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Neuro-Music Therapy for Recent-Onset Tinnitus: A Pilot Study

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Miriam Grapp¹, Elisabeth Hutter¹, Heike Argstatter¹,
 Peter K. Plinkert² and Hans Volker Bolay¹

Abstract

The aim of this pilot study was the evaluation of the neuro-music therapy approach as a new treatment option for patients with recent-onset tinnitus whose tinnitus symptoms were enduring after initial pharmacological treatment. In all, 15 patients with recent-onset tinnitus took part in our manualized short-term music-therapeutic treatment. Tinnitus severity and individual tinnitus distress were assessed by the German version of the tinnitus questionnaire (TQ) and the Attention and Performance Self-Assessment Scale (APSA) at three different measurement times: baseline (T_0), start of treatment (T_1), and end of treatment (T_2). Score changes in TQ and APSA from start to end of treatment indicated significant improvements in tinnitus-related distress. According to the Jacobson and Truax reliable change index (RC), 73.3% of the patients showed a reliable reduction in individual TQ-score. The neuro-music therapy for recent-onset tinnitus according to the “Heidelberg Model” introduced in this pilot study seems to provide an effective treatment option for patients with recent-onset tinnitus.

Keywords

tinnitus, recent-onset, tinnitus distress, neuronal tinnitus network, pilot study

Introduction

Tinnitus, the phenomenon of ringing or buzzing in the ears without an external sound source has evolved into one of the most common symptoms in ENT medicine. Its prevalence rate is estimated to be about 10% to 15% of the general population (Hall et al., 2011). In Germany, about three million people suffer from tinnitus, and this number is rising by 235,000 annually (Hesse & Laubert, 2010).

Tinnitus is classified according to the duration of the symptoms. The term *chronic tinnitus* refers to tinnitus symptoms lasting longer than 3 months. The diagnosis of acute tinnitus comprises those perceptions that are persisting for a maximum of 3 months.

The sudden appearance of tinnitus can be triggered by different factors. The most common causes are sudden sensorineural hearing loss as well as noise-induced hearing loss, resulting from exposure to high-intensity sounds (acute acoustic trauma). Furthermore, acute tinnitus frequently occurs as a result of stressful and emotionally charged life situations or as a side effect of medication.

The persisting tinnitus symptoms are often leading to substantial distress and, as a consequence, many tinnitus patients display other psychiatric comorbidities or psychological stress symptoms (Gabr, Abd El-Hay, & Badawy, 2011). For patients with acute tinnitus, D'Amelio et al. (2004) showed that depression and strong emotional reactions experienced immediately after initial manifestation of tinnitus might be

of prognostic value concerning the level of emotional distress and decompensation in chronic stage of tinnitus.

To date, there are several treatment options for patients with recent-onset tinnitus. Pharmacological approaches have been established equating tinnitus with sudden sensorineural hearing loss (Hesse & Laubert, 2010) or with any cochlear damage (Shim, Song, Choi, Lee, & Yoon, 2011). However, none of these treatment modalities has yet shown repeated efficacy in controlled trials (Elgoyhen & Langguth, 2011). Furthermore, different types of psychotherapeutic intervention supporting and accompanying medical treatment have been evaluated (Gerhards & Brehmer, 2010; Schildt, Tönnies, & Böttcher, 2006). These adjuvant psychotherapeutic interventions consist of one or more of the following elements: psycho-educative counseling, relaxation training, and general as well as tinnitus-related stress management. In particular with regard to coping with tinnitus, their effectiveness has been demonstrated in the above-mentioned studies. However, these psychotherapeutic interventions are mainly

¹German Center for Music Therapy Research, Heidelberg, Germany

²University Hospital for Ear, Nose, and Throat, University of Heidelberg, Germany

Corresponding Author:

Miriam Grapp, German Center for Music Therapy Research (Deutsches Zentrum für Musiktherapieforschung [Viktor Dulger Institut] DZM e.V.), Maaßstraße 32/1, 69123 Heidelberg, Germany.
 Email: miriam.grapp@dzm-heidelberg.de

concerned with symptom management and are not intended to cure the symptom.

Although the exact causes for tinnitus generation are not completely understood yet, structural and functional alterations of neuronal networks seem to play a crucial role. So far, the research on neural changes associated with tinnitus perception has focused almost exclusively on patients with chronic tinnitus. Electrophysiological and neuro-imaging studies in patients with chronic tinnitus give increasing evidence of alterations both within the central auditory system (Husain et al., 2011; Lanting, de Kleine, Bartels, & van Dijk, 2008; Robert et al., 2010) and in nonauditory brain areas (Landgrebe et al., 2009; Lanting, de Kleine, & van Dijk, 2009).

Concerning the auditory pathway (e.g., dorsal and ventral cochlea nucleus, inferior colliculus) and the central auditory system, three neural mechanisms underlying tinnitus generation have been identified (Adjajian, Sereda, & Hall, 2009; Eggermont, 2003, 2006; Norena, 2011): (a) increased spontaneous firing rate and hyperactivity of neurons in the auditory pathway, (b) changes in the temporal firing patterns resulting in an increased neural synchrony, and (c) reorganization of the cortical tonotopic map. Thus, tinnitus-related brain changes are the result of an increased neuronal plasticity, a form of “reprogramming the brain” (Bartels, Staal, & Albers, 2007; Møller, 2006).

In recent neuro-imaging studies in patients with chronic subjective tinnitus, the involvement of nonauditory brain areas is moving more and more into the scientific focus. These brain areas include structures involved in attention and concentration such as the dorsolateral prefrontal cortex (DLPFC), the ventrolateral prefrontal cortex (VLPFC), and the anterior cingulate cortex (ACC; Vanneste et al., 2010; Wunderlich et al., 2010) as well as areas of memory recollection and consolidation, such as the hippocampus and the parahippocampal gyrus (Landgrebe et al., 2009; Vanneste et al., 2010). Two highly integrative structures also seem to be of importance for neural tinnitus generation: the insular cortex and the precuneus (van der Loo, Congedo, Vanneste, van De Heyning, & De Ridder, 2011). The involvement of these manifold brain structures implies the existence of neural tinnitus networks with coactivation of tinnitus areas all over the brain (Schlee, Hartmann, Langguth, & Weisz, 2009). Within these networks special attention shall be given to the limbic system, which may be responsible for the emotional evaluation of tinnitus sounds. The amygdala in particular is suspected of mediating emotional decompensation in chronic tinnitus (de Ridder et al., 2006). Current research regarding the role of the limbic system in the pathophysiology of tinnitus emphasizes that its influence is much more extended than previously proposed (Leaver et al., 2011; Rauschecker, Leaver, & Mühlau, 2010).

However, studies investigating neural changes in the case of recent-onset tinnitus are still rare. Job et al. (2012) found neural hyperactivities in attention- and emotion-related areas

especially in the insular, the prefrontal, and the ACC in military adults with acute acoustic trauma and consequent tinnitus. The main objective of a recent study conducted by Vanneste, van den Heyning, and de Ridder (2011) was to investigate the differences of the neural network between tinnitus of recent-onset and chronic tinnitus. Their results indicate that the neural structures detected in both acute and chronic tinnitus were not only identical (comprising auditory cortices, insula, dorsal ACC, and premotor cortex) but also revealed differential activity and connectivity patterns within this network.

Within the context of an increased understanding of neural mechanisms underlying tinnitus generation, the need for a new therapy approach based on neuroscientific findings becomes apparent, especially for patients with acute tinnitus.

The neuro-music therapy for recent-onset tinnitus introduced in this research paper strives for an integration of strategies to manage the psychological state and possibly for a restore of the underlying neurophysiological reorganization.

Complementary music- and psychotherapeutic interventions were developed to intervene at different levels of the neural tinnitus network: (a) a targeted auditory training focusing on tinnitus processing in the central auditory system, (b) techniques of auditory attention control and concentration, as well as (c) psychotherapeutic intervention strategies for enhancing emotional control of tinnitus. These techniques and interventions were structured into modules leading to a manualized short-term music-therapeutic treatment concept (see “Materials and Methods” section for a detailed description of this music therapy manual).

Previous studies demonstrated that in chronic subjective tinnitus such an integrative music therapy approach, referred to as the “Heidelberg Model of Music Therapy,” has proven to be an efficient means to reduce tinnitus distress and loudness (Argstatter, 2009; Argstatter, Grapp, Hutter, Plinkert, & Bolay, 2012).

The aim of this pilot study was to adapt and to evaluate the neuro-music therapy approach as a new treatment option for patients with recent-onset tinnitus after initial medical treatment has failed. The specific interventions were expected to be able to intervene at an early stage in those neuronal processes leading to a chronic manifestation of the tinnitus symptom. The efficacy of the therapy should initially be reflected in a significant reduction of subjective perceived tinnitus distress.

Materials and Methods

Patients

The pilot study was conducted in accordance with the Declaration of Helsinki and approved by the local ethics committee. To decide whether patients were eligible for our study, they underwent some initial examinations. The inclusion and exclusion criteria are shown in Table 1.

Table 1. Inclusion/Exclusion Criteria.

Inclusion criteria	Exclusion criteria
Clinical diagnosis of acute tinnitus persisting for a maximum of 3 months	Clinical diagnosis of chronic tinnitus persisting for longer than 3 months
Initial medical intervention according to AWMF guidelines (glucocorticoid or rheological therapy) is accomplished during the first 6 weeks of tinnitus without significant impact	Initial medical intervention according to AWMF guidelines (glucocorticoid or rheological therapy) is not accomplished during the first 6 weeks of tinnitus
	Tinnitus related to anatomic lesions of the ear, to retrocochlear lesions or to cochlear implantation
	Clinical diagnosis of Menière's Disease
	Clinical diagnosis of severe mental disorder
	Hearing loss exceeding 40 dB
	Severe hyperacusis
Adults aged 18 or over	Children/adolescents younger than 18
Patients are able to give written informed consent	Patients are not able to give written informed consent

Table 2. Demographic and Tinnitus-Related Characteristics.

Patient	Gender	Age (years)	Tinnitus duration (weeks)	Tinnitus laterality	Initial tinnitus core frequency (Hz)	Tinnitus sound	Cause of tinnitus
P01	M	50	10	Left	1900	Tonal	Stress
P02	M	39	9	Left	2028	Noise-like	SSHL
P03	M	35	12	Right	5054	Tonal	SSHL
P04	W	49	10	Left + right	420	Noise-like	Stress
P05	M	52	11	Right	7203	Tonal	SSHL
P06	W	29	10	Right	3208	Noise-like	Not clear
P07	W	48	6	Left + right	5937	Noise-like	SSHL
P08	M	38	9	Right	4412	Tonal	AAT
P09	M	48	8	Left	5227	Tonal	Not clear
P10	M	37	7	Left	7135	Tonal	SSHL
P11	W	48	8	Left + right	2131	Tonal	Stress
P12	W	37	8	Left	6330	Tonal	Stress
P13	W	55	10	Left + right	6380	Tonal	SSHL
P14	M	37	9	Left	4167	Noise-like	AAT
P15	W	59	11	Left + right	2520	Tonal	Stress

Note: SSHL = sudden sensorineural hearing loss; AAT = acute acoustic trauma.

In all, 15 patients (7 woman and 8 men, 29-59 years old) with acute tinnitus (6-12 weeks) were included in our pilot study. They gave written, informed consent. Some important demographic and tinnitus-related characteristics of the included patients are provided in Table 2.

Measures and Covariates

Prior to music-therapeutic treatment, patients underwent a standard audiological evaluation and otolaryngological examination, including pure-tone audiogram, tympanometry, otoacoustic emission, stapedius reflex tests, and vestibular diagnostics. If these results were without pathological findings, patients were included in this pilot study.

To investigate the patients' general mental state, the German version of the Symptom Check List-90-Revised (SCL-90-R; Franke, 1995) was used at the beginning of treatment. The SCL-90-R helps to evaluate a broad range of psychopathological symptoms. It contains 90 items yielding nine scores of the primary symptom dimensions: (a) somatization, (b) obsession-compulsion, (c) interpersonal sensitivity, (d) depression, (e) anxiety, (f) hostility, (g) phobic anxiety, (h) paranoid ideation, and (i) psychoticism. The arithmetic mean of these individual scales results in a global severity index (GSI).

Tinnitus severity and individual tinnitus-related distress were assessed by the German version of the tinnitus questionnaire (TQ; Goebel & Hiller, 1994) and the Attention and

Performance Self-Assessment Scale (APSA; Görtelmeyer, Korbelt, & Elkin, 2010).

The TQ consists of a total of 52 items. The questionnaire records tinnitus-related complaints on a global TQ-score as well as on the five subscales: (a) emotional and cognitive distress, (b) tinnitus intrusiveness, (c) auditory perception difficulties, (d) sleep disturbances, and (e) somatic complaints. The range of values is between the minimum score of 0 and the maximum score of 84, whereas high values indicate high tinnitus-related distress.

The APSA is a self-rating scale comprising 30 items. It has been developed to measure especially attention and performance problems in tinnitus patients. The range of values for this questionnaire is between the minimum score of 0 and the maximum score of 120. Higher scores indicate more problems with attention and performance.

To measure and quantify therapy success, TQ-scores as well as APSA-scores obtained at three different measurement times (baseline [T_0], start of treatment [T_1], and end of treatment [T_2]) were compared. Statistical analysis was performed by using the program IBM SPSS Statistics 20. Due to the small sample size, the comparison of means at different assessment times was conducted by the nonparametric Wilcoxon Signed Ranks Test for two related samples using a level of significance of p value $< .05$. In addition, Cohen's d effect size was calculated to measure the magnitude of the treatment effect.

Changes in individual TQ-score were evaluated by the reliable change index (RC) according to Jacobson and Truax (1991). This approach allows for individual changes being classified as reliable changes if they are unlikely to be due to simple measurement unreliability. The RC is defined as the change in a client's score ($x_{\text{prae}} - x_{\text{post}}$) divided by the standard error of the differences (S_{diff}) for the test being used. Thus, the formula for calculating the RC is

$$RC = \left(\frac{x_{\text{prae}} - x_{\text{post}}}{S_{\text{diff}}} \right).$$

S_{diff} can be calculated from the standard error of measurement (SE):

$$S_{\text{diff}} = \sqrt{2(SE)^2},$$

SE can be estimated using a test's standard deviation (s_x) and reliability (r_{xx}):

$$SE = s_x \times \sqrt{(1 - r_{xx})}.$$

If the RC is 1.96 or greater, then the difference is statistically significant at the .05 significance level. To compute the RC for the global TQ-score, standard deviation and reliability of the TQ manual (Goebel & Hiller, 1998) were used. This yields a critical difference of 6.1 in TQ raw score which equals a change of at least 8 percentage points.

Neuro-Music Therapy According to the "Heidelberg Model"

The neuro-music therapy for recent-onset tinnitus is a manualized short-term music-therapeutic treatment lasting for 10 consecutive 50-min sessions of individualized therapy. Therapy took place in the German Center of Music Therapy Research in Heidelberg on 5 consecutive days (from Monday to Friday) with two therapy sessions per day. The complementary music- and psychotherapeutic interventions were structured into the following modules.

Module 1: Psychotherapeutic Interventions

1. Counseling: All patients received a comprehensive psycho-educative counseling to establish a cognitive model of tinnitus. Patients were informed about the underlying neuroscientific principles of the music therapy. As the specific modules used in therapy were based on the patients' individual tinnitus sound, their "tinnitus-equivalent" had to be set up. For patients who described their tinnitus as tonal, tinnitus frequency was matched by a sine wave generator of the type GwINSTEK SFG-2104 which produced pure sinusoidal tones in Hertz. For patients with noise-like tinnitus, the program "noise estimator" which generated noises of diverse bandwidth and pitch designed by ©Dr.rer.med. Christoph M. Krick, Neurocenter of the Saarland University, was used to match the subjective tinnitus.
2. Individual Consultation: After the fifth therapy session, a psychotherapeutic consultation took place to review the course of treatment up to now. During this consultation, patients could also talk about stressful life situations or tinnitus-related fear for the future.

Module 2: Resonance Training

The Resonance Training was intended to increase blood circulation of the entire head, especially in tinnitus-related brain regions, and to innervate the auditory pathway via somatosensory stimulation (Levine, Abel, & Cheng, 2003). The patients learned a vocal exercise stimulating the cranio-cervical resonating cavities.

To ensure that the Resonance Training was performed correctly, the therapist palpated the nasal root, the frontal and paranasal sinuses, as well as so-called "trigger points" on the back (Alvarez & Rockwell, 2002). At these points, resonance produces a clearly discernible vibration. During the interval between the sessions, the patients had to exercise in Resonance Training for 3 min every hour.

Module 3: Neuroauditive Cortex Training

The Neuroauditive Cortex Training used tone sequences centered around the transposed frequency of the patients'

previously determined “tinnitus-equivalent.” These tone sequences were performed live on a piano by the therapist and had to be vocally imitated by the patient. At the beginning of the intervention, the sequences consisted of only two tones. With increasing difficulty, up to five tones were presented. The tone sequences should be atonal and performed in quick succession.

A systematic and targeted training of inaccurately intoned musical sounds enabled the patients to exert influence on their auditory processes as they learned to actively filter out irrelevant information and to concentrate on relevant acoustic stimuli. In addition to an increased auditory attention control, this training aimed at a neuronal reorganization of the auditory cortex.

Module 4: Tinnitus Reconditioning

The Tinnitus Reconditioning offered coping mechanisms related to stress control along with a sound-based habituation procedure.

1. Relaxation training: As it was a well-known and effective relaxation exercise, the music-therapeutic relaxation training according to Bolay and Selle (1984) was adapted to the needs of the tinnitus therapy. By means of music as calming background stimulus, the balance between the activity of the sympathetic and the parasympathetic branches of the autonomic nervous system should be restored. The attention was diverted from the tinnitus, and physical relaxation was supported. In addition, the patients imagined a positive autobiographic episode (e.g., reminiscence of a holiday experience) that served as anchor stimulus: the retrieval of this “well-being-imagination” should trigger bodily and mental relaxation.
2. Habituation training: During the relaxation exercise, the tinnitus sound was integrated intermittently into the background music. The volume was adapted to the individual hearing level compensating for a potential hearing deficit. For this purpose, before the training session started, the patients had to set the background music to a convenient level such that they could easily listen to the music while still being able to follow verbal instructions from the therapist.
3. Stress management (Tinnitus Map): Subsequently the patients had to set up a “tinnitus-map.” This map identified situations aggravating or intensifying the tinnitus. These aversive situations were imagined occasionally during the relaxation when instructed by the therapist. The patients thus learned to decouple tinnitus and aversive associations.

Results

Psychological Characteristics of Acute Tinnitus Patients

To evaluate patients’ general psychological distress, the SCL-90-R questionnaire was applied prior to treatment. To enhance the informational value and comparability of the results, individual raw scores were transformed into standard *T*-scores based on a German representative population sample (Hessel, Schumacher, Geyer, & Brähler, 2001). The data revealed high psychological distress in patients with recent-onset tinnitus: 12 out of 15 patients (80%) achieved *T*-values above the normal range on the GSI-score and on three or more subscales. Besides the GSI-score ($M = 63.3$, $SD = 9.78$), the scales Obsessive-Compulsive ($M = 64.1$, $SD = 12.4$), Depression ($M = 61.2$, $SD = 9.34$), and Anxiety ($M = 1.0$, $SD = 12.2$) reached particularly high values.

Therapy Outcome

Subjective Tinnitus-Related Distress. Score changes in TQ from baseline to start of treatment as well as from start to end of treatment are presented in Table 3. For a better comparison of the single values, TQ raw scores were transformed into cumulative percentages based on a German representative population sample (Goebel & Hiller, 1998). The TQ-scores indicated a slight improvement in subjective experienced tinnitus distress from T_0 to T_1 , even without any therapeutic intervention. These improvements were primarily related to the subscale Sleep Disturbances.

When, comparing TQ-scores at T_1 with TQ-scores at T_2 , there were significant improvements in global TQ-score and in all but one TQ subscales. The most notable changes were achieved in the subscales Emotional and Cognitive Distress and Tinnitus Intrusiveness. With the exception of Sleep Disturbances, Cohen’s effect size values exceeded $d = 0.8$ indicating large effects and a high clinical significance of the intervention.

TQ-score changes on individual level were evaluated by the RC. According to the formula developed by Jacobson and Truax, a change that exceeds 8% can be regarded as reliable (see “Materials and Methods” section). Inspecting the data, 4 of the 15 patients (26.7%) achieved a change smaller than this. The lowest change was zero (for 1 patient) so there were no patients with reliable deterioration and 73.3% showed reliable improvement. The individual TQ-score changes are displayed in Figure 1. Each point reflects the scores of one patient: the x-axis is the T_1 (beginning of treatment) score, and the y-axis is the T_2 (end of treatment) score. Thus, points lying between the two dashed diagonals show no reliable change and points below the lower dashed line show reliable improvement.

Table 3. Changes in Tinnitus Questionnaire (Values of T_0 , T_1 , and T_2 Are Displayed as Percentages).

I. From baseline (T_0) to start of treatment (T_1)

		T_0	T_1	Z	p	Cohen's d
		M (SD)	M (SD)			
TQ		46.2 (21.9)	42.5 (24.3)	-1.29	.198	.22
	EC	54.9 (24.4)	44.4 (24.2)	-2.16	.031	.61
	I	43.7 (22.3)	44.1 (21.2)	-.315	.753	.03
	A	51.0 (25.5)	46.4 (27.2)	-.949	.342	.25
	SD	67.8 (19.2)	49.3 (21.9)	-.266	.008	1.27
	SC	49.6 (25.9)	42.8 (28.7)	-2.07	.039	.35

2. From start (T_1) to end of treatment (T_2)

		T_1	T_2	Z	p	Cohen's d
		M (SD)	M (SD)			
TQ		42.5 (24.3)	21.1 (19.5)	-3.29	.001	1.37
	EC	44.4 (24.2)	21.1 (15.9)	-2.81	.005	1.61
	I	44.1 (21.2)	24.7 (11.9)	-2.75	.006	1.59
	A	46.4 (27.2)	32.9 (15.3)	-2.31	.021	.87
	SD	49.3 (21.9)	44.1 (23.6)	-1.07	.286	.32
	SC	42.8 (28.7)	27.3 (26.6)	-2.98	.003	.81

Note: TQ = global tinnitus questionnaire score; EC = emotional and cognitive distress; I = tinnitus intrusiveness; A = auditory perception difficulties; SD = sleep disturbances; SC = somatic complaints. Cohen's d: Bold letters indicate a large effect ($d > 0.8$).

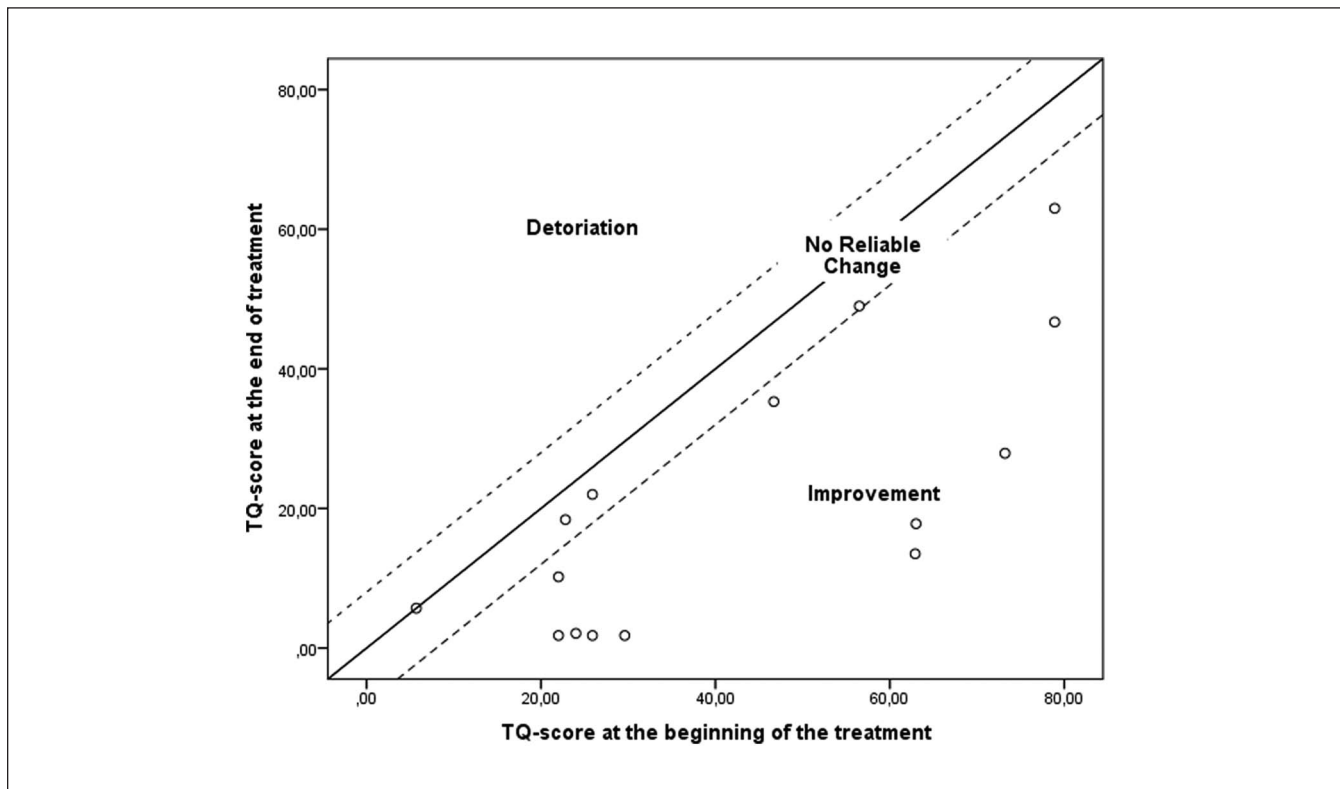


Figure 1. Jacobson-Plot of TQ-scores.

Note: TQ = tinnitus questionnaire.

Attention and Performance Problems. In addition to subjective psychological and physiological-tinnitus-related distress, almost all patients with acute tinnitus explicitly complain of deficits in attention as well as concentration difficulties. Therefore, the APSA was used as a complementary questionnaire to evaluate therapy success. A Wilcoxon signed-ranks test indicated no significant APSA-score change from baseline ($M = 54.3$, $SD = 11.4$) to start of therapy ($M = 54.9$, $SD = 9.85$), $Z = -.251$ $p = .801$, $d = .08$. However, comparing APSA-score at start of therapy ($M = 54.9$, $SD = 9.85$) versus APSA-score at end of therapy ($M = 48.6$, $SD = 11.5$) revealed a significant improvement in attention and performance problems, $Z = -2.98$ $p = .003$, $d = .83$.

Discussion

The neuro-music therapy for recent-onset tinnitus according to the “Heidelberg Model” introduced in this pilot study seems to provide an effective treatment option for patients with acute tinnitus after initial medical treatment has failed. Both a significant improvement in subjective perceived tinnitus distress and a reduction in tinnitus-related attention deficits are evident immediately after the treatment. Moreover, the large effect sizes indicate a high clinical and practical significance of the intervention.

The improvements in tinnitus-related distress (measured via TQ) concern the patients’ not only cognitive and emotional dealing with tinnitus but also tinnitus intrusiveness and auditory perception difficulties. It may therefore be inferred that neuro-music therapy goes far beyond pure symptom management. Instead, the individual treatment modules are able to intervene at an early stage in those neuronal processes leading to a chronic manifestation of the tinnitus symptom: On one hand, a controlled intervention into the neuronal mechanisms of tinnitus generation in the central auditory system is possible by means of “Resonance Training” and “Neuroauditive Cortex Training,” and on the other hand, the ability of the limbic system to identify and inhibit irrelevant sensory signals is thought to be strengthened through “Tinnitus Reconditioning.”

Concerning changes in TQ subscales, it must be noted that there is a significant improvement on the TQ subscale Sleep Disturbances from baseline to start of therapy, even if this single subscale has to be interpreted carefully due to its small number of items. Poor sleep additionally increasing the psychological strain is a common accompaniment of acute tinnitus. The reduction of sleep disturbances prior to music therapy may be explained by habituation mechanisms or by the consumption of sleeping medication.

This pilot study continues the line of research evaluating the effectiveness of the “Heidelberg Model of Music Therapy for Tinnitus.” Previous studies by Argstatter (2009) and Argstatter et al. (2012) have shown that this integrative music therapy approach is an efficient means to reduce tinnitus distress and loudness in patients with chronic tinnitus.

The data collected in this study allow for initial conclusions that the “Heidelberg Model of Music Therapy for Tinnitus” can be extended to the treatment of recent-onset tinnitus.

Apart from the successful therapy outcome, the majority of tinnitus patients included in our study displayed a striking profile of high psychological distress. In particular, depression and anxiety seem to be an intrinsic part of the everyday life of most patients with acute tinnitus. These findings are consistent with earlier studies indicating high prevalence rates of psychiatric comorbidity among tinnitus patients (D’Amelio et al., 2004; Gabr et al., 2011).

As a pilot study, our sample size consisting of only 15 patients was very small. Moreover, because there was no control group of patients receiving no treatment, we cannot rule out that other factors apart from the music-therapeutic interventions had influenced the positive therapy outcome. To strengthen our results, the neuro-music therapy approach for recent-onset tinnitus will be reevaluated based on a wider patient sample. In addition, two control groups will be included in the study design: a waiting group and a group of healthy controls.

This pilot study was based solely on questionnaire data representing improvements in subjectively perceived tinnitus distress. However, as the proposed music therapy concept focuses on neural mechanisms underlying tinnitus generation, a reduction in tinnitus distress should be reflected in structural and functional alterations of the neural tinnitus network.

Based on previous studies and relating to the expected effects of the respective modules, we hypothesize that there will be functional and anatomical changes (a) in primary auditory areas due to the targeted auditory training, (b) in brain structures involved in attention and concentration (e.g., DLPFC and VLPFC, ACC) due to the concentration training and the increased auditory attention control, and (c) in limbic areas due to increased emotional control of the tinnitus and its aversive associations.

In our forthcoming study (ClinicalTrials.gov registration: NCT01566708), task-based functional magnetic resonance imaging (fMRI) will be used to test these hypotheses. We expect to identify both relevant neuronal correlates of tinnitus-related distress in the acute phase and changes in neuronal activity from the start to the end of the treatment.

As an intrinsic noise cancellation system, the limbic system plays a crucial role in chronic manifestation of tinnitus. If the limbic filtering function is impaired, the evaluation of the tinnitus sensation’s perceptual relevance is affected and the gain control of the tinnitus perception is disturbed. By testing this model of Rauschecker et al. (2010) using fMRI in patients with chronic tinnitus, Leaver et al. (2011) showed functional and anatomical anomalies in limbic and primary auditory areas. These anomalies were highly intercorrelated indicating the importance of auditory-limbic interactions in tinnitus. For further research, it might be of interest to confirm these results for recent-onset tinnitus, especially with

regard to the question of how tinnitus develops into a chronic condition.

In this pilot study, we reported a significant change in tinnitus-related distress immediately after the treatment. However, the neuro-music therapy strives not only for short-term improvement but also and above all for a durable symptom reduction. To investigate the stability of the therapy outcomes, our future research will include systematic follow-up examinations of the patients 3 months after the completion of therapy.

Another important aspect for future research is the comparison between patients receiving Psychotherapeutic Intervention only, patients receiving Resonance Training only, patients receiving Neuroauditive Cortex Training only, and patients receiving Tinnitus Reconditioning only. Thus, it can be investigated to what extent the individual interventions contribute to the therapy success and if the interaction of the single treatment modules is of particularly significance for the effectiveness of the “Heidelberg Model of Music Therapy” for recent-onset tinnitus.

Conclusion

The results of this pilot study show, in a small group of patients, the efficacy of the neuro-music therapy for recent-onset tinnitus according to the “Heidelberg Model.” To confirm and to generalize these results, this treatment approach will be reevaluated based on a wider patient sample and compared with both a waiting group and a group of healthy controls.

The neuro-music therapy is expected to intervene at an early stage in those neuronal processes leading to a chronic manifestation of the tinnitus symptom. Beyond a reduction of subjective perceived tinnitus distress, a successful therapy outcome should be reflected in alterations of the neural tinnitus network. In our forthcoming study, task-based fMRI will be used to investigate neuronal correlates of tinnitus-related distress in the acute phase and changes in neuronal activity from the start to the end of the treatment.

Declaration of Conflicting Interests

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Author Biographies

Miriam Grapp is a research scientist and doctoral candidate at the German Center for Music Therapy Research (Viktor Dulger Institut) DZM e.V. in Heidelberg. Since 2010, she works as a clinical psychologist at the outpatient department for tinnitus and chronic pain in Heidelberg. Her special research interest is the development and scientific evaluation of a music therapeutic treatment manual for patients with acute tinnitus.

Elisabeth Hutter is a research scientist and doctoral candidate at the German Center for Music Therapy Research (Viktor Dulger Institut) DZM e.V. in Heidelberg. Since 2011, she works as a clinical psychologist at the outpatient department for tinnitus and chronic pain in Heidelberg. Her special research interest is music therapy for patients with cochlea implant.

Heike Argstatter, PhD, is a research scientist at the German Center for Music Therapy Research (Viktor Dulger Institut) DZM e.V. in Heidelberg. Moreover, she works as a clinical psychologist at the outpatient department for tinnitus and chronic pain in Heidelberg. Her special research interest is the effectiveness of music therapy for chronic tinnitus. She is the author of several scientific publications, among others she published the treatment manual for patients with chronic tinnitus.

Peter K. Plinkert, MD, is the chairman and director of the Department of ORL-HNS, University Heidelberg. His clinical and research emphasis is on otology, lateral skull base surgery, and functional and reconstructive ORL-HNS. Inter alia, he is president of the Association for German Speaking Audiologists and Neurootologists (ADANO) and editor of the *HNO*, the official journal of the German Society of Oto-Rhino-Laryngology, Head and Neck Surgery.

Hans Volker Bolay, PhD, is the second chairman and managing director of the German Center of Music Therapy Research (Viktor Dulger Institut) DZM e.V. in Heidelberg which he founded in 1995. He is director of the outpatient department for tinnitus and chronic pain in Heidelberg. In the area of music therapy, he has published numerous scientific music therapeutic books and journals.