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Beyond the Sound: The Role of the Source of Human-Made Trigger Sounds in Misophonia

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ABSTRACT

Introduction: Misophonia is a neuropsychiatric disorder characterised by abnormally extreme reactions to certain sensory stimuli. In this paper, we aimed to investigate the effect of the individual producing the human-generated trigger sound on the level of discomfort reported to the trigger sound. Our hypothesis was that when the misophonic sound is presented with the information that it is produced by a relative, it will create more subjective discomfort than the sound presented with the information that is not produced by a relative.

Methods: This experimental study was conducted with 15 participants aged 18–65 years living in Antalya who volunteered to participate in the study.

Results: In the first comparison, participants reported more subjective discomfort when the voice from the sound bank was presented with the information that it was produced by the relative than when the relative's voice was presented with the information that it was not produced by the relative ($p<0.001$). In the second comparison, participants reported more subjective discomfort when the voice of the relative was presented with the information that it was produced by the relative than when the voice of the relative was presented with the information that it was not produced by the relative ($p=0.001$). In the final comparison, there was no significant difference in subjective discomfort between presenting the voice of the voice bank with the information that it was produced by the relative and presenting the voice of the relative with the information that it was produced by the relative ($p=0.783$).

Conclusion: In conclusion, it seems source of the trigger, especially for human-made sounds, is more important than the trigger sound itself.

Keywords: Misophonia, source, subjective disturbance

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INTRODUCTION

Misophonia is a neuropsychiatric disorder characterised by abnormally extreme reactions to certain sensory stimuli. The term 'misophonia' was coined in the early 2000 s, combining the Greek words *miso*, meaning hatred, and *phonia*, meaning sound, to describe a group of patients who differ from other patients in terms of decreased sound tolerance (1). Individuals with misophonia are often sensitive to sounds that are considered insignificant by other people (2). Triggers in misophonia can be human, such as throat clearing, chewing, slurping, smacking, breathing and gasping are examples of human-induced sounds or environmental sounds (3). The intensity of the emotional response to the trigger is expressed through emotional reactions (anger, anxiety, disgust) and physiological activation (muscle tension, increased heart rate, skin reactions) (4). People who respond to misophonic triggers report difficulty separating their attention from the sounds and negative thoughts, sometimes accompanied by aggressive impulses ('I hate that person' or 'I can' t stand it'). Common behavioural responses include staring at or imitating the person making the sound, verbal agitation or aggression, and rarely physical aggression (5).

Considering current research, Jastreboff et al. (2014) reported that 3% of the general population and 90% of cases of decreased sound tolerance were reported to have misophonia. In another study, it was observed that 20% of the participants had clinically significant symptoms of misophonia (6). In the study conducted by Naylor et al. in 2021 with medical students in the United Kingdom, approximately 49.1% of the participants were found to have clinically significant misophonia (7). In a study conducted in Türkiye, the prevalence of misophonia was found to be 12.8% and it was observed that only 5.8% of the participants sought help (8). There are also studies suggesting that misophonia may be genetically transmitted. In one study, a total of 15 people in 3 generations of the family studied had

Highlights

- **Sound bank voice as a relative's voice is more disturbing than their voice as another's.**
- **Relative's voice as itself is more disturbing than as the voice of someone else.**
- **Sound bank voice as a relative's voice is not more disturbing than their own voice.**

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symptoms of misophonia. This has led to the discussion that misophonia may be genetically transmitted of (9). In a study of approximately 500 participants who met the criteria for misophonia, it was found that 33% of participants had a family history of misophonia (10).

Studies have suggested that misophonia is not caused by a pathology related to audiological problems, but that abnormal processes occur because of increased or strong connections in the limbic and sympathetic nervous systems that occur when exposed to trigger sounds (11,12). The study in which Kumar et al. addressed the neurological processes in the aetiology of misophonia suggested that it may be a neurological disorder (13). They also investigated which regions of the brain may be associated with the triggering sounds in misophonia. Based on their functional magnetic resonance imaging (fMRI) results, it was suggested that misophonia may be associated with increased activity in the anterior insular cortex and regions associated with the processing and regulation of emotion, including the ventromedial prefrontal cortex, amygdala, posteromedial cortex, and hippocampus. It has also been reported that when misophonics are exposed to triggering sounds, they exhibit high autonomic responses, such as increased heart rate, and the anterior insular cortex plays a mediating role in this situation. Another study investigating the neurobiological processes of misophonia found that the volume of the right amygdala was larger in misophonics, and the connection between the left amygdala and the cerebellum was increased. The reason for all this is thought to be increased emotional reactivity, physical responses to triggers and the effect of visual triggers. In other words, it has been suggested that there are abnormalities including emotional and attentional dysfunction in misophonia (14).

A review of the studies shows that the onset of the participants' symptoms was in childhood and adolescence. In the study by Schröder et al. (2013), the average age of onset of the participants was 13 years (15). In another study, 80% of participants reported that their symptoms started in pre-adolescence. These participants mostly reported that their symptoms started in childhood, when they were disturbed by the sounds made by family members while eating (16). Furthermore, in some studies, participants stated that the sounds that disturbed them were of human origin (such as family members with whom they had a close relationship), that they were not affected by their own sounds or animal and baby sounds, and that they were sometimes even disturbed by their own inner voices (2,15,17). However, there is no empirical study that investigates the statement pointing out "If the source of the trigger is someone who is close to (18) the misophonic, it generates more disturbance". The most recent study pointing to this statement is the study presented by Natalini et al. where three cases were presented in which maladaptive schemas and personality were examined in misophonia. In two of these cases, it was observed that, in one of them, the feeling of discomfort was reduced when he realised that a pigeon was making the noise; in both, the state of their relationship with their partner influenced the feeling of discomfort related to the misophonia.

In this paper, we aimed to investigate the effect of the person producing the human-generated trigger sound on the level of discomfort reported to the trigger sound. Our hypothesis was that when the misophonic sound is presented with the story of the voice of the relative, it will create more subjective discomfort than the sound presented with the story of not being the voice of the relative.

METHODS

Participants

This experimental study was conducted with 15 participants aged 18–65 years living in Antalya who volunteered to participate in the study. A power analysis was conducted via G*Power 3.1.9.7. With 0.05 alpha error and 0.9 effect size, the sample size was calculated as 16. However, the sample size was determined in line with the recommendations of Cohen (2013), in which at least 15 participants are needed for an experimental study (19). In addition, all participants were informed about the study and their written informed consent was obtained. The participants were given the socio-demographic information form, A-MISO-S (Amsterdam Misophonia Scale) and Misophonia Questionnaire (MQ). Inclusion criteria were as follows: being an individual between the ages of 18–65, having moderate and high scores on the MQ and A-MISO-S, not having a neurological disorder, not having a severe psychiatric disorder such as schizophrenia spectrum disorder, bipolar spectrum disorder, and volunteering to participate in the study.

Measurement Tools

The subjects who participated in the selection/acceptance phase of the study were given an 'informed consent form' before the study began and were asked to confirm that they were participating in the study voluntarily. The MQ and the A-MISO-S were completed online for subject selection/acceptance, and those who met the inclusion criteria completed them again by hand with other scales before the experiment.

Socio-demographic information form

The socio-demographic information form we used in our study included questions about gender, education level, employment status, occupation, marital status, whether they had children, whether they were taking medication, and whether they had a psychiatric disorder. This form was completed jointly by the participant and the clinician.

Amsterdam misophonia scale (A-MISO-S)

An adapted version of the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS), which has been adapted for various conditions and is mostly used to measure OCD, was developed by Schröder et al. (2013) to measure the severity of misophonia (15). The Turkish validity and reliability study was conducted by Sarıgedik and Gülle in 2021. As a result of the study, it was found to be valid and reliable above the age of 15 (20). This Likert-type scale (range 0–24), consisting of 6 sub-domains, measures 1) the amount of time patients spend with misophonia; 2) its impact on social functioning; 3) the level of anger; 4) the level of resistance to impulses; 5) how much control they have over their thoughts and anger; 6) the amount of time they spend avoiding misophonia situations. A score of 0–4 is given for each item. Scores between 0–4 are considered subclinical, between 5–9 as mild, between 10–14 as moderate, and between 15–19 as severe, between 20–24 as extreme.

Misophonia questionnaire (MQ)

The MQ developed by Wu et al. (2014) and adapted into Turkish by Sakarya and Çakmak (2022), aims to measure the symptoms of misophonia and the emotions and behaviours that occur when encountering the triggering sound (6,21). The scale is divided into 2 factors. The first factor examines the presence of symptoms of misophonia and consists of 7 statements. The items are answered on a 5-point Likert scale ranging from 'definitely not true' [0] to 'always true' [4]. The second factor measures the emotions and behaviours experienced when encountering the trigger sound and consists of 10 items. These items are answered on a 5-point Likert scale ranging from 'never' [0] to 'always' [4]. The scale is scored by looking at the responses to a total of 17 statements in these two factors. The total scale score ranges from 0–68. As the scale score increases, it is assumed that there is an increase in the frequency of misophonia symptoms and the negative emotions and behaviours developed by the person in response to them. In the last part of the scale, the patient is asked to select the number and degree of sounds to which he/she is sensitive, and how much they interfere with his/her daily life, on a scale of '1–15' . This section provides information on the severity of the misophonia and is not

included in the factor structure or scoring. In this section, scores of 7 and above indicate clinically significant misophonia.

Procedure

Ethical approval was obtained from the Social and Human Sciences Ethics Committee of Antalya Bilim University before the study started (Approval No: 2023/25). All volunteers who met the inclusion criteria and agreed to participate in the study were explained the tests to be applied and the experimental procedure in detail and their written consent was obtained. The Sociodemographic Data Form, A-MISO-S and MQ were administered to all volunteer participants.

The experimental phase started with individuals with moderate and high scores on the A-MISO-S and MQ. Participants were contacted using the contact details provided in the socio-demographic information form they had filled in and were first asked to record for at least 20 seconds the triggering sound of their relative that disturbed the participant the most, in a place with as little external noise as possible. After the participants transmitted the sound, the sounds were processed using the Apple Inc. IMovie application on the Apple Inc. Macbook Pro computer used by the researcher and ByteDance Capcut application on A. Ş. Acer computer, and the triggering sound was amplified to minimise the possibility of the participant recognising the sound and giving a biased response. In terms of the content of the sounds obtained from the participants, 12 of them were the slurping sound when chewing food and 3 of them were the crunching smacking sound when eating a food such as chips and crackers. Due to the different sound contents, 1 sound of the slurping sound when chewing food and 1 sound of the crunchy smacking sound when eating a food such as crisps and crackers were selected as fixed sounds, like the sound contents obtained from the participants in the ByteDance Capcut application, to be listened to while presenting a false story. In addition, in order not to increase the clients' discomfort and to provide an objective measure, the sound of water was selected and listened to from the Spotify AB application as a neutral sound before listening to each triggering sound. 5 repetitions of breathing exercises were performed, and 5-minute breaks were taken between the sounds for relaxation. The interviews were conducted in the same room for each participant, creating the same experimental environment and using the same materials (computer, headphones). The applications were conducted in a quiet and normally lit room, with the participant and researcher sitting opposite each other and the computer facing the researcher. Subjective levels of discomfort were measured verbally using the VAS scale (Figure 1).

Experimental Design

Participants were exposed to a 3-step experimental procedure. The experimental set-up was performed in the same order and in the same way for each participant. The participant and researcher were seated at a desk facing each other, with the computer screen facing the researcher. The participant wore a pair of Apple Inc. AirPods headphones. The misophonic trigger sounds transmitted by participants, neutral and constant sounds selected by the researcher were presented through the headphones at 75% of the computer volume.

An individual trial started with 5 repetitions of breathing exercises before the trigger sounds and stories were presented and the neutral voice was played for 1 minute. The voice from the sound bank is presented to the participant as the voice of a relative and listened to for 20 seconds, and the subjective level of discomfort at this time is measured and recorded on a VAS scale between 1 and 10. The participant is made to listen to the neutral voice for 1 minute with 5 repetitions of breathing exercises and a break of 5 minutes. The voice of a relative is presented as someone else's voice and listened to for 20 seconds, and the subjective level of discomfort at this time is measured and noted on a VAS scale between 1 and 10. The participant is made to listen to the neutral voice for 1 minute by performing 5 repetitions of the breathing exercise, and a break of 5 minutes is taken. The voice of the relative is presented as the voice of the relative and listened to for 20 seconds, and the subjective level of discomfort at this time is measured and noted on a VAS scale between 1 and 10. The participant is made to listen to the neutral voice for 1 minute with 5 repetitions of breathing exercises, and the application is terminated after 5 minutes. A representative version of the experimental set-up is shown in Figure 1. Participants were informed in advance that a subjective discomfort rating of '1' on the VAS scale indicated little or no discomfort, whereas a rating of '10' indicated extreme discomfort, a strong reaction that they wanted to avoid or could not tolerate.

Statistical Analysis

Frequency and descriptive analysis were conducted for socio-demographic variables and scale scores. To investigate differences between VAS scoring belonging to each experimental phase, the Wilcoxon Signed-Rank Test was used. The confidence interval in the study was 95%. For this reason, the Type-1 error level was used and evaluated as 5%; $p<0.05$ indicates significance. For analysis, IBM Statistical Package for Social Sciences (SPSS) program version 22.0 was used.

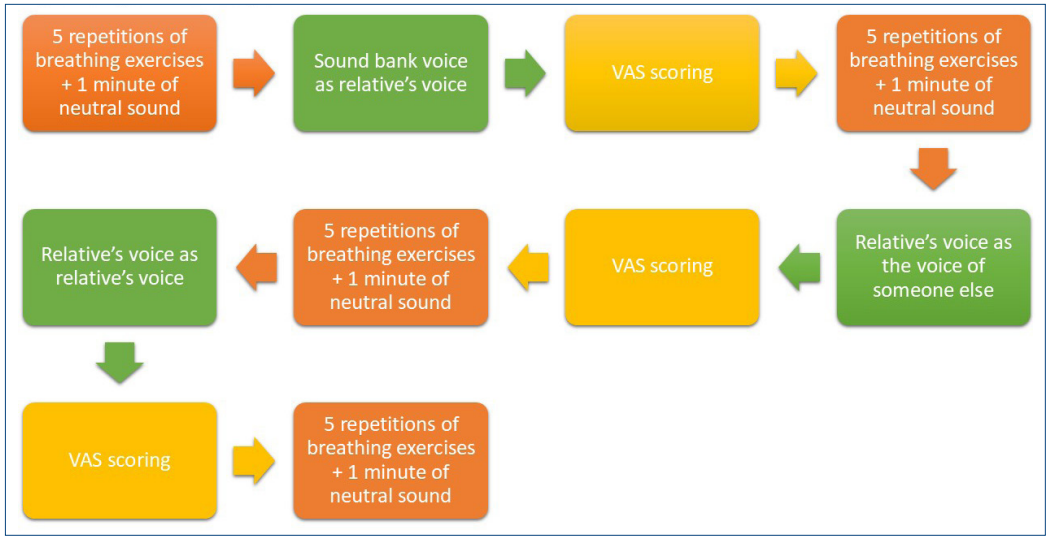

Figure 1. Experimental Desing

RESULTS

Socio-demographic variables are presented in Table 1. Data-related scale scores and VAS scoring are exhibited in Table 2.

There was no significant difference between genders (respectively p=0.840; p=0.840), educational status (p=0.448; p=0.536), marital status (p=0.859; p=1.000), occupational status (p=0.056; p=0.104), having children (p=1.000; p=0.840), psychiatric disorder (p=0.463; p=0.281) and medicine usage (p=0.136; p=0.295) in terms of A-MISO-S and MQ scores.

Comparison 1: *Sound bank voice as relative's voice vs. relative's voice as the voice of someone else*

As the result of the Wilcoxon Signed rank test for the comparison of disturbance levels between sound bank voice as the relative's voice and the relative's voice as the voice of someone else, participants reported significantly higher subjective disturbance level to sound bank voice as the relative's voice (p<0.001, Z=-3.482).

Comparison 2: *Relative's voice as relative's voice vs. relative's voice as the voice of someone else*

In the second comparison, the subjective disturbance level was significantly higher to the relative's voice as the relative's voice in comparison with the relative's voice as the voice of someone else (p=0.001, Z=-3.472).

Table 1. Socio-demographic variables

Variables	N / Mean	% / SD
Gender		
Female	12	80
Male	3	20
Age	29.53	5.66
Educational status		
University	12	80
Above university	3	20
Occupational status		
Employee	11	73.3
Unemployed	4	26.7
Marital status		
Married	5	33.3
Single	10	66.7
Having children		
Yes	3	20
No	12	80
Psychiatric disorder		
Yes	7	46.7
No	8	53.3
Medicine usage		
Yes	3	20
No	12	80

Table 2. Scale scores

	Median	Min	Max
A-MISO-S	15	13	20
MQ	46	41	66
VAS 1	8	6	10
VAS 2	5	2	7
VAS 3	8	7	10

A-MISO-S: Amsterdam misophonia scales; MQ: misophonia questionnaire; VAS 1: disturbance from sound bank voice as relative's voice; VAS 2: disturbance from relative's voice as the voice of someone else; VAS 3: relative's voice as relative's voice.

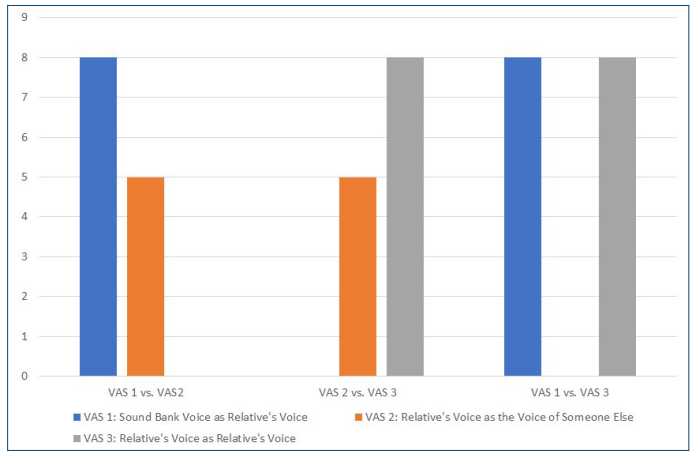

Figure 2. Comparison of the Medians of Subjective Disturbance Levels Towards Three Sounds

Comparison 3: *Sound bank voice as relative's voice vs. relative's voice as relative's voice*

In the final comparison, it was detected that there was no difference between subjective disturbances to sound bank voice as the relative's voice and the relative's voice as the relative's voice (p=0.783, Z=-0.276).

All three comparisons are presented in Figure 2.

DISCUSSION

In this study, we only focused on one single hypothesis. The hypothesis is that when the misophonic trigger is presented with the information of a relative's voice, it will cause more subjective discomfort than the voice presented with the information of a non-relative's voice. The results of the analysis confirmed this hypothesis.

The results of the study by Edelstein et al. (2020), in which they investigated the influence of context on the way misophonic react to voices, showed that the source of the misophonic trigger plays an important role. Schröder et al. (2013) reported that animal or infant sounds are generally less disturbing than adult human sounds. Not only did the study show that human eating sounds were generally perceived as significantly more annoying than animal non-eating sounds for misophonic, but it also showed that the interpretation of these sounds can significantly influence how annoying they are perceived to be. In the present study, significant differences were found between the subjective discomfort scores of subjects who thought the voice source was not their relative, even when it was not their relative, and the subjective discomfort scores of subjects who thought the voice source was someone else's voice, even when it was their relative. This finding suggests that the source of the voice is more important than the trigger sound itself.

Research on misophonia shows that people feel more uncomfortable with the sounds made by their relatives and that they cause more discomfort (2,15,17). In the study conducted by Schröder et al. (2013), it was found that the misophonic responses were more intense, especially to the sounds made by family members. At this stage of the current study, results have been obtained that support the previous studies and this discourse of patients with misophonia. The factor that should be considered here is not who the source of the misophonic sound is, but who the patient perceives the sound to be.

The existing literature states that the context is more important than the structural characteristics of the misophonic trigger. Although it has been stated by experts in the field that who produces the sound within the

context is also important, there has been no objective data beyond an interpretation of the patients' statements. In this study, we aimed to reveal this subjective statement in an experimental setting. In accordance with the hypothesis, the discomfort felt was greater when it was presented in the story that the sound was produced by the relative, regardless of the sound itself. This finding shows us that misophonia is more than just exposure to so-called triggering sounds. Misophonia patients react more intensely when a relative makes the sounds or when they realise that they cannot get away from these sounds (17). At the same time, there are also patients who state that the sounds are made deliberately to disturb them and even report that their discomfort increases when they believe this (18). Again, in a study conducted by Edelstein et al. in 2013, 80% of the participants stated that their first symptoms began in childhood, when they were disturbed by the sounds made by family members during meals. Putting all this information together, it can be thought that the condition may have arisen because of interactions with family members during childhood, and that in subsequent periods, relationship problems with that family member may manifest themselves through misophonic responses. In other words, it is thought that in addition to sensory sensitivity to the triggering sound, there is a matching of negative feelings towards the family member who made the triggering sound.

When we look at the neurobiological part of the pairing of negative emotions with misophonic trigger sounds and the reactions that occur when exposed to the trigger sound, it is necessary to mention the amygdala in the structure of the limbic system. Sensory stimuli arriving at the thalamus go to the amygdala on the short pathway and to the sensory cortex on the long pathway, and sensory responses are generated. In other words, the amygdala evaluates incoming stimuli (22). The amygdala system is faster. The amygdala is an important structure for the emergence and learning of the fear response and related emotional processes. The amygdala is stimulated in situations of fear, stress, or anxiety (23). Once stimulated, the central nucleus of the amygdala stimulates many centres via glutamate. In other words, the amygdala helps to recognise these situations to avoid situations that are mapped as dangers that may reappear in evolutionary processes related to survival from the past to the present. However, because of these mappings, it is said that it can re-enact the traumatic experience if there are no triggering factors and cues to remind it of the traumatic event (24). This re-experiencing leads to avoidance. Looking at misophonia from this perspective, the amygdala can be thought of as negatively mapping the traumatic and/or dangerous situation for misophonics. In this context, for a misophonic who expresses that he is more disturbed by his family members, especially the sound of his relative's mouth spluttering affects him badly, considering the amygdala's relationship with unconscious processes and the automatic reactions it gives, it can be thought that the mapping after the negative experience he may have had with his relative is actually paired with the normal sound, resulting in a reaction and avoidance. In the context of this study, it can be argued that the fact that the participants were more disturbed when they heard the sound source because they thought it was a close person may be related to the stimulation mechanism and negative mapping of the amygdala, and the fact that they were less disturbed by people outside may also be related to the emotional mapping in the amygdala.

The function of the amygdala is controlled by the hippocampus and the prefrontal cortex (PFC). Considering the relationship between the amygdala and the hippocampus, the hippocampus is responsible for regulating the stress response triggered by the amygdala, if the hippocampus can function properly, the stress response can be stopped, but prolonged stress can impair the functioning of the hippocampus (25). The hippocampus is known to be effective in memory and almost all sensory stimuli such as sight, hearing and smell activate the hippocampus, especially in recent studies (26). This connection between the amygdala and the hippocampus makes us think that the state of being more disturbed by relatives' voices in misophonia may be the negative form of a mechanism such as "the effect of the good affect that occurs when a positively mapped recognised sound or smell is perceived on the formation of good affect when similar sounds or smells are perceived". In other words, it should be discussed that the hippocampus may be disrupted in its relationship with the amygdala as a result of prolonged exposure to stressful events, and that when the triggering sound is exposed, negative past life experiences are recalled from the hippocampus with the unconscious effect, and now automated sensory responses are produced by the amygdala, and that this may be the reason why misophonics feel more uncomfortable when they hear the source of the sound, thinking it is a relative. In addition, smacking one's mouth while eating is a sign of appreciation in some societies, but an unwelcome behaviour in others. If we look at the research on mouth smacking, which is considered normal in China, we find findings related to misophonia (27). This further supports the idea that misophonia may be related to the negative mapping of sounds, regardless of the environment.

Another neurobiological explanation for our results could be attained from the study conducted by Kumar et al (28). In this study, authors indicated that misophonia could be hyper-mirroring of the orofacial action of others and they observed stronger activation of the orofacial motor area in response to trigger sound and stronger resting state fMRI connectivity between both visual cortex and auditory cortex and the ventral premotor cortex responsible for orofacial movements. In our study, all the participants brought us an orofacial action-related trigger sound in the misophonia group. When we gave them sound with the information that 'This sound was produced by your relatives' , this statement could stimulate participants to image visually their relatives while they are producing the trigger sound.

As a result of the findings, it was observed that the discomfort of hearing the sound source as a relative of the patient with misophonia, even if the sound source is not a relative of the patient with misophonia, is higher than the discomfort that occurs when the sound source is a relative of the patient with misophonia and is perceived as a different sound source. Looking at the psychological interpretation of the neurobiological interpretation, one study found that after exposure to the triggering sound, misophonics had discourses such as "why am I like this? The people making the sound are very inconsiderate and rude, I hate them, I want to hurt them, they could have been more considerate" (16). Taking these discourses into account, it can be suggested that when it comes to misophonic triggers, patients with misophonia use projection and displacement defence mechanisms and associate them with sound.

There are several limitations to the study. The first limitation of the current study is that the participants were selected from people with moderate and high levels of misophonia. As the level of discomfort in misophonia increases, so does avoidance. In the experiment, some of the misophonics who were told they would be exposed to the trigger sound refused to take part in the study. It was therefore difficult to find participants. Another limitation of the current study is the measurement of subjective discomfort scores saying that the first story presented to the participants was "the sound of the sound bank, the sound of a relative – the sound of a relative, the sound of someone else". Although it is taken into account that the participant, who already knows that he/she is disturbed by his/her relative at the beginning of the study, is honestly reporting the scores, psychological bias may be an issue. However, it is believed that this limitation is minimised by the model used in the study. Another limitation is that the participants were not asked whether the sound of water, which was used as a neutral sound, was neutral for them. This sound was selected from the sound list in the study of Kumar et al. (28). However, no participant reported any discomfort after neutral sound exposure during the study. Added to this we did not evaluate

factors which are observed as variables increasing the irritability of the participants such as smoking, fasting, caffeine consumption etc. Finally, Participants' subjective level of discomfort was assessed using the VAS scale, and the physiological response was not measured objectively.

In conclusion, it seems the source of the trigger, especially for human-made sounds, is more important than the trigger sound itself. These data show that misophonia is a neuropsychiatric disorder that is more than an exaggerated negative response to certain sounds. With better experimental design, a larger sample and the addition of physiological measurements or fMRI, our findings will be taken further.

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Ethics Committee Approval: Ethical approval was obtained from the Social and Human Sciences Ethics Committee of Antalya Bilim University before the study started (Approval No: 2023/25).

Informed Consent: All volunteers who met the inclusion criteria and agreed to participate in the study were explained the tests to be applied and the experimental procedure in detail and their written consent was obtained.

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