitz JS. Mental contamination obsessions: an examination across the obsessive-compulsive symptom dimensions. *J Obsessive Compuls Relat Disord*. 2018;17:9-15. https://doi.org/10.1016/j.jocrd.2017.08.005
71. Dougherty DD, Brennan BP, Stewart SE, Wilhelm S, Widge AS, Rauch SL. Neuroscientifically informed formulation and treatment planning for patients with obsessive-compulsive disorder: a review. *JAMA Psychiatry*. 2018;75(10):1081-1087. https://doi.org/10.1001/jamapsychiatry.2018.0930
72. Shephard E, Stern ER, van den Heuvel OA, et al. Toward a neurocircuit-based taxonomy to guide treatment of obsessive-compulsive disorder. *Mol Psychiatry*. 2021;26(9):4583-4604. https://doi.org/10.1038/s41380-020-01007-8 PMID:33414496
73. Park HR, Kim IH, Kang H, et al. Electrophysiological and imaging evidence of sustained inhibition in limbic and frontal networks following deep brain stimulation for treatment refractory obsessive compulsive disorder. *PLoS*

One. 2019;14(7):e0219578-e0219578. https://doi.org/10.1371/journal.pone.0219578 PMID:31323037

74. Carmi L, Tendler A, Bystritsky A, et al. Efficacy and safety of deep transcranial magnetic stimulation for obsessive-compulsive disorder: a prospective multicenter randomized double-blind placebo-controlled trial. *Am J Psychiatry*. 2019;176(11):931-938. https://doi.org/10.1176/appi.ajp.2019.18101180 PMID:31109199
75. Lewin AB, Dickinson S, Kudryk K, et al. Transdiagnostic cognitive behavioral therapy for misophonia in youth: methods for a clinical trial and four pilot cases. *J Affect Disord*. 2021;291:400-408. https://doi.org/10.1016/j.jad.2021.04.027 PMID:34001373