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Mechanisms and Research Progress of Personalized Music Therapy in the Treatment of Tinnitus

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Abstract

Personalized music therapy has shown promising application prospects in the management of tinnitus. Although domestic and international scholars have discussed related literature on music-based interventions, the mechanisms, specific methods and research progress of personalized music therapy have not been described in a systematic and detailed way. In view of this gap, this article reviews several main approaches that use personalized or individualized sound and music in tinnitus treatment, including neuromonics tinnitus therapy, tailor-made notched music training, phase-shift treatment, the Heidelberg model of music therapy, and Traditional Chinese Medicine (TCM) five-tone therapy. It also briefly introduces our department's practical experience with using natural sound for non-masked sound therapy in idiopathic tinnitus. We hope this review will provide a useful reference for further research and clinical application of music therapy for tinnitus.

Keywords: tinnitus; personalization; music therapy

1. Introduction

Subjective tinnitus refers to a subjective auditory perception arising in the ear or head in the absence of any external acoustic or electrical stimulation. With the rapid development of

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modern society, mental stress has increased, environmental noise pollution has become more serious, and both population ageing and the "younger onset" trend of tinnitus have become more evident. As a result, the prevalence of tinnitus has been rising year by year.

Epidemiological investigations from other countries report that the prevalence of tinnitus in the adult population ranges from 4.4% to 15.1%, among whom 1%–3% experience a severe impact on quality of life, often accompanied by irritability, insomnia, anxiety, depression and, in some cases, even suicidal ideation (Hoffman & Reed, 2004). A 2017 epidemiological survey of tinnitus among 1,748 individuals undergoing routine physical examination in Dalian, China, found an overall prevalence of 32.4% (566/1748; Hong et al., 2017).

Because the etiology and pathogenesis of tinnitus remain uncertain, there is still a lack of universally effective and evidence-based treatment options. However, a review of recent domestic and international literature suggests that, compared with other approaches, sound-based therapy has been widely used in clinical tinnitus management. The 2014 *Clinical Practice Guideline: Tinnitus* from the United States also recommends sound therapy as a treatment option.

Among the various sound-based methods, masking therapy and tinnitus retraining therapy (TRT, a representative partial-masking habituation protocol) are currently recognized as effective. Yet both approaches have limitations. Feldman reported that masking is ineffective in patients whose psychoacoustic masking curves show "separated" or "non-maskable" types when any kind of noise is used; although habituation-based therapy can be applied to all tinnitus patients, it usually requires a long treatment period, and many patients have difficulty maintaining adherence.

With advances in medicine and digital technology and the introduction of the concepts of precision medicine and personalized care, researchers worldwide have developed individualized music and sound therapy protocols tailored to different types of tinnitus. This review summarizes the mechanisms and recent research progress of several representative personalized music therapies for tinnitus.

2. Neuromonics Tinnitus Therapy

Neuromonics tinnitus therapy (NTT) mainly consists of structured tinnitus counseling combined with individualized music stimulation. The method was first proposed by Davis in Australia in 1996. In NTT, customized music replaces traditional broadband noise masking. By using intermittent music stimulation to dynamically mask the tinnitus signal, the therapy seeks to reduce a patient's sensitivity to tinnitus and their emotional distress.

The personalized music used in NTT is designed according to each patient's audiogram.

The frequency spectrum is modified to compensate for hearing loss and to ensure broad frequency coverage (up to approximately 12.5 kHz), so that the corresponding auditory neurons can all receive relatively balanced stimulation. At the same time, relaxing music is selected, with tempo matched to the resting heart rate (about 60–80 beats/min), in order to help patients reach an optimal state of relaxation and thereby attenuate maladaptive interactions between the auditory system, limbic system and autonomic nervous system.

Since 1996, Davis and colleagues have conducted three clinical trials involving around 110 patients (Davis et al., 2007, 2008). In the first trial, 30 patients were alternately assigned to a music group and a noise group and received either personalized music or white noise for 7 months. The results showed no significant difference in overall efficacy between the two groups, but the music group reported better relaxation. Moreover, after the study ended, the investigators found that patients whose tinnitus was not fully masked achieved longer-term improvement in tinnitus-related distress.

To verify this observation, a second clinical trial was conducted in 2002. Fifty patients were randomly allocated to four groups: (1) personalized music with complete masking, (2) personalized music with intermittent masking, (3) white noise with partial masking, and (4) counseling only. All four groups received the same tinnitus counseling. After 12 months of treatment, the improvement in Tinnitus Reaction Questionnaire (TRQ) scores in the two personalized music groups (66%) was significantly greater than in the non-music groups (22% and 15%). The music groups also showed greater improvements in anxiety level, tinnitus severity, relaxation, minimum masking level and loudness than the white noise partial-masking and counseling-only groups. Among the music groups, the intermittent masking protocol showed particularly marked improvement compared with non-music groups.

Based on earlier findings that many patients in the complete-masking group gradually reduced the intensity of music stimulation (transitioning to intermittent masking) and reported even better improvements, the authors designed a third clinical trial. Thirty-five patients were randomized into an intermittent-masking group (personalized music for 6 months) and a mixed group (complete-masking treatment with personalized music plus broadband noise for 2 months, followed by 4 months of intermittent masking with personalized music). After 6 months, 91% of patients had at least a 40% reduction in tinnitus-related interference, with the greatest improvement occurring during the first 2 months. At the end of treatment, both groups showed significant improvements in irritability, tinnitus-related cognition, minimum masking level and loudness discomfort level, with a slightly better outcome in the mixed group, although the difference between groups was not statistically significant.

A multi-center clinical study involving nine institutions further confirmed the feasibility and effectiveness of neuromonics tinnitus therapy (Wazen et al., 2011). However, NTT is not suitable for all types of tinnitus. In a cohort study of 552 tinnitus patients, Hanley et al. (2008) found that neuromonics therapy produced the best outcomes in patients with monotypic tonal tinnitus and idiopathic tinnitus with hearing loss $\leq$ 50 dB; more than 92% of such patients experienced at least a 40% reduction in tinnitus-related interference, with an average improvement of 72%.

3. Tailor-Made Notched Music Training

Tailor-made notched music training (TMNMT) is based on the "central gain" and lateral inhibition theories of tinnitus. According to these models, tinnitus arises because cochlear damage and deafferentation of auditory nerve fibers lead to maladaptive neural plasticity and aberrant cortical reorganization in the auditory cortex. When hearing is normal, auditory neurons not only transmit excitatory signals to higher-order neurons but also exert lateral inhibition on neighboring neurons. This lateral inhibition contributes to a balanced representation of frequencies (Diesch et al., 2010; Noreña, 2011).

When hearing loss occurs, neurons in the auditory cortex do not simply disappear; instead, they lose input from the cochlea and thus provide less lateral inhibition to adjacent frequency channels. Neurons in the deprived frequency region, especially at the borders of the hearing-loss area, begin to respond to inputs from non-deprived frequencies. At the same time, weakened lateral inhibition and changes in neuronal sensitivity can increase central gain and lead to excessive representation of edge frequencies. Enhanced spontaneous firing and synchronous activity of neural populations above the perceptual threshold may then be perceived as tinnitus (Noreña, 2011).

If this mechanism is indeed involved in tinnitus generation, then increasing lateral inhibition to the overactive neurons might help suppress tinnitus. TMNMT aims to achieve this by applying a "notch filter" centered on the tinnitus frequency. Music is digitally processed so that a specific frequency band around the individual tinnitus pitch (often a half or one octave wide) is removed. When patients listen repeatedly to this notched music, neurons coding for adjacent frequencies are stimulated, whereas neurons coding for the tinnitus frequency receive little or no input, thereby enhancing lateral inhibition onto tinnitus-related neurons.

Experimental studies have shown that notched noise processed through a band-stop filter can suppress neural activity in the auditory cortex corresponding to the notched frequency band (Pantev et al., 1999). Moreover, frequency tuning is one of the fundamental properties of auditory neurons. With long-term listening to notched music, neurons representing frequencies adjacent to the notch may shift their tuning toward the notched region and exert stronger lateral inhibition on tinnitus-related neurons, while the tinnitus-frequency neurons receive less excitatory input. In this way, notched music training may reduce the hyper-excitability and/or abnormal synchronous activity of cortical neurons coding the tinnitus frequency, and gradually reverse maladaptive neural plasticity.

Animal experiments have also shown that amplifying the spectral energy around the edges of a notch can significantly suppress responses at the notch center frequency (Catz & Noreña, 2013). Clinically, Stracke et al. (2010) and Okamoto et al. (2010) conducted year-long TMNMT interventions in tinnitus patients and found significant reductions in tinnitus loudness in the treatment groups. Auditory steady-state responses and N1m results indicated that tinnitus-related neural activity in the temporal auditory cortex was significantly reduced after treatment.

It appears that TMNMT may operate via two complementary mechanisms. On the one hand, prolonged listening to notched music effectively deafferents the tinnitus-frequency channel, transiently blocking input to the corresponding cortical neurons and thereby decreasing their excitability. On the other hand, neurons at the edges of the notch receive stronger stimulation from the enriched music, which enhances lateral inhibition onto tinnitus-frequency neurons.

The effectiveness of TMNMT is related to the tinnitus frequency range. Teismann et al. (2011) conducted a 5-day intensive TMNMT program in 20 patients with chronic tinnitus and hearing loss $\leq$ 50 dB HL. The results showed that patients with tinnitus frequencies below 8 kHz experienced significant reductions in tinnitus loudness, tinnitus-related distress and tinnitus-related cortical activity, whereas patients with tinnitus frequencies above 8 kHz showed no obvious change. This may be because musical signals contain relatively less high-frequency energy and the human cochlea is less sensitive to very high frequencies (Fastl & Zwicker, 2007).

The efficiency of lateral inhibition also depends on the width of the spectral notch. Earlier studies reported that removing one octave or half an octave around the tinnitus frequency was effective for tinnitus patients (Stein et al., 2015). In healthy participants, Okamoto et al. (2005) compared notched broadband noise with notch widths of one octave, half an octave, and a quarter octave, and found that the N1m amplitude decreased significantly after stimulation with half- or quarter-octave notches compared with the one-octave condition. Clinical research (Wunderlich et al., 2015) similarly showed that three different notch widths (one octave, half an octave, and quarter octave) all reduced tinnitus distress and tinnitus-related neural activity after three months of TMNMT, with the half-octave notch producing the greatest improvement on a global clinical rating scale. A notch width of one-eighth octave appears to be a critical limit; narrower notches no longer enhance lateral inhibition.

In general, TMNMT requires at least three months of training before tinnitus loudness shows a clear and stable reduction (Stein et al., 2016).

4. Phase-Shift Treatment for Tinnitus

Phase-shift treatment was proposed by Choy at the 2004 New York Academy of Medicine conference. The basic idea is to deliver an external sound wave with the same frequency and intensity as a patient's tonal tinnitus but with a phase shift of 180 degrees, so that the two waveforms cancel each other, thereby eliminating cortical perception of tinnitus. The theoretical essence is to prolong the duration of residual inhibition. In principle, this approach is similar to the active noise cancellation principle used in noise-canceling headphones.

The waveform of a tonal tinnitus can be approximated as a sinusoidal wave that describes the frequency and intensity of the tinnitus. However, the exact temporal and spatial trajectory of tinnitus perception is not fully understood, making it difficult to generate a perfectly opposite-phase sound. Therefore, in practice, a tinnitus-matching sound whose phase is continuously shifted at a certain rate (e.g., 60 degrees per 30 seconds) is used instead. After 30 minutes of stimulation, the tinnitus percept is theoretically expected to be suppressed for about 10 minutes.

Lipman and Lipman (2007) conducted a four-week study in 61 patients with predominant tonal tinnitus. For the first two weeks, patients received sound stimulation using their individually matched tinnitus frequency and intensity; for the subsequent two weeks, they received phase-shift treatment. The stimulation was delivered three times per week, 30 minutes per session. The results showed that 37% of patients had a one-grade reduction in Tinnitus Handicap Inventory (THI) scores, and 5% had a two-grade reduction. Fifty-seven percent of patients reported a tinnitus loudness decrease of more than 6 dB, and 42% experienced complete residual inhibition lasting from 1 hour to 7 days (mean 2 days).

In another study, Choy et al. (2010) compared three sound types (a pure tone at 1,000 Hz, 77 dB; a tinnitus-matched pure tone at 77 dB; and phase-shifted stimulation) in 35 tinnitus patients who had failed other treatments. Each sound was delivered for 30 minutes. The proportions of patients who experienced a loudness reduction of at least 6 dB were 24%, 27%, and 82%, respectively. To further verify these findings, the research team conducted a multi-center clinical trial at six centers in the United States, Europe, and Asia. Using a reduction of at least 6 dB in tinnitus loudness as the criterion for effectiveness, 301 of 493 patients (61%) responded to phase-shift therapy, with center-specific response rates ranging from 49% to 72%. Residual inhibition lasted 3–43 days, which is substantially longer than the typical duration achieved with masking or habituation-based methods.

These results suggest that phase-shift treatment can produce robust and long-lasting reductions in tinnitus loudness. However, at present, this approach is mainly applicable to patients with relatively stable, monotone tinnitus.

5. Heidelberg Model of Music Therapy

The Heidelberg model of music therapy (HMMT) was first proposed in 2004. This neuro-music therapy combines psychological regulation with targeted remediation of maladaptive neural plasticity in both lemniscal and non-lemniscal auditory pathways. The protocol consists of four modules.

Counseling

Through guided counseling, patients are helped to develop an appropriate understanding of tinnitus, including its mechanisms and benign nature. The principles of music therapy are explained, and the clinician systematically reviews the patient's medical history and medication use, answers questions, and uses a sinus tone generator to help patients identify a tone that subjectively resembles their tinnitus.

Resonance training

Patients perform vocal exercises to stimulate resonance in the cranial and cervical cavities (typically about 3 minutes per hour). The goal is to increase blood circulation in tinnitus-related brain regions and to indirectly stimulate auditory pathways via somatosensory input. The brain processes somatosensory and auditory stimuli through multiple cross-modal pathways. Many patients can change their tinnitus perception by clenching their teeth, pressing specific head or neck points, turning the head, or abducting the shoulders (Baguley, 2002). Latifpour et al. (2009) suggested that the interaction between somatosensory and auditory input may occur at the level of the dorsal cochlear nucleus. Therefore, resonance and muscle activation in the head and neck may indirectly modulate cochlear nucleus activity.

Auditory cortex training

Because the brain can actively filter out irrelevant information and selectively attend to relevant auditory stimuli, purposefully introducing "wrong notes" or pitch deviations into music can influence auditory processing. Frequency discrimination training may interfere with tinnitus-related cortical reorganization and alter the internal tinnitus spectrum. In

HMMT, structured listening tasks and discrimination exercises are used to re-train the auditory cortex.

Tinnitus refocusing and relaxation

Through music therapy, the balance between sympathetic and parasympathetic nervous activity is expected to be restored. During relaxation training, patients are guided to recall personally meaningful and pleasant memories, which helps divert attention away from tinnitus and promotes psychophysiological relaxation. At the same time, intermittent presentation of tinnitus-like sounds is embedded into the music at a comfortable loudness level that still allows the therapist's verbal instructions to be heard. Patients are encouraged to deliberately recall and confront negative factors that tend to amplify their tinnitus perception, gradually reducing their sensitivity and emotional reactivity to tinnitus. The core idea is not to eliminate tinnitus at all costs, but to help patients face tinnitus directly and learn to ignore it.

In a study of 19 patients with acute tinnitus who received a 5-day HMMT program, structural MRI showed a significant increase in gray matter volume in the right Heschl's gyrus after treatment compared with 22 untreated tinnitus patients and 22 healthy controls (Krick et al., 2015). Tinnitus-related distress improved significantly more in the treatment group than in the control group. In a separate morphometric study of 257 tinnitus patients, Schecklmann et al. (2013) reported that higher levels of tinnitus distress were associated with smaller gray matter volumes in auditory cortical areas. A follow-up study in 78 patients yielded similar findings (Krick et al., 2017).

HMMT has also been shown to activate the posterior cingulate cortex, a core hub of the default-mode network (DMN). Resting-state DMN activation is often reduced in tinnitus patients, and DMN dysfunction has been linked to typical stress-related symptoms such as sleep disturbance, anxiety, depression, irritability and difficulty concentrating (Krick et al., 2017). Therefore, HMMT may alleviate tinnitus-related distress partly by restoring DMN function and specifically activating the posterior cingulate cortex.

In a cohort of 107 patients with chronic tinnitus who underwent a 5-day HMMT program, 76% showed a reduction in tinnitus rating scales, and all patients reported reduced tinnitus-related distress. The therapeutic effect was long-lasting, with follow-up periods up to 5.4 years (mean 2.65 years; Li et al., 2016). These results indicate that HMMT can effectively improve both acute and chronic tinnitus and its comorbid symptoms, with sustained benefits. Although tinnitus involves multiple brain regions, gray matter changes in tinnitus-related areas appear to be closely associated with the level of tinnitus distress. Krick's research further showed that tinnitus patients have reduced gray matter in Heschl's gyrus and medial frontal regions, and that Heidelberg music therapy can specifically increase the volume of the right Heschl's gyrus, indirectly supporting its role in improving tinnitus-related emotional disturbances and reversing maladaptive neural plasticity.

6. Traditional Chinese Five-Tone Therapy

Five-tone therapy is a form of personalized sound treatment based on the Traditional Chinese Medicine (TCM) theory of "the five viscera and their corresponding tones." It applies syndrome differentiation—especially organ (zang-fu) pattern differentiation—to select musical modes corresponding to individual patients. In this system, different musical tones are believed to resonate with specific internal organs and thereby regulate emotions and organ function. Classical texts describe such correspondences: "gong" (do) belongs to the spleen, "shang" (re) to the lung, "jue" (mi) to the liver, "zhi" (so) to the heart, and "yu" (la) to the kidney. In the *Huangdi Neijing*, the five tones are further linked to the five elements: jue–wood, zhi–fire, gong–earth, shang–metal, yu–water.

Modern research (Pan et al., 2016) suggests that each zang organ has an inherent frequency, and that the vibration of this frequency produces energy corresponding to physiological function. When an organ becomes diseased, its energy is altered. By applying specific musical tones associated with an organ, resonance may occur and correct the abnormal energy, thereby achieving "reducing excess and supplementing deficiency." Classical TCM statements such as "music moves the blood vessels, circulates vitality, and harmonizes the mind" and "deviant sounds evoke deviant qi and disorder; proper sounds evoke harmonious qi and order" reflect this view. Some TCM physicians have even directly called music a form of medicine.

Guided by both modern sound therapy concepts and TCM five-tone and five-element theory, five-tone therapy has been applied as a unique form of music intervention in clinical tinnitus treatment, providing a new path for comprehensive care. For example, ancient texts noted that a "hollow stomach and deficiency of ancestral qi" could lead to tinnitus. For patients with tinnitus due to spleen-stomach deficiency accompanied by anxiety, music in the gong mode that "enters the spleen meridian"—such as *Moonlight on the Spring River* or *Idle Chant*—may be selected. On the one hand, such music is used to regulate the ascending and descending and transportive functions of the spleen and stomach; on the other hand, because fear and anxiety are associated with water (kidney), music that tonifies earth (spleen) to restrain water can help alleviate fear and anxious mood using calm, gentle gong-mode melodies.

The *Neijing* also states that "wood constraint, when severe, leads to tinnitus and vertigo." In cases of tinnitus due to liver qi stagnation transforming into fire, the therapeutic principle is to drain excess fire by treating the child organ. Zhi-mode music such as *Step by Step Higher* or *Blooming Flowers under the Full Moon* can be used. A study of 80 patients with idiopathic tinnitus of the liver qi stagnation pattern showed that zhi-mode five-tone music therapy for four weeks significantly reduced tinnitus loudness and THI scores and was superior to conventional masking treatment (Zhang et al., 2018).

As early as the 1990s, a "sound information therapy" device based on the principle of acoustic resonance was used to treat tinnitus. Recent studies have again confirmed its safety and efficacy (Li et al., 2005). Its theoretical foundation lies precisely in the TCM concept of "five tones entering the five zang organs," and its mechanism may be related to changes in plasma 5-hydroxytryptamine (serotonin) levels (Wang & Li, 1996).

7. Discussion and Outlook

Sound-based therapy for tinnitus is generally divided into two main categories: partial masking and complete masking. Partial masking is typically implemented as part of habituation-based therapies such as tinnitus retraining therapy. It is analogous to the "candlelight effect"—by introducing background sound, patients' attention is actively or passively diverted away from tinnitus, and maladaptive connections between the auditory system and limbic/autonomic systems can be weakened. Over time, this can reduce tinnitus perception and its associated symptoms (Jastreboff, 2000).

Complete masking uses externally generated sounds that are carefully matched in pitch and loudness to the tinnitus, with the goal of completely covering it. By compensating for reduced auditory input resulting from cochlear damage, masking can decrease abnormal spontaneous activity of hair cells, restore excitability in efferent pathways, directly suppress aberrant neural firing in the central auditory system, and influence maladaptive plasticity to relieve tinnitus (Goldstein et al., 2005). Although both partial and complete masking can be effective, they each have shortcomings.

Complete masking can often provide rapid symptom relief, but its efficacy largely depends on residual inhibition, which tends to be short-lived. For example, the average duration of residual inhibition has been reported to be only around 5.1 minutes (4.5–6.2 minutes; Goldstein et al., 2005). Consequently, the long-term benefit of pure masking is limited. Some patients may also become dependent on masking sounds and find themselves even less able to tolerate tinnitus in the absence of masking. Because complete masking typically uses narrowband noise at a level higher than the tinnitus loudness, long-term use may be difficult to tolerate and might carry a risk of further hearing damage. In addition, masking is mostly suitable for patients with cochlear tinnitus who show positive residual inhibition.

Partial masking and habituation-based therapies (such as TRT) tend to have better long-term effects than pure masking, but they require prolonged training. A full TRT protocol usually involves wearing noise generators for at least 6 hours per day over a period of about 18 months (Jastreboff, 2000). If no clear benefit is felt in the short term, many patients are unable to maintain adherence. Furthermore, there is no universally accepted standard for habituation protocols. For instance, some clinicians require patients to attend closely to both tinnitus and background sound during treatment, whereas others allow patients to work or study while listening. From a theoretical perspective, tinnitus must first be perceived before it can be habituated; if patients simultaneously engage in other activities, their perception of tinnitus may be weakened in ways that do not promote central re-training. These controversies have led some researchers to question the efficacy and practicality of traditional habituation approaches.

Against this background, various forms of personalized music therapy have been developed based on the mechanisms of masking, residual inhibition, lateral inhibition, neural plasticity and limbic–auditory interactions. As reviewed in this article, these include neuromonics tinnitus therapy, tailor-made notched music training, phase-shift treatment, the Heidelberg model of music therapy, and TCM five-tone therapy. Overall, music as a carrier of sound therapy is well received by patients and highly valued by tinnitus researchers.

One current hypothesis proposes that tinnitus perception may be related to a "noise cancellation" mechanism involving limbic–auditory feedback loops (Rauschecker et al., 2010). According to this view, environmental noise is normally suppressed by feedback from paralimbic structures before reaching auditory cortex. However, if the amygdala and/or nucleus accumbens become hyperactive, such as under chronic stress or emotional dysregulation, this noise cancellation system can break down, and internally generated noise is no longer filtered out, resulting in tinnitus perception. Pleasurable music has been shown to reduce amygdala activity (Menon & Levitin, 2005). As a sound therapy carrier, music also offers at least three practical advantages: (1) a broad frequency spectrum that can cover the tinnitus frequency range in most patients; (2) the possibility for patients to choose music they enjoy, which promotes attention engagement, dopamine release and experience-dependent cortical plasticity (Bao et al., 2001); and (3) the ability to modulate frontal alpha activity, which may be relevant because tinnitus intensity has been linked to reduced frontal alpha power (Dohrmann et al., 2007; Schmidt & Trainor, 2001).

It should be emphasized that although sound (music) therapy is an important component of comprehensive tinnitus management and can be used throughout the treatment process, tinnitus care should not rely solely on sound therapy. Overemphasizing sound therapy may lead to unrealistic expectations, disappointment and increased emotional distress if patients do not achieve rapid improvements. In our department, non-masking sound therapy for idiopathic tinnitus is divided into four stages:

1. **Counseling, communication and clarification.** At the first visit, the clinician carefully listens to and documents the patient's tinnitus history and performs detailed audiological and tinnitus psychoacoustic assessments. The results are explained in understandable language to help patients form a realistic, non-catastrophic understanding of tinnitus. Counseling is typically conducted 2–3 times, 30–60 minutes per session.

2. **Initial stage.** After the first counseling session, and under the guidance of an audiologist, patients select natural sounds they find pleasant from a tinnitus device. They are informed of the importance of maintaining a sound-enriched environment in daily life (at work and at home) to reduce tinnitus perception. The use of natural sounds is explained in detail: (a) *Sound level:* for patients with hyperacusis, the volume is set to the maximum level they can tolerate, 1–2 times per day, 30 minutes each time. After hyperacusis improves, sound therapy is adjusted to target tinnitus, with the natural sound set at or slightly below the tinnitus loudness. For patients whose tinnitus severely affects sleep, masking mode can be used at bedtime (volume above tinnitus loudness) for 40–60 minutes before sleep; (b) *Duration:* patients are advised to listen to sound therapy every morning, afternoon and evening, 30–60 minutes per session; (c) *Listening environment:* sound therapy should not be performed in very noisy environments. It can be combined with work or study, but patients are encouraged to maintain general bodily relaxation. During this stage, short-term pharmacological interventions may be used to relieve negative emotions, such as flupentixol–melitracen for anxiety or clonazepam for sleep.

3. **Adaptation stage.** After 2 weeks to 1 month in the initial stage, once sleep and emotional symptoms have improved, patients are instructed to gradually taper and discontinue medication, increase participation in social and recreational activities, and continue sound therapy.

4. **Full habituation stage.** After 3–6 months, many patients can completely adapt to tinnitus. At this stage, sound therapy can be discontinued, and patients enter a "tinnitus-experienced" group who maintain regular follow-up and periodic audiological review.

In conclusion, personalized music therapy draws on advances in neuroscience, audiology, psychology and, in some cases, TCM theory to offer more refined and individualized options for tinnitus management. Future research should further clarify the neural mechanisms of different music-based interventions, optimize patient selection and treatment parameters, and explore how these approaches can be integrated into multidisciplinary tinnitus clinics to achieve more stable and long-lasting benefits.

References

Bao, S., Chan, V. T., & Merzenich, M. M. (2001). Cortical remodelling induced by activity of ventral tegmental dopamine neurons. *Nature, 412*(6842), 79–83.

Baguley, D. M. (2002). Mechanisms of tinnitus. *British Medical Bulletin, 63*, 195–212.

Catz, N., & Noreña, A. J. (2013). Enhanced representation of spectral contrasts in the primary auditory cortex. *Frontiers in Systems Neuroscience, 7*, 21.

Choy, D. S., Lipman, R. A., & Tassi, G. P. (2010). Worldwide experience with sequential phase-shift sound cancellation treatment of predominant tone tinnitus. *Journal of Laryngology & Otology, 124*(4), 366–369.

Davis, P. B., Paki, B., & Hanley, P. J. (2007). Neuromonics tinnitus treatment: Third clinical trial. *Ear and Hearing, 28*(2), 242–259.

Davis, P. B., Wilde, R. A., Steed, L. G., & Hanley, P. J. (2008). Treatment of tinnitus with a customized acoustic neural stimulus: A controlled clinical study. *Ear, Nose & Throat Journal, 87*(6), 330–339.

Diesch, E., Andermann, M., Flor, H., & Rupp, A. (2010). Interaction among the components of multiple auditory steady-state responses: Enhancement in tinnitus patients, inhibition in controls. *Neuroscience, 167*(2), 540–553.

Dohrmann, K., Weisz, N., Schlee, W., Hartmann, T., & Elbert, T. (2007). Neurofeedback for treating tinnitus. In T. C. Eggermont (Ed.), *Progress in brain research* (Vol. 166, pp. 473–485). Elsevier.

Fastl, H., & Zwicker, E. (2007). *Psychoacoustics: Facts and models* (3rd ed.). Springer.

Goldstein, B. A., Lenhardt, M. L., Shulman, A., et al. (2005). Tinnitus improvement with ultrahigh-frequency vibration therapy. *International Tinnitus Journal, 11*(1), 14–22.

Hanley, P. J., Davis, P. B., Paki, B., Quinn, D., Bellekom, S., Burgess, C., & De Oliveira, C. (2008). Treatment of tinnitus with a customized, dynamic acoustic neural stimulus: Clinical outcomes in general private practice. *Annals of Otology, Rhinology & Laryngology, 117*(11), 791–799.

Hoffman, H. J., & Reed, G. W. (2004). Epidemiology of tinnitus. In J. B. Snow (Ed.), *Tinnitus:*

Theory and management (pp. 16–41). BC Decker.

Hong, Z., Liu, X., & Liu, Q. (2017). Epidemiological investigation of tinnitus in 1,748 physical examination subjects. *Chinese Journal of Otorhinolaryngology Head and Neck Surgery, 24*(4), 171–174. (in Chinese)

Jastreboff, P. (2000). *Tinnitus handbook*. Singular Publishing Group.

Krick, C. M., Argstatter, H., Grapp, M., Plinkert, P. K., Reith, W., & Weisser, R. (2017). Heidelberg neuro-music therapy enhances task-negative activity in tinnitus patients. *Frontiers in Neuroscience, 11*, 384.

Krick, C. M., Grapp, M., Daneshvar-Talebi, J., Reith, W., Plinkert, P. K., & Vernon, J. A. (2015). Cortical reorganization in recent-onset tinnitus patients by the Heidelberg model of music therapy. *Frontiers in Neuroscience, 9*, 49.

Latifpour, D. H., Grenner, J., & Sjödahl, C. (2009). The effect of a new treatment based on somatosensory stimulation in a group of patients with somatically related tinnitus. *International Tinnitus Journal, 15*(1), 94–99.

Li, S. A., Bao, L., & Chrostowski, M. (2016). Investigating the effects of a personalized, spectrally altered music-based sound therapy on treating tinnitus: A blinded, randomized controlled trial. *Audiology and Neurotology, 21*(5), 296–304.

Li, Y., Zhong, Z., & Liang, M. (2005). Clinical observation of sound information therapy in 54 cases of neurogenic tinnitus. *Chinese Journal of Otorhinolaryngology Integrated Medicine, 13*(4), 219–220. (in Chinese)

Lipman, R. I., & Lipman, S. P. (2007). Phase-shift treatment for predominant tone tinnitus. *Otolaryngology–Head and Neck Surgery, 136*(5), 763–768.

Menon, V., & Levitin, D. J. (2005). The rewards of music listening: Response and physiological connectivity of the mesolimbic system. *NeuroImage, 28*(1), 175–184.

Noreña, A. J. (2011). An integrative model of tinnitus based on a central gain controlling neural sensitivity. *Neuroscience and Biobehavioral Reviews, 35*(5), 1089–1109.

Okamoto, H., Kakigi, R., Gunji, A., & Pantev, C. (2005). The dependence of the auditory evoked N1m decrement on the bandwidth of preceding notch-filtered noise. *European Journal of Neuroscience, 21*(7), 1957–1961.

Okamoto, H., Stracke, H., Stoll, W., & Pantev, C. (2010). Listening to tailor-made notched music reduces tinnitus loudness and tinnitus-related auditory cortex activity. *Proceedings of the National Academy of Sciences, 107*(3), 1207–1210.

Pan, L., Fan, D., & Hu, H. (2016). Discussion of the mechanism of five-tone therapy based on the principle of acoustic resonance. *Journal of Beijing University of Chinese Medicine, 39*(9), 731–733. (in Chinese)

Pantev, C., Wollbrink, A., Roberts, L. E., Engelien, A., & Lütkenhöner, B. (1999). Short-term plasticity of the human auditory cortex. *Brain Research, 842*(1), 192–199.

Rauschecker, J. P., Leaver, A. M., & Mühlau, M. (2010). Tuning out the noise: Limbic-auditory interactions in tinnitus. *Neuron, 66*(6), 819–826.

Schecklmann, M., Lehner, A., Poeppl, T. B., et al. (2013). Auditory cortex is implicated in tinnitus distress: A voxel-based morphometry study. *Brain Structure and Function, 218*, 1061–1070.

Schmidt, L. A., & Trainor, L. J. (2001). Frontal brain electrical activity (EEG) distinguishes valence and intensity of musical emotions. *Cognition & Emotion, 15*(4), 487–500.

Stein, A., Engell, A., Junghoefer, M., Wunderlich, R., Lau, P., Wollbrink, A., & Pantev, C. (2015). Inhibition-induced plasticity in tinnitus patients after repetitive exposure to tailor-made notched music. *Clinical Neurophysiology, 126*(5), 1007–1015.

Stein, A., Wunderlich, R., Lau, P., Engell, A., Wollbrink, A., & Pantev, C. (2016). Clinical trial on tonal tinnitus with tailor-made notched music training. *BMC Neurology, 16*, 38.

Stracke, H., Okamoto, H., & Pantev, C. (2010). Customized notched music training reduces tinnitus loudness. *Communicative & Integrative Biology, 3*(3), 274–277.

Teismann, H., Okamoto, H., & Pantev, C. (2011). Short and intense tailor-made notched music training against tinnitus: The tinnitus frequency matters. *PLoS ONE, 6*(9), e24685.

Wang, D., & Li, H. (1996). Effect of sound information on plasma 5-hydroxytryptamine levels in patients with migraine during attack period. *Chinese Journal of Neuroimmunology and Neurology, 2*, 7–8. (in Chinese)

Wazen, J. J., Daugherty, J., Pinsky, K., Newman, C. W., Sandridge, S. A., Battista, R. A., & Pyle, G. M. (2011). Evaluation of a customized acoustical stimulus system in the treatment of chronic tinnitus. *Otology & Neurotology, 32*(4), 710–716.

Wunderlich, R., Lau, P., Stein, A., Engell, A., Wollbrink, A., Shaykevich, A., & Pantev, C. (2015). Impact of spectral notch width on neurophysiological plasticity and clinical effectiveness of the tailor-made notched music training. *PLoS ONE, 10*(9), e0138595.

Zhang, Q., Shi, L., Leng, H., et al. (2018). Clinical study of TCM five-element music therapy for idiopathic tinnitus of liver qi stagnation type. *Journal of Liaoning University of Traditional Chinese Medicine, 20*(3), 170–172. (in Chinese)