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Effectiveness of Neural Repatterning-Based Therapy in Reducing Misophonia Symptoms and Physical Reflex Responses in Individuals with Misophonia Disorder

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A B S T R A C T

Purpose: This study aimed to determine the effectiveness of neural repatterning-based therapy in reducing misophonia symptoms and physical reflex responses among individuals diagnosed with misophonia disorder.
Methods and Materials: This study employed a quasi-experimental single-case design with multiple baselines. The statistical population consisted of individuals with misophonia disorder who attended psychiatric clinics in Tabriz, Iran, in 2025. Four eligible participants were selected through purposive sampling based on the study inclusion criteria. Each participant received eight individual sessions of neural repatterning-based therapy, with each session lasting approximately 60 minutes. Assessments were conducted repeatedly during the baseline, intervention, and follow-up phases. Data were collected using the Misophonia Questionnaire developed by Wu et al. (2014) and the Misophonia Physical Response Scale developed by Dozier (2015). Treatment effectiveness was evaluated through visual analysis of changes across phases, percentage improvement calculations, and the Reliable Change Index to determine whether the observed changes exceeded measurement error and represented clinically meaningful improvement.
Findings: Neural repatterning-based therapy produced a clinically significant reduction in misophonia symptoms across the participants. The mean Reliable Change Index for misophonia symptoms was 3.62, exceeding the accepted threshold for reliable clinical change, while the mean percentage improvement was 58.66%. The intervention also significantly reduced physical reflex responses associated with triggering sounds. For physical responses, the mean Reliable Change Index was 2.28, indicating reliable improvement, and the mean percentage improvement reached 62%. The reductions observed during the intervention phase were generally maintained during the follow-up period, supporting the stability of the therapeutic effects.
Conclusion: Neural repatterning-based therapy appears to be an effective intervention for reducing both the psychological symptoms of misophonia and the involuntary physical responses elicited by triggering sounds. By modifying maladaptive neural and conditioned response patterns, this approach may help individuals regulate their emotional and bodily reactions to misophonic triggers. The findings support its potential application as a focused clinical intervention for individuals with misophonia, although further controlled studies with larger samples are required.

Keywords: *Misophonia disorder; neural repatterning-based therapy; misophonia symptoms; physical reflex responses; single-case experimental design*

1. Introduction

Misophonia is an emerging clinical condition characterized by markedly reduced tolerance to specific repetitive sounds or sound patterns and by intense emotional, cognitive, behavioral, and physiological reactions when these triggers are encountered. Common triggering stimuli include chewing, breathing, sniffing, throat clearing, tapping, pen clicking, and other human-generated sounds, although visual and contextual cues may also contribute to symptom activation. The consensus definition developed through a Delphi process emphasizes that misophonia involves disproportionate reactions to particular sounds, rather than a general intolerance of sound intensity, and that these reactions can impair social, occupational, educational, and family functioning (Swedo et al., 2022). This distinction is clinically important because misophonia differs from hyperacusis, phonophobia, and general noise sensitivity, even though these phenomena may overlap in some individuals. Contemporary reviews have consequently described misophonia as a rapidly developing field in need of clearer assessment procedures, explanatory models, and empirically supported interventions (Ferrer-Torres & Giménez-Llort, 2022; Wiese et al., 2021).

The prevalence of misophonia appears to be substantial, although estimates vary depending on the population, assessment instrument, and threshold used to define clinically significant symptoms. Research in nationally representative adult samples has shown that misophonic reactions are not restricted to specialized clinical populations and may be associated with meaningful distress and functional impairment in the general community (Dixon et al., 2024). Population-based research in Germany has similarly indicated that misophonia symptoms occur across a continuum and are associated with a range of clinical and psychosocial correlates (Jakubovski et al., 2022). Studies of young adults have also reported appreciable rates of misophonia symptoms and have highlighted the need for culturally valid measurement tools and carefully defined severity thresholds (Paunovic & Milenković, 2022; Silva et al., 2024). In Iran, the psychometric evaluation of the Misophonia Questionnaire has provided preliminary support for assessing sound-aversion symptoms in Persian-speaking populations, thereby facilitating further epidemiological and clinical investigation (Mehrabizadeh Honarmand & Roshni, 2018). Collectively, these findings indicate that misophonia cannot be regarded as a rare or trivial complaint and that its clinical relevance extends beyond highly selected treatment-seeking samples.

Although the phenomenology of misophonia is heterogeneous, anger, disgust, anxiety, irritation, distress, and an urge to escape or stop the sound are among the most frequently reported responses. These reactions may emerge rapidly and may be accompanied by muscular tension, autonomic arousal, changes in breathing, gastrointestinal discomfort, and other physical reflex responses. Emotional functioning appears to play a central role in the severity and persistence of the condition. Individuals with greater affective instability and more pronounced difficulties in emotion regulation tend to report more severe misophonia symptoms and greater impairment (Guetta et al., 2022). Disgust sensitivity and anxiety sensitivity have also been identified as possible vulnerability factors, suggesting that individuals who are especially reactive to aversive bodily sensations or contamination-related cues may be more susceptible to intense misophonic responses (Barahmand et al., 2023). In addition, anxiety sensitivity may moderate the relationship between misophonia and aggressive reactions, indicating that fear of internal arousal may amplify anger or defensive behavior when triggering sounds occur (Schadegg et al., 2021).

Recent work has further suggested that misophonia may be embedded within a broader pattern of sensory-emotional reactivity. Strong reactions to everyday sensory experiences, including nonauditory stimuli, have been found to correlate with misophonic responses in the general population (Mednicoff et al., 2024). This finding is consistent with the view that misophonia may reflect altered integration of sensory, emotional, and salience-related processes rather than a purely auditory disturbance. Clinical comparisons with individuals who exhibit auditory overresponsivity have likewise shown that misophonia has both psychiatric and audiological features, while retaining a distinctive symptom profile (Siepsiak et al., 2022). Such evidence supports a multidimensional conceptualization in which auditory triggers activate learned emotional meanings, threat appraisals, bodily reflexes, and avoidance patterns that become increasingly consolidated over time.

Neurobiological findings have provided additional support for this formulation. Functional neuroimaging research has shown that misophonia is associated with altered activity in the auditory cortex and salience network, suggesting atypical processing of trigger sounds and

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increased assignment of emotional significance to them (Schröder et al., 2019). The salience network is involved in detecting and prioritizing behaviorally relevant stimuli, and its heightened engagement may help explain why relatively ordinary sounds become difficult to ignore and are experienced as intrusive or threatening. These neural responses may be strengthened through repeated pairing of specific sounds with aversive emotions and physiological arousal. Over time, the trigger may evoke a rapid conditioned response before the individual has sufficient opportunity to reinterpret the situation or regulate the reaction. This sequence is particularly relevant to interventions that seek to modify conditioned neural and bodily responses rather than focusing exclusively on the conscious content of thoughts.

Cognitive processes also appear to contribute to symptom maintenance. Difficulties disengaging attention from trigger sounds and sustaining flexible attention have been documented in individuals with misophonia (Frank et al., 2020; Simner et al., 2021). Once a trigger is detected, attentional capture may increase monitoring of the sound, intensify anticipation of its recurrence, and reduce the individual's ability to redirect attention toward competing stimuli. Heightened rumination and impaired cognitive flexibility may further prolong distress after the trigger has ended and increase the perceived uncontrollability of the response (Black et al., 2025). These cognitive characteristics may interact with emotional sensitivity and conditioned physiological reactivity, producing a self-reinforcing cycle in which attention, interpretation, arousal, and avoidance mutually strengthen one another.

The consequences of misophonia can be extensive. Individuals may avoid eating with family members, withdraw from shared workspaces, use headphones excessively, terminate conversations, or experience recurrent conflict with close others. For children and adolescents, these difficulties may interfere with school attendance, peer relationships, family routines, and developmental opportunities. Research on young people has shown that poorer quality of life is associated with internalizing symptoms and pessimistic expectations, suggesting that misophonia may influence broader emotional development and everyday functioning (Kook et al., 2024). Family accommodation is another clinically important factor, particularly when relatives alter routines, prohibit ordinary sounds, eat separately, or continuously reassure the affected child in an effort to prevent distress (Storch et al., 2024). Although such responses may provide immediate relief, they may inadvertently reinforce avoidance and communicate that the trigger is intolerable, thereby maintaining symptoms over time.

Misophonia also frequently co-occurs with anxiety, mood symptoms, obsessive-compulsive features, and other forms of psychopathology. Clinical work with individuals who have comorbid mood and anxiety disorders has demonstrated that treatment planning can become especially complex when misophonia is intertwined with generalized distress, avoidance, and rigid coping patterns (Karalis et al., 2022). Research among patients with obsessive-compulsive disorder has also reported associations among misophonia, disgust sensitivity, and anger expression, reinforcing the possibility that certain emotional and behavioral vulnerabilities are shared across conditions (Mavi & Çalıkuşu, 2025). Nevertheless, misophonia should not be reduced to a manifestation of another disorder, as many affected individuals present with a distinctive sound-triggered pattern that cannot be adequately explained by co-occurring diagnoses. A transdiagnostic perspective may therefore be useful, provided that the unique sensory and conditioned features of misophonia remain central to case formulation.

The assessment of treatment effects in misophonia requires attention not only to group-level changes but also to clinically meaningful individual improvement. This is especially relevant because the condition is heterogeneous and treatment studies have often relied on small samples, case series, or single-case experimental designs. Reliable or likely change indexes provide a method for determining whether an observed change in a patient-reported outcome exceeds the amount expected from measurement error (Peipert et al., 2023). In single-case research, such indexes can complement visual analysis, percentage improvement, stability assessment, and follow-up data. This combined approach is well suited to early-stage intervention research because it allows investigators to examine whether change occurs consistently after treatment introduction, whether the magnitude of change is clinically meaningful, and whether improvement is maintained over time.

Despite growing recognition of misophonia, the evidence base for treatment remains limited. Systematic reviews have identified cognitive behavioral therapy as the most frequently studied psychological approach, but they have also emphasized substantial methodological variability, small sample sizes, and a lack of standardized protocols (Mattson et al., 2023). Reviews of nonpharmacological treatments similarly indicate that available interventions

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include cognitive restructuring, exposure-based methods, mindfulness, acceptance strategies, sound-based techniques, and multimodal programs, although robust comparative evidence remains scarce (Khanmohammadi Otaghsara & Ahmadi, 2023). Patients and clinicians also differ in their perceptions of treatment acceptability, particularly regarding exposure, sound desensitization, and family involvement (Smith et al., 2022). These differences underscore the importance of developing interventions that are theoretically coherent, tolerable, and responsive to the specific mechanisms maintaining each patient's symptoms.

Cognitive behavioral therapy has produced promising results in several studies. A randomized clinical trial demonstrated that a structured cognitive behavioral intervention could reduce misophonia severity and related impairment (Jager et al., 2020). Subsequent work has described a systemic group protocol that integrates psychoeducation, cognitive and behavioral strategies, attention training, arousal reduction, and interpersonal components (Jager et al., 2022). Transdiagnostic cognitive behavioral therapy has also been adapted for young people, with pilot cases suggesting that interventions addressing avoidance, emotion regulation, cognitive rigidity, and family responses may be feasible and beneficial (Lewin et al., 2021). Family-based cognitive behavioral therapy has likewise been used in youth, reflecting the need to address accommodation, communication, and household triggers alongside individual coping skills (Dover & McGuire, 2023).

Exposure remains one of the most debated elements of misophonia treatment. Case-based evidence suggests that exposure may be helpful when it is carefully graded, collaborative, and paired with strategies for reducing avoidance and increasing tolerance, rather than implemented as prolonged or overwhelming confrontation with trigger sounds (Cecilione et al., 2022). Poorly designed exposure may be perceived as invalidating or may increase distress, particularly when the patient believes that the goal is simply to endure intolerable sounds. By contrast, exposure embedded within a broader learning-based framework may facilitate inhibitory learning, reduce conditioned physiological responses, and help the individual experience triggers without automatically engaging in escape or defensive behavior. This distinction is important because effective sound-based treatment should modify the trigger-response association rather than merely suppress observable reactions.

Other therapeutic approaches have also shown preliminary promise. Eye movement desensitization and reprocessing has been examined in a pilot case series, with findings suggesting that targeting distressing memories and emotionally charged sound-related experiences may reduce symptom severity in some patients (Jager et al., 2021). Online group interventions based on mindfulness, acceptance, and cognitive behavioral principles have also been associated with improvements in misophonia-related outcomes (Ghorbani et al., 2022). Mindfulness and acceptance strategies may be particularly useful for reducing secondary struggle with internal experiences, increasing tolerance of bodily arousal, and weakening the tendency to react automatically to trigger-related thoughts and emotions. However, these methods may be insufficient when rapid physical reflexes and deeply conditioned responses constitute the core of the clinical presentation.

Case reports and practice-oriented studies further demonstrate the complexity of intervention. Clinical management of adolescent misophonia has required individualized assessment, environmental modification, family education, and careful sequencing of coping and exposure procedures (Grayless, 2021). Treatment challenges are especially pronounced when severe anxiety, depression, anger, or family conflict is present, because these problems may interfere with engagement and increase the likelihood of avoidance (Karalis et al., 2022). The diversity of available approaches suggests that misophonia is unlikely to respond uniformly to a single generic protocol. Instead, treatment may need to address the interaction among sensory triggers, conditioned bodily reflexes, emotional responses, attentional fixation, maladaptive beliefs, avoidance, and interpersonal consequences.

Neural repatterning-based therapy is conceptually relevant within this context because it directly targets the learned association between trigger sounds and automatic emotional and physical responses. The intervention is grounded in principles of classical conditioning, counterconditioning, graded exposure, response modification, and repeated pairing of trigger sounds with neutral or positive states. From this perspective, the misophonic response is understood as an acquired neural pattern in which a specific sound rapidly activates autonomic arousal, muscular reactions, aversive emotion, and escape behavior. Treatment therefore seeks to weaken the established association and develop an alternative response pattern through controlled sound presentation, relaxation, attentional regulation, positive or neutral sound pairing,

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cognitive support, and real-world practice. This model is compatible with evidence showing altered salience processing, heightened sensory-emotional reactivity, attentional capture, and inflexible responding in misophonia (Black et al., 2025; Mednicoff et al., 2024; Schröder et al., 2019; Simner et al., 2021).

A particular strength of neural repatterning-based therapy is its focus on physical reflex responses. Many treatments evaluate only self-reported distress or global symptom severity, even though patients often describe immediate bodily reactions as among the most involuntary and disruptive aspects of misophonia. These may include jaw tightening, muscle contraction, chest pressure, stomach discomfort, altered breathing, and a powerful urge to flee or stop the sound. When bodily reactions are repeatedly followed by avoidance, the trigger-response pattern may become increasingly automatic. Intervening at the level of conditioned physical responding may therefore reduce both primary arousal and secondary emotional escalation. This focus may also increase treatment credibility for patients who experience their symptoms as reflexive rather than deliberate.

The present literature therefore supports the need for mechanism-focused interventions that integrate sound exposure with emotional, cognitive, and physiological retraining. Although existing cognitive behavioral, acceptance-based, family-based, group, and trauma-focused approaches have contributed valuable clinical strategies, the evidence remains insufficient to determine which components are most effective for changing automatic physical responses and whether improvements persist after treatment (Khanmohammadi Otaghsara & Ahmadi, 2023; Mattson et al., 2023; Smith et al., 2022). Single-case experimental research offers an appropriate framework for examining these questions in detail because it permits repeated measurement across baseline, intervention, and follow-up phases and allows the temporal relationship between treatment introduction and symptom change to be evaluated for each participant.

Accordingly, the aim of the present study was to determine the effectiveness of neural repatterning-based therapy in reducing misophonia symptoms and physical reflex responses among individuals with misophonia disorder.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a single-case experimental design with a nonconcurrent multiple-baseline arrangement across participants and continuous repeated measurement. In this design, participants entered the baseline, intervention, post-intervention, and follow-up phases at different time points, allowing changes in the dependent variables to be examined both within and across participants. The staggered introduction of the intervention made it possible to evaluate whether changes in misophonia symptoms and physical reflex responses occurred systematically after the initiation of neural repatterning-based therapy rather than as a consequence of the passage of time or repeated measurement. The statistical population comprised all individuals with misophonia who attended psychological and psychiatric clinics in Tabriz, Iran, in 2025. Four participants were selected through purposive sampling after undergoing psychiatric evaluation and a structured clinical interview. Eligibility criteria included receiving a diagnosis of misophonia based on the psychiatrist's clinical judgment, being between 20 and 50 years of age, having an educational level above a high-school diploma, expressing willingness to participate in the study, and providing written informed consent. The exclusion criteria included the presence of neurological disorders, depressive disorders, panic disorder, or other medical or psychiatric conditions that could provide a more appropriate explanation for the individual's sound intolerance or associated impairments; an educational level below a high-school diploma; participation in any behavioral or cognitive treatment during the preceding six months; and absence from more than two intervention sessions. After enrollment, each participant was repeatedly assessed during the baseline phase to establish the initial level, trend, and stability of the outcome variables. Participants subsequently received the intervention and completed repeated assessments throughout the treatment, post-intervention, and follow-up phases. Participation was voluntary, the confidentiality of personal information was maintained, and participants were informed that they could withdraw from the study at any time without any adverse consequences.

2.2. Measures

The Structured Clinical Interview for DSM-5 Disorders was used to evaluate participants' psychiatric status and identify possible co-occurring mental disorders that could

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influence sound sensitivity or provide a better explanation for the presenting symptoms. The interview is a semistructured diagnostic instrument developed on the basis of the diagnostic criteria presented in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders. It is administered by trained mental health professionals to standardize diagnostic assessment and examine the presence, severity, course, and subtypes of psychiatric disorders. Administration commonly requires approximately 45 to 90 minutes, depending on the participant's clinical condition and the number of diagnostic modules examined. Because misophonia is not classified as an independent psychiatric disorder in the DSM-5, the interview was not used as the sole instrument for establishing a diagnosis of misophonia. Instead, it was used alongside the psychiatrist's clinical assessment to screen for psychiatric conditions that could better account for the participant's symptoms and to determine eligibility for the study. Previous psychometric investigations have reported acceptable inter-rater reliability for the interview. Martin et al. reported an inter-rater kappa coefficient of .70, while an Iranian investigation involving 299 participants obtained an overall diagnostic agreement coefficient of .65 for the Persian version. Another Iranian study reported reliability coefficients of .95 using both Cronbach's alpha and a one-week test–retest procedure, indicating satisfactory reliability for use in Iranian clinical populations.

The Misophonia Questionnaire was developed by Wu et al. in 2014 as a self-report measure for assessing the presence and severity of misophonia-related symptoms and the emotional and behavioral reactions elicited by triggering sounds. The instrument contains 17 items assessing two principal domains: a seven-item misophonia symptom domain and a ten-item domain measuring emotional and behavioral responses associated with misophonic triggers. The questionnaire also provides an indication of the overall severity of the respondent's sound sensitivity. Items are rated on a five-point Likert scale ranging from 0 to 4, with response options of never, rarely, sometimes, often, and always. The total score is calculated by summing the item scores, resulting in a possible score range from 0 to 68. Higher scores indicate more frequent or severe misophonia symptoms and stronger emotional and behavioral reactions to triggering sounds. In the present study, the questionnaire was administered repeatedly during the baseline, intervention, post-intervention, and follow-up phases to evaluate changes in participants' misophonia symptoms over time. The Persian version of the instrument has demonstrated satisfactory internal consistency in an Iranian student population, with Mehrabizadeh Honarmand and Roshani reporting a Cronbach's alpha coefficient of .88.

The Dozier Physical Response Questionnaire was developed by Dozier in 2015 to assess bodily and reflexive responses to sounds that trigger misophonia. The questionnaire consists of 15 items rated on a five-point Likert scale ranging from 1 to 5, corresponding to never, rarely, sometimes, often, and always. Total scores range from 15 to 75, with higher scores representing more frequent or intense physical reactions to triggering sounds. These reactions may include muscular contractions, bodily tension, tightening of the chest, stomach discomfort, changes in breathing, autonomic arousal, or an immediate urge to escape or interrupt the triggering sound. The questionnaire was administered repeatedly throughout the study phases to determine whether neural repatterning-based therapy altered participants' conditioned physical responses to misophonic triggers. Construct validity was initially examined by the instrument developer through factor analysis, which showed that the items loaded on a principal factor, with factor loadings ranging from .77 to .83. These findings supported the unidimensional structure and construct validity of the questionnaire. Dozier also reported a test–retest correlation coefficient of .74, indicating acceptable temporal stability. Before its use in the present study, the researcher evaluated the internal consistency of the questionnaire in a separate sample of 50 university students and obtained a Cronbach's alpha coefficient of .71, supporting its acceptable reliability.

2.3. Intervention

The neural repatterning-based therapy protocol used in this study was developed by Dozier in 2015 specifically for the treatment of misophonia and was delivered to each participant in eight individual 60-minute sessions. The protocol is based primarily on classical conditioning, counterconditioning, gradual exposure, and the modification of conditioned neural, emotional, and physiological responses to triggering sounds. Although the protocol comprises seven sequential therapeutic steps, its components were distributed across eight sessions to allow sufficient time for assessment, practice, graded exposure, review, and relapse-prevention planning. During the initial stage, participants received psychoeducation explaining misophonia as a learned and conditioned response of the nervous system rather than evidence of personal abnormality, intentional overreaction, or moral weakness.

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Each participant prepared a detailed list of triggering sounds, rated the intensity of reactions to each trigger on a scale from 1 to 10, identified associated emotions such as anger, anxiety, disgust, shame, or distress, and recorded the situations in which the sounds produced the strongest reactions. In the preparation stage, a calm and psychologically safe therapeutic environment was established, and appropriate equipment, including headphones or a small speaker, was used to present recorded trigger sounds alongside neutral or pleasant sounds such as ocean waves or soft music. Counterconditioning and neural repatterning were then initiated by first presenting a neutral or pleasant sound and subsequently combining it with a low-volume, brief presentation of a misophonic trigger. The pairing was repeated several times while the participant maintained a relaxed posture, regulated breathing, observed negative emotions without engaging in avoidance or defensive physical reactions, and practiced tolerating the sound in a controlled context. As the participant's response decreased, the volume, duration, and salience of the trigger were gradually increased while remaining within a manageable level of distress. Emotional and cognitive support was subsequently incorporated to address guilt, anger, shame, helplessness, and negative self-appraisals associated with misophonia. Participants were taught to replace maladaptive beliefs, such as viewing themselves as abnormal or incapable of controlling their responses, with realistic and compassionate self-statements emphasizing that the body had developed a conditioned response that could be relearned. Lifestyle regulation was also addressed to reduce general nervous-system irritability and improve emotional and physiological stability. Participants were encouraged to maintain regular sleep, reduce excessive caffeine and sugar consumption, engage in light physical activity such as walking or yoga, and practice meditation, diaphragmatic breathing, and relaxation exercises. After participants demonstrated reduced reactivity under controlled therapeutic conditions, graded exposure was extended to real-life situations involving naturally occurring trigger sounds. Exposure tasks were planned hierarchically and conducted gradually to prevent overwhelming distress or premature withdrawal. The final stage focused on consolidating newly acquired responses and preventing relapse through periodic review of exercises, continued use of neutral or pleasant background sounds when necessary, maintenance of lifestyle adjustments, planned practice in everyday environments, identification of early signs of symptom recurrence, and development of a personalized strategy for responding to future triggers. Homework was assigned throughout the intervention and included monitoring trigger situations, rating emotional and physical reactions, practicing sound-pairing exercises, using positive self-talk, completing relaxation practices, and recording experiences with real-world exposure.

2.4. Data Analysis

Data were analyzed in accordance with the methodological principles of single-case experimental research. Because the study included four participants who were repeatedly assessed across baseline, intervention, post-intervention, and follow-up phases, the primary analytic approach consisted of systematic visual analysis of individual data series rather than conventional group-based statistical testing. For each participant, changes in the level, trend, variability, stability, immediacy of effect, and degree of overlap between adjacent phases were examined. Particular attention was given to whether reductions in misophonia symptoms and physical reflex responses occurred only after the intervention was introduced, whether similar patterns were replicated across participants despite the staggered baselines, and whether the observed improvements were maintained during the follow-up phase. Baseline stability was evaluated before the intervention began to ensure that changes could not reasonably be attributed to an already declining pattern. The magnitude of treatment response was also quantified by calculating the percentage of improvement from the baseline phase to the post-intervention and follow-up phases. Improvement percentages were determined by comparing participants' baseline scores with their scores after treatment, with higher percentages indicating greater reductions in symptoms. In addition, the Reliable Change Index was calculated to determine whether the magnitude of change exceeded the amount expected from measurement error. Reliable Change Index values greater than 1.96 in absolute magnitude were interpreted as evidence of statistically reliable change at the 95% confidence level. The visual findings, improvement percentages, and Reliable Change Index values were considered jointly to determine the clinical effectiveness of neural repatterning-based therapy. Evidence of intervention effectiveness was inferred when symptom reductions were temporally associated with treatment initiation, replicated across participants, exceeded measurement error, demonstrated limited overlap with baseline observations, and remained evident during follow-up.

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3. Findings and Results

Four individuals participated in this study. Participant 1 was a 39-year-old married woman with a bachelor's degree. Participant 2 was a 45-year-old married man with a master's degree. Participant 3 was a 42-year-old married woman with a bachelor's degree, and Participant 4 was a 47-year-old married man with a master's degree. Visual analysis, the Reliable Change Index, clinically significant improvement, diagnostic improvement, and percentage improvement were used for statistical analysis.

Hypothesis 1: Neural repatterning-based therapy is effective in improving misophonia symptoms among patients with misophonia disorder.

To analyze the data related to this hypothesis, line graphs, the Reliable Change Index, percentage improvement, and the data-trend variability index were used, as described below. Tables 1–4 and Figure 1 present the pattern of effectiveness of neural repatterning-based therapy in improving misophonia symptoms.

Table 1

Measures of Change in Misophonia Symptoms

Participant	Baseline Mean	Baseline Median	Baseline Range	Baseline Stability Envelope	Intervention Mean	Intervention Median	Intervention Range	Intervention Stability Envelope	Intervention Including Follow-Up Mean	Intervention Including Follow-Up Median	Intervention Including Follow-Up Range	Intervention Including Follow-Up Stability Envelope
1	22.50	22.50	2	28.13–16.87	13.50	13.50	9	16.06–9.64	11.67	10.50	10	13.13–7.87
2	23.00	23.00	1	28.75–17.25	12.50	12.00	8	15.00–9.00	10.83	9.50	10	11.88–7.12
3	23.50	23.50	1	29.38–17.62	13.25	13.00	11	16.25–9.75	11.00	9.50	13	11.88–7.12
4	22.00	22.00	2	27.50–16.50	12.50	13.00	10	16.13–9.75	10.33	9.50	11	11.88–7.12

Table 2

Determination of Stability or Variability in the Data Trend for Misophonia Symptoms

Participant	Baseline Phase	Intervention Phase	Intervention Phase Including Follow-Up Data
1	100% (stable)	75% (relative stability)	66.67% (relative stability)
2	100% (stable)	75% (relative stability)	66.67% (relative stability)
3	100% (stable)	50% (unstable)	33.33% (unstable)
4	100% (stable)	50% (unstable)	33.33% (unstable)

Table 3

Reliable Change Index for Misophonia Symptoms

Participant	End of Intervention	After Follow-Up
1	5.38	5.45
2	6.12	6.32
3	6.33	6.86
4	6.37	6.71

Table 4

Percentage Improvement in Misophonia Symptoms

Participant	End of Intervention	After Follow-Up
1	59%	63%
2	61%	69%
3	66%	75%

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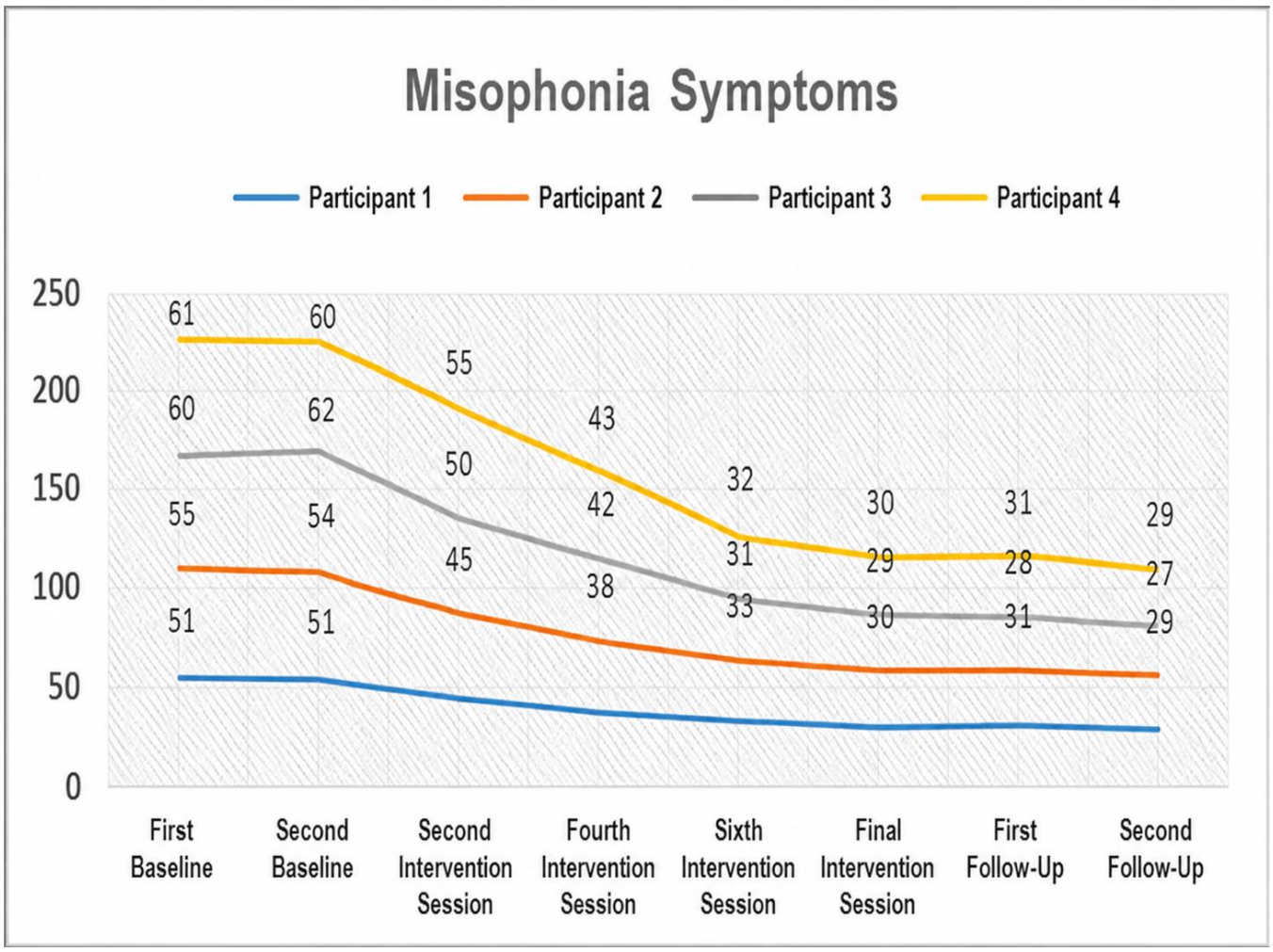
4	68%	72%

Figure 1

Line graph illustrating changes in misophonia symptoms among the participants.



As shown in Table 1 and Figure 1, all four participants demonstrated a substantial reduction in misophonia symptoms after receiving the intervention. In addition, the positive pattern of change in misophonia symptoms was maintained during the follow-up assessments conducted after the intervention. According to Figure 1, misophonia symptom levels remained stable during the baseline phase. Following the introduction of the intervention, an abrupt change occurred in the level and trend of the data during the intervention and follow-up phases for all three participants, based on the data-trend variability analysis presented in Table 2. The direction of the data subsequently shifted toward a reduction in misophonia symptoms. Moreover, the results presented in Table 2 indicate that changes in misophonia symptoms during the intervention and follow-up phases were sufficient to produce stability in the pattern of change. Furthermore, based on the Reliable Change Index values presented in Table 3, it can be inferred that the changes observed in misophonia symptoms were significant for all four participants and that these significant changes were maintained when the follow-up data were included. Because the percentage improvement in misophonia symptoms exceeded 50% for most participants during the intervention and follow-up phases, as shown in Table 4, the magnitude of change in misophonia symptoms was considered substantial. In addition, according to the criteria proposed by Jacobson and Truax (1991), the intervention was classified as therapeutically successful in improving misophonia symptoms because the Reliable Change Index was greater than 1.96 for all four participants. Therefore, based on the analyses conducted, Hypothesis 1, concerning the effectiveness of neural repatterning-based therapy in improving misophonia symptoms among patients with misophonia disorder, was supported.

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Hypothesis 2: Neural repatterning-based therapy is effective in reducing physical reflex responses among patients with misophonia disorder.

To analyze the data related to this hypothesis, line graphs, the Reliable Change Index, percentage improvement, and the data-trend variability index were used, as described below. Tables 5–8 and Figure 2 present the pattern of effectiveness of neural repatterning-based therapy in reducing physical reflex responses.

Table 5

Measures of Change in Physical Reflex Responses

Participant	Baseline Mean	Baseline Median	Baseline Range	Baseline Stability Envelope	Intervention Mean	Intervention Median	Intervention Range	Intervention Stability Envelope	Intervention Including Follow-Up Mean	Intervention Including Follow-Up Median	Intervention Including Follow-Up Range	Intervention Including Follow-Up Stability Envelope
1	54.50	54.50	1	68.13–40.82	36.50	35.50	15	44.38–26.62	34.33	31.50	16	39.38–23.62
2	55.50	55.50	1	69.38–41.62	34.50	33.50	13	41.88–25.12	32.17	30.00	15	37.50–22.50
3	61.50	61.50	1	76.88–46.12	37.75	36.50	22	45.63–27.37	33.83	29.50	25	36.88–22.12
4	60.50	60.50	1	75.63–45.37	40.00	37.50	25	46.88–28.12	36.67	31.00	26	38.75–23.25

Table 6

Determination of Stability or Variability in the Data Trend for Physical Reflex Responses

Participant	Baseline Phase	Intervention Phase	Intervention Phase Including Follow-Up Data
1	100% (stable)	75% (relative stability)	87% (relative stability)
2	100% (stable)	75% (relative stability)	67% (relative stability)
3	100% (stable)	75% (relative stability)	67% (relative stability)
4	100% (stable)	75% (relative stability)	67% (relative stability)

Table 7

Reliable Change Index for Physical Reflex Responses

Participant	End of Intervention	After Follow-Up
1	6.19	6.59
2	6.67	6.87
3	7.12	7.36
4	6.62	6.90

Table 8

Percentage Improvement in Physical Reflex Responses

Participant	End of Intervention	After Follow-Up
1	44%	46%
2	47%	51%
3	55%	60%
4	50%	52%

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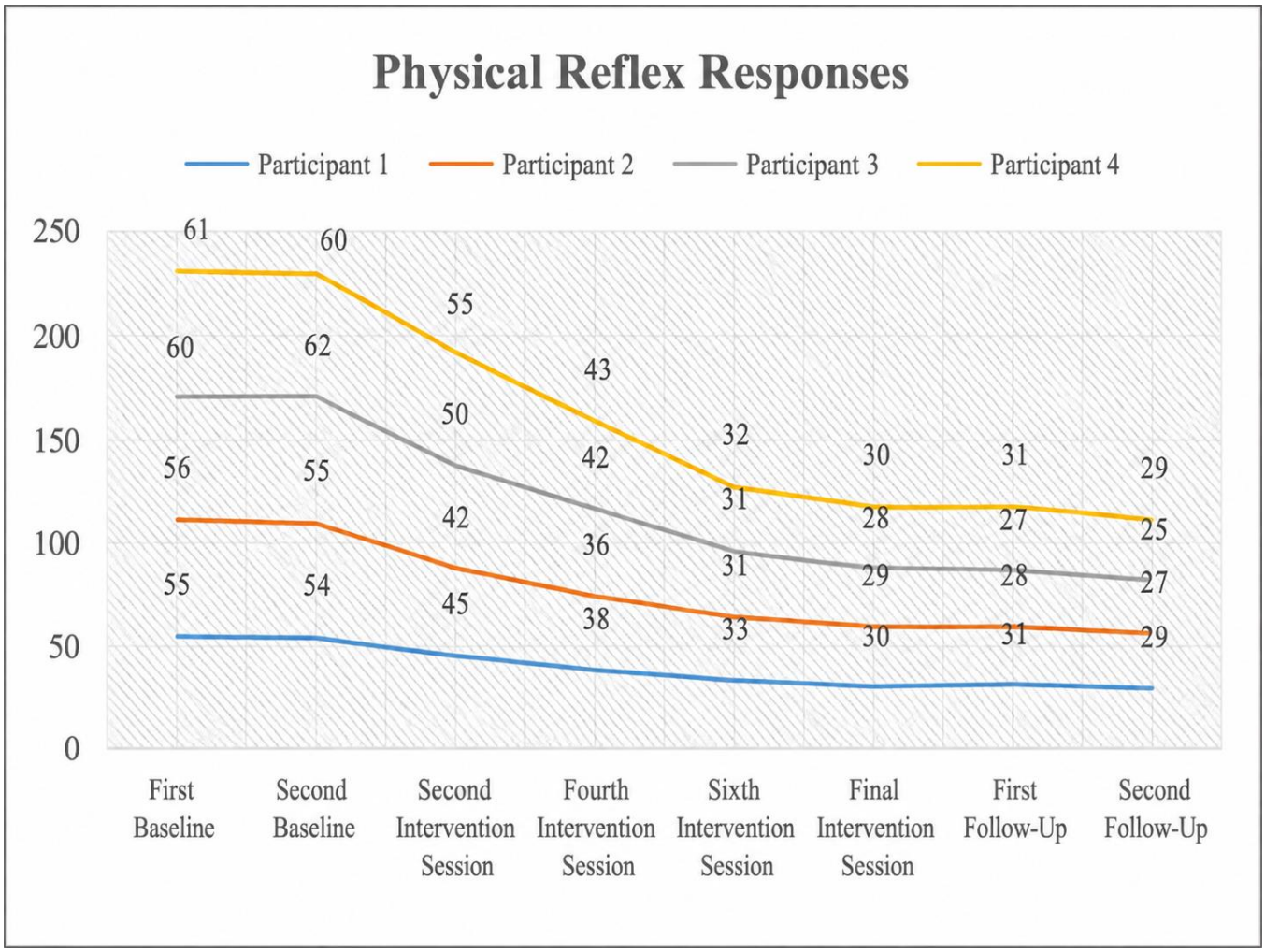
Figure 2

Line graph illustrating changes in physical reflex responses among the participants.



As shown in Table 5 and Figure 2, all four participants demonstrated a substantial reduction in physical reflex responses after receiving the intervention. In addition, the downward pattern of change in physical reflex responses was maintained during the follow-up assessments conducted after the intervention. According to Figure 2, physical reflex response levels remained stable during the baseline phase. Following the introduction of the intervention, an abrupt change occurred in the level and trend of the data during the intervention and follow-up phases for all four participants, based on the data-trend variability analysis presented in Table 6. The direction of the data subsequently shifted toward a reduction in physical reflex responses. Moreover, the results presented in Table 6 indicate that changes in physical reflex responses during the intervention and follow-up phases were sufficient to produce stability in the pattern of change. Furthermore, based on the Reliable Change Index values presented in Table 7, it can be inferred that the changes observed in physical reflex responses were significant for all four participants and that these significant changes were maintained when the follow-up data were included. Because the percentage improvement in physical reflex responses exceeded 50% for most participants during the intervention and follow-up phases, as shown in Table 8, the magnitude of change in physical reflex responses was considered satisfactory. In addition, according to the criteria proposed by Jacobson and Truax (1991), the intervention was classified as relatively successful in improving physical reflex responses because the Reliable Change Index was greater than 1.96 for all four participants. Therefore, based on the analyses conducted, Hypothesis 2, concerning the

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effectiveness of neural repatterning-based therapy in reducing physical reflex responses, was supported.

Overall, the magnitude of change in misophonia symptoms and physical reflex responses was substantial because all four participants demonstrated meaningful treatment-related improvement, as indicated by the downward trajectories of misophonia symptoms and physical reflex responses. The generalizability of the changes was also noteworthy because all four participants reported that their satisfaction with the intervention outcomes progressively increased as the intervention sessions continued. Treatment acceptability was also considerable, as all four participants completed the entire treatment process through the final stage, namely the second follow-up assessment. The intervention was also safe for all four participants because their psychological and physical health was not adversely affected by participation in the intervention sessions; rather, improvements in their health were observed. Furthermore, the changes demonstrated stability, as reductions in misophonia symptoms and physical reflex responses began during the second intervention session and continued through the second follow-up assessment. In addition, according to the conservative dual-criteria method proposed by Fisher et al. (2003), the intervention was clinically significant because of the large number of plotted data points demonstrating improvement among all four participants, specifically the number of intervention-phase data points beyond the criterion established by the final baseline observation.

4. Discussion and Conclusion

The present study examined the effectiveness of neural repatterning-based therapy in reducing misophonia symptoms and physical reflex responses among individuals with misophonia disorder. The findings supported both study hypotheses. Across all four participants, the introduction of the intervention was followed by a clear reduction in misophonia symptoms relative to the stable baseline phases. At the end of treatment, improvement in misophonia symptoms ranged from 59% to 68%, while follow-up improvement ranged from 63% to 75%. The Reliable Change Index values were greater than 1.96 for every participant at both post-intervention and follow-up, indicating that the observed reductions were unlikely to reflect measurement error alone. Visual inspection also showed downward changes in the level and trend of scores after treatment began, and the reductions were generally maintained or strengthened during follow-up. These findings suggest that neural repatterning-based therapy produced both statistically reliable and clinically meaningful changes in the psychological, emotional, and behavioral manifestations of misophonia.

The findings also demonstrated reductions in physical reflex responses to triggering sounds. Improvement percentages at the end of treatment ranged from 44% to 55%, increasing to between 46% and 60% at follow-up. Although the magnitude of improvement varied across participants and was somewhat smaller than the improvement observed for broader misophonia symptoms, the Reliable Change Index exceeded 1.96 for all participants at both assessment points. The data trajectories also shifted downward after treatment initiation and remained lower through the follow-up phase. This pattern is important because physical reflex responses are often described by people with misophonia as rapid, involuntary, and difficult to regulate. The findings therefore indicate that the intervention affected not only consciously experienced distress and behavioral reactions but also bodily responses that may be conditioned to specific auditory triggers.

The reduction in misophonia symptoms is consistent with the broader literature demonstrating that structured psychological interventions can modify the severity and functional consequences of the condition. A randomized clinical trial of cognitive behavioral therapy reported significant improvement in misophonia symptoms and associated impairment, supporting the general proposition that maladaptive responses to trigger sounds are modifiable through systematic psychological treatment (Jager et al., 2020). A subsequent systemic group cognitive behavioral protocol also emphasized psychoeducation, attention modification, arousal reduction, cognitive restructuring, and behavioral practice as central components of treatment (Jager et al., 2022). Neural repatterning-based therapy shares several of these therapeutic elements but places greater emphasis on weakening the learned association between trigger sounds and automatic responses. Thus, the present findings extend previous cognitive behavioral evidence by suggesting that explicitly targeting conditioned neural and physiological patterns may produce meaningful reductions in symptom severity.

The results also align with evidence from transdiagnostic and family-based cognitive behavioral interventions. Pilot work with young people has shown that targeting emotional reactivity, avoidance, cognitive rigidity, and maladaptive coping can reduce misophonia-related distress (Lewin et al.,

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2021). Family-based cognitive behavioral therapy has similarly produced promising changes by addressing both the individual's reactions and interpersonal patterns that maintain symptoms (Dover & McGuire, 2023). Although the participants in the present study were adults and the intervention did not primarily focus on family accommodation, the underlying treatment logic was comparable. Participants learned to identify trigger-response patterns, reinterpret their reactions as conditioned rather than uncontrollable, gradually encounter triggering sounds, and replace avoidance with more adaptive responses. These processes may have enhanced perceived control and reduced the threat value assigned to specific sounds.

The observed improvement may be explained partly through the conditioning framework on which neural repatterning-based therapy is based. Misophonic reactions often occur within seconds of hearing a trigger, suggesting that they are not fully dependent on deliberate cognitive appraisal. Repeated pairing of particular sounds with anger, disgust, anxiety, interpersonal conflict, or physiological arousal may gradually transform neutral auditory stimuli into conditioned triggers. Once this association is established, the sound can evoke an immediate bodily and emotional reaction. The present intervention repeatedly paired triggering sounds, initially presented at low intensity and short duration, with neutral or pleasant sounds, regulated breathing, physical relaxation, supportive self-statements, and a psychologically safe context. Such repeated pairing may have weakened the original association and facilitated the acquisition of a less threatening response pattern.

This interpretation is compatible with neurobiological evidence showing that misophonia is associated with altered activation in the auditory cortex and salience network (Schröder et al., 2019). Heightened salience processing may cause specific sounds to be detected rapidly, prioritized over competing stimuli, and experienced as especially meaningful or threatening. When a trigger repeatedly activates both auditory and salience-related systems, the response may become increasingly automatic. By presenting trigger sounds in a controlled setting while preventing full emotional and physical escalation, neural repatterning may reduce the salience assigned to those sounds. Gradually increasing the volume and duration of exposure may also provide corrective learning that the sound can occur without the anticipated negative consequence.

The reductions in physical reflex responses are particularly consistent with this explanation. Misophonia is not limited to dislike or annoyance; it can involve muscular tightening, chest pressure, changes in breathing, gastrointestinal reactions, autonomic arousal, and an urgent impulse to escape or stop the sound. Psychiatric and audiological research has demonstrated that misophonia has a distinctive pattern of sensory, emotional, and bodily responses that cannot be fully explained by ordinary noise sensitivity or generalized auditory overresponsivity (Siepsiak et al., 2022). Evidence that misophonic reactions are associated with strong emotional responses to other everyday sensory experiences also suggests a broader sensitivity in sensory-emotional processing (Mednicoff et al., 2024). Neural repatterning may therefore have reduced physical responses by repeatedly interrupting the usual sequence from sound detection to autonomic arousal, muscular reaction, emotional escalation, and avoidance.

The improvements can also be understood in relation to attentional mechanisms. Individuals with misophonia may have difficulty disengaging from triggering sounds once they are detected, and this attentional fixation can amplify the perceived intensity and intrusiveness of the stimulus (Frank et al., 2020). Attention, cognitive flexibility, and mental imagery have also been implicated in the exacerbation of everyday sound intolerance (Simner et al., 2021). During treatment, participants were instructed to observe their reactions without immediately acting on them, maintain regulated breathing, attend to neutral or pleasant auditory stimuli, and tolerate brief trigger exposure. These exercises may have increased attentional flexibility by teaching participants that their focus could be shifted or broadened even when a trigger was present. Reduced monitoring of the sound may subsequently have weakened anticipatory distress and prevented escalation.

The findings are also consistent with evidence linking symptom severity to rumination and impaired flexibility. Individuals who repeatedly analyze triggering experiences, anticipate future exposure, or mentally rehearse conflicts related to sounds may maintain distress even after the auditory stimulus has ended (Black et al., 2025). Cognitive support within the intervention addressed negative interpretations such as "I am abnormal," "I cannot tolerate this," or "this reaction cannot change." Replacing these beliefs with the understanding that the response was conditioned and potentially modifiable may have reduced hopelessness and post-trigger rumination. Positive self-statements may also have increased participants' willingness to remain in contact with manageable levels of discomfort rather than escaping immediately.

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Emotional regulation is another plausible mechanism. Misophonia severity has been associated with affective instability and difficulty regulating emotional states (Guetta et al., 2022). Disgust sensitivity and anxiety sensitivity have likewise been identified as vulnerability factors that may intensify reactions to triggers and bodily arousal (Barahmand et al., 2023). Anxiety sensitivity may further strengthen the relationship between misophonia and aggressive reactions because individuals may interpret their own physiological activation as intolerable or dangerous (Schadegg et al., 2021). The intervention included relaxation, diaphragmatic breathing, meditation, cognitive reassurance, and gradual exposure, all of which may have increased tolerance of internal arousal. As participants learned that bodily reactions could rise and then decline without escape or confrontation, the secondary fear of those reactions may have diminished.

The continuation of improvement during follow-up is also noteworthy. For both outcomes, most participants showed further improvement after treatment had ended rather than returning to baseline levels. This finding suggests that participants may have continued applying the acquired skills in their natural environments. Real-world exposure, regular practice with neutral or pleasant sounds, lifestyle regulation, and relapse-prevention planning were included to promote generalization beyond the therapy setting. Continued exposure to daily triggers may therefore have served as an opportunity for further corrective learning. The delayed strengthening of treatment effects is compatible with a learning-based model in which new responses become more accessible and automatic through repeated practice over time.

The results are consistent with studies indicating that exposure can be beneficial when it is carefully graded and embedded within a supportive therapeutic framework. Cognitive behavioral treatment of adolescent misophonia has emphasized that exposure should not consist of overwhelming or forced contact with triggers but should be collaboratively planned and combined with emotional regulation and cognitive preparation (Cecilione et al., 2022). This distinction may explain the acceptability of the intervention in the present study. All participants completed treatment and both follow-up assessments, suggesting that the gradual presentation of sounds did not result in intolerable distress or treatment withdrawal. By beginning with low-intensity stimuli and pairing them with safety, relaxation, and neutral or positive sounds, the intervention may have avoided the invalidating experience sometimes associated with poorly planned exposure.

The present findings also correspond with preliminary evidence for mindfulness- and acceptance-based treatment. Online group interventions using mindfulness, acceptance, and cognitive behavioral methods have been associated with reductions in misophonia symptoms (Ghorbani et al., 2022). In the present protocol, participants were encouraged to notice negative emotions and physical sensations without immediately engaging in avoidance or defensive action. This component may have weakened experiential avoidance and increased willingness to remain in contact with triggers. Acceptance in this context did not mean resignation to symptoms; rather, it allowed the person to experience temporary discomfort while practicing an alternative response. This process may have been especially relevant to the reduction in bodily reflexes.

The results can also be compared with preliminary findings from other individualized interventions. Eye movement desensitization and reprocessing has shown potential in a case series involving individuals with misophonia, particularly where emotionally charged memories or previous adverse experiences were associated with trigger sounds (Jager et al., 2021). Case studies of adolescents have also highlighted the usefulness of individualized assessment, environmental modification, coping-skill development, and graded behavioral practice (Grayless, 2021). These studies, together with the present findings, indicate that successful treatment may require attention to the specific pathways through which triggers acquired emotional significance. Neural repatterning-based therapy may be particularly useful when the dominant clinical feature is an immediate conditioned response rather than prolonged deliberate appraisal.

The reduction in symptoms may additionally have improved participants' functioning and perceived treatment satisfaction. Misophonia can disrupt close relationships, work activities, social participation, and quality of life. In young people, poorer quality of life has been associated with internalizing symptoms and pessimism (Kook et al., 2024), while family accommodation may reinforce avoidance and maintain impairment (Storch et al., 2024). Although functional outcomes and accommodation were not directly measured in the present study, participants reported increasing satisfaction as treatment progressed. This may reflect a growing ability to remain in previously difficult situations, reduced interpersonal conflict, or decreased dependence on avoidance strategies. However, these

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possibilities require direct assessment in future investigations.

The findings should also be interpreted within the broader state of the treatment literature. Systematic reviews have concluded that available interventions are promising but remain limited by small samples, methodological heterogeneity, inconsistent outcome measures, and a shortage of controlled trials (Mattson et al., 2023). Reviews of nonpharmacological interventions have likewise identified cognitive behavioral, mindfulness-based, acceptance-based, sound-focused, and multimodal approaches but have emphasized the need for stronger evidence regarding their active components (Khanmohammadi Otaghsara & Ahmadi, 2023). Patient and clinician perceptions of treatment also vary, particularly concerning the use of exposure and sound-based procedures (Smith et al., 2022). The present single-case findings therefore provide preliminary rather than definitive evidence. Nevertheless, the replication of improvement across four participants, stable baseline patterns, reliable-change values above the clinical threshold, and maintenance at follow-up support further evaluation of neural repatterning-based therapy.

This study had several limitations. The sample consisted of only four participants selected purposively from clinical centers in one city, which limits the statistical and population generalizability of the findings. The absence of random sampling, a control condition, and assessor blinding means that expectancy effects, therapist attention, repeated measurement, and other nonspecific influences cannot be ruled out completely. Outcomes were primarily assessed through self-report instruments and may therefore have been affected by response bias or participants' awareness of the study hypotheses. The follow-up period was relatively limited, and the persistence of improvement over longer intervals remains unknown. The study also did not assess changes in functional impairment, quality of life, family accommodation, interpersonal conflict, or use of avoidance behaviors. Furthermore, treatment fidelity and homework adherence were not quantified independently, and the relative contribution of individual protocol components could not be determined.

Future studies should evaluate neural repatterning-based therapy in larger and more diverse samples and compare it with control conditions, treatment as usual, cognitive behavioral therapy, and other sound-focused interventions. Randomized controlled trials with blinded assessment would provide stronger evidence regarding efficacy. Longer follow-up periods are needed to determine whether treatment gains remain stable and whether booster sessions are necessary. Researchers should include behavioral, physiological, and functional measures in addition to self-report scales, such as autonomic arousal, muscle tension, sound-tolerance tasks, quality of life, occupational functioning, and interpersonal adjustment. It would also be useful to examine potential moderators and mediators, including baseline symptom severity, disgust sensitivity, anxiety sensitivity, emotion-regulation difficulties, cognitive flexibility, attentional fixation, comorbid disorders, and treatment adherence. Component-analysis studies could determine whether counterconditioning, graded exposure, cognitive support, relaxation, or lifestyle regulation contributes most strongly to improvement.

Clinicians working with misophonia should conduct a detailed assessment of auditory triggers, physical reflexes, emotional reactions, avoidance patterns, interpersonal consequences, and co-occurring psychological difficulties before treatment begins. Neural repatterning procedures should be introduced gradually, collaboratively, and within a safe therapeutic environment rather than through intense or involuntary exposure. Trigger sounds should initially be presented at tolerable levels and paired with regulated breathing, relaxation, neutral or pleasant stimuli, and supportive cognitive statements. Therapists should monitor distress continuously, adapt exposure intensity to the individual's response, and avoid interpreting involuntary reactions as resistance or lack of motivation. Treatment should also include structured home practice, lifestyle regulation, real-world generalization, and relapse-prevention planning. Where family members are involved in trigger situations, psychoeducation and guidance may help reduce conflict and prevent excessive accommodation while maintaining empathy and support.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent.

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