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"Heidelberg Neuro-Music Therapy" for chronic-tonal tinnitus - treatment outline and psychometric evaluation

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Abstract

Introduction: Musical training positively influences the cortical plasticity of the brain and has proven to be effective in treating chronic tinnitus. **Objectives:** A neuro-music therapy concept, the "Heidelberg Neuro--Music Therapy" treatment was developed and evaluated. **Design:** A prospective, cross-sectional design was used. **Materials and Methods:** N = 135 patients (mean age 47 years) with chronic, tonal tinnitus attended a standardized protocol for Neuro-Music Therapy (either "standard therapy" ST or "compact therapy" CT). The results were compared to a cognitive behavioral placebo music therapy procedure (PT). Tinnitus distress was assessed using the German version of the Tinnitus-Questionnaire (TQ) at admission, at discharge and six months after therapy. Changes were assessed statistically and by means of clinical significance. **Results:** TQ scores significantly improved - independent of group allocation. But more than 80% of the music therapy patients (both ST and CT) revealed a reliable improvement ("responder") compared to 44% in the PT group. Therapy impact seems to be lasting since TQ scores remained stable until follow-up at six months. **Conclusions:** The "Heidelberg Neuro-Music Therapy" is a method with fast onset and long lasting effect for patients with "tonal" tinnitus. A number of potential working factors accounting for the treatment success are highlighted.

Keywords: acoustic stimulation, music therapy, neuronal plasticity, tinnitus, training.

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INTRODUCTION

Apart from emotional disturbances such as anxiety, depression, sleep impairments or irritation[1], the main complaints of the persons concerned with ringing in the ear are difficulties in concentrating their attention[2] and in auditory perception[3]. The main reason seems to be the permanent awareness of the tinnitus and the diminished ability to habituate to the sounds[4]. For that reason the predominant wish of the patients is to get rid of the "annoying" and "intrusive" sounds[5] and to regain confidence in their sense of hearing.

Data from human neuroimaging support the hypothesis of a final common pathway for tinnitus[6] and propose a compromised "noise cancellation mechanism"[7] to be liable for the enduring tinnitus percept. According to these assumptions, the tinnitus sounds originate from lesions in the auditory pathways. Usually these sounds should be blocked off by feedback connections from limbic regions before reaching the auditory cortex. If however emotional reactions (possibly due to overly active amygdala and/or nucleus accumbens) suppress the inhibition, this "noise-cancellation system" fails and the person affected is no longer able to fade out the sounds. Mutual stimulation via both the thalamic and paralimbic pathways ultimately lead to tonotopic changes in the auditory cortex[7] while reciprocal innervations of the medial temporal lobe system give rise to memory consolidation leading to a paradoxical "tinnitus memory"[6].

It is known that pleasant music verifiably reduces activities in the amygdala and enhances activity in nucleus accumbens and thalamus[8,9]. Musical training positively influences the cortical plasticity of healthy brains[10]. Musically based interventions[11,12,13] also have proven to be highly effective in treating chronic tinnitus - possibly by correcting tinnitus evoking neuronal mechanisms[14].

Disadvantages are the rather lengthy application and the passive "sounding" of the tinnitus instead of an active exposition to the tinnitus sound. Many patients ask for more active ways for coping with their tinnitus. If they could actively influence their tinnitus, their control beliefs will rise and thus let down the strains[15].

Therefore a short-term Neuro-Music Therapy based on active treatment modules seems to be fruitful in treating chronic tinnitus.

The "Heidelberg Model of Neuro-Music Therapy"

The World Federation of Music Therapy[16] defines music therapy as "*the use of music and/or its musical elements (sound, rhythm, melody and harmony) by a qualified music therapist, with a client or group, in a process designed to facilitate and promote communication, relationships, learning, mobilisation, expression, organisation and other relevant therapeutic objectives in order to meet physical, emotional, mental, social and cognitive needs*."

The novel treatment according to the "Heidelberg Model of Neuro-Music Therapy" is based on the notion that tinnitus is experienced as an auditory percept - just as musical stimuli are experienced as auditory percepts. Therefore the patients shall be enabled to actively control the sounds in order to reorganize the underlying neuronal mechanisms maintaining the tinnitus[17]. Purpose-built music therapeutic interventions were merged to modules and integrated into a standardized manual. The western heptatonic musical tonality forms the basis of the active music therapy procedures. Therefore the Neuro-Music Therapy is indicated only if the patients indentify their tinnitus as "tonal" (sinus tones).

About 40% of all tinnitus patients describe their tinnitus characteristic as "tonal"[18].

Two standardized protocols for tinnitus music therapy were defined: a "standard therapy" (ST) and a "compact therapy" (CT) (see patient flow-chart). The overall therapeutic dose rate (500 minutes of therapy) was equal just as were the intervention modules (including the counseling). Thus the two protocols merely differed in terms of temporal extension (ST: 10 weeks, CT: 5 days)[19].

Module 1: Counseling

All patients receive a comprehensive psycho--educative counseling in order to establish a cognitive model of tinnitus[20]. They are informed about the neuroscientific principles of the music therapy. Possible physical diseases and current medications are examined. In case of doubt, a physician is consulted. Any psychiatric disorder or ongoing medication with antidepressants or antipsychotic drugs yields to exclusion of the patients.

As the specific modules used in therapy are based on the individual tinnitus sound, a tinnitus--equivalent has to be set up by means of a commercially available sinus generator. The aim is not to reproduce a psychometrical pitch-matched tone but rather a sound that is subjectively equivalent to the patients' "ear sounds".

Module 2: Resonance Training

In the *Resonance Training* the patient learns a vocal exercise stimulating the cranio-cervical resonating cavities. The supposed cranial activation can easily be inspected by palpating trigger points[21]. During the interval between the sessions, the patients have to exercise themselves in *Resonance Training* for three minutes every hour. The most common side effects are headache and laryngitis if the exercise is not executed properly, either too often, too long or with too much pressure. The therapist therefore has to check if the execution is correct.

Module 3: Neuroauditive Cortex Training

The *Neuroauditive Cortex Training* uses tone sequences performed live by the therapist on a piano which have to be vocally imitated by the patient. A systematic and targeted training of inaccurately intonated musical sounds enables the patients to exert influence on their auditory processes since they learn to actively filter out irrelevant information and to concentrate on relevant acoustic stimuli.

Module 4: Tinnitus Reconditioning

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

1) Relaxation training

A well known and effective relaxation exercise, the music therapeutic relaxation training according to Bolay/Selle[22] 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 shall be restored. The attention is diverted from the tinnitus and physical recreation is supported. Additionally the patients imagine a positive autobiographic episode (e.g. reminiscence of a holiday experience) which serves as anchor stimulus: every time the patients call up this "well-being-imagination", the bodily and mental relaxation should be triggered.

2) Habituation training

During the relaxation exercise, the tinnitus sound will be integrated intermittently into the background music. The volume is adapted to the individual hearing level compensating for a potential hearing deficit. For this purpose, before the training session starts, the patients have to set the background music to a convenient level such that they can easily listen to the music while still being able to follow verbal instructions from the therapist.

3) Stress management (Tinnitus Map)

Subsequently the patients have to set up a "tinnitus-map". This map identifies situations aggravating or intensifying the tinnitus. These aversive situations can be imagined during the relaxation. The patients thus learn to decouple tinnitus and aversive associations (Table 1).

MATERIAL AND METHODS

Patients were eligible if they suffered from chronic tinnitus (duration > six months) which could be musically compiled (distinct frequency) and had no psychiatric co-morbidity. The therapy concept was announced by press releases (newspapers and magazines, radio and TV) and offered to patients at the outpatient department of the local ENT-clinic of the university hospital. N = 197 patients were assessed for eligibility. N = 47 patients had to be excluded, the remaining n = 151 patients met the inclusion criteria and were allocated to one of three therapy groups (standard music therapy ST: n = 64; compact music therapy CT: n = 69; psychological control therapy with placebo music therapeutic elements PT: n = 18). N = 135 data records were completed until follow-up and entered analysis (ST: n = 53, CT: n = 66; PT: n = 16).

Since patients were recruited nationwide it was not possible to randomize the patients to the groups in the true sense of the word. Therefore, group allocation was done in a quasi-randomized way. Only patients coming from the proximity of Heidelberg were allocated in a randomized way (computer generated) either to the ST group or the PT group. The farther patients were allocated to the CT group. Group allocation for the ST and CT groups was stratified according to age and gender.

Based on data from a pilot study[23] we calculated the a priori power and thus estimated the minimum control group size with the power analysis program "GPOWER"[24] to n = 15. With respect to potential drop-outs we included n = 16 patients in the PT group.

Reasons for exclusion and drop-out are given in the patient flow-chart.

As part of the medical history, psychosomatic and audiologic co-morbidities as well as socio--demographic data and tinnitus characteristics were assessed.

Table 1. Manual outline of the "Heidelberg Model of Neuro-Music Therapy".

Module	Technique	Proposed working factor
Counseling	Neuroscientifically founded education on tinnitus aetiopathology	NW: Counselling, facilitation of therapy motivation
	Compilation of a tinnitus-sound equivalent by means of a sine-wave generator and conversion to the heptatonic scale	SW: Externalisation of the tinnitus, musical conversion
Resonance exercise	Establishment of a "sound layer" on a great gong, vocal intonation of the individual tinnitus into this "sound layer" stimulation of cranio-cervical resonating cavities	SW: Regain confidence in own hearing; active masking of the tinnitus sound; increase of blood circulation, corrective stimulation of the auditory pathway by means of somatosensory innervations
Neuroauditive Cortex Training	Audition of unknown, standardized atonal music sequences	SW: Attention diversion, increase of discriminative abilities, enhancement of auditive skills
	Intonation exercise of erroneous intervals in the range of the tinnitus frequency	SW: Neuronal reorganisation of the tonotopic representation in the auditory cortex
Tinnitus Reconditioning	Relaxation:Music therapeutic relaxation training and creation of a "well-being image" as anchor for physiological relaxation	SW: Physical relaxation and regulation of physiological processes
	Habituation training: Systematic desensitization in order to decouple tinnitus from psychophysiological reaction patterns	SW: Subliminal training of auditory filtering; self--efficient steering of physical reactions on tinnitus perception
	Stress management: Compilation of tinnitus evoking/attenuating factors and situations (temporal "tinnitus map")	NW: Identification of unspecific factors

SW: Specific Working factor (proposed to be specific for the music therapy concept). NW: non-specific working factor (general factors).

On the whole 69% of the patients presented with high frequency hearing loss (> 20 dB hearing impairment present in at least three test frequencies > 3000 Hz) and about 42% presented with low frequency hearing loss (> 30 dB hearing impairment present in at least one test frequency 0-2000 Hz). 16% were provided with hearing aids.

Due to the stratified group allocation, no group differences in socio-demographic data were obtained.

Interventions

Patients in the music therapy groups ST and CT received a treatment according to the „Heidelberg Model of Neuro-Music Therapy" as described above.

Patients in the control group PT received a psychosocial intervention based on psychological tinnitus treatment strategies[25] combined with placebo music therapy elements. The therapy was designed as group intervention with five weekly sessions à 90 minutes and an additional individual counselling (50 minutes) leading to therapy duration of 500 minutes equal to the music therapy intervention. The counselling was identical with the counselling in the music therapy groups. Each of the group sessions of the PT comprised three phases: 1) opening round focussing on individual experiences since the last therapy session; 2) psychotherapeutic phase focussing on specific psychological strategies in order to manage the tinnitus symptoms; 3) musical intervention focussing on conscious listening to musical pieces. Selection of the musical pieces was based on the individual musical taste and preferences as well as on the emotion evoking impact of the musical pieces. In detail the following pieces were used: 1. session: Wolfgang A. Mozart, Theme and Variations in G Major, K. 501; 2. session: Johann Strauss, "The Bat" (Overture); 3. session: Felix Mendelssohn-Bartholdy, piano trio op. 49 (Scherzo: Leggiero e vivace); 4. session: André Rieu, 1. piece: Emile Waldteufel "Les Patineurs" op. 183; 2. piece: Franz Léhar, "Song of the Wolga"; 5. session: Georg Friedrich Händel, "Jephtha" HWV 70 (highlights); 6. session: George Gershwin, "I got rhythm".

Tinnitus outcome measurements

Assessment of tinnitus symptoms was performed three times, at admission ("pre"), at discharge ("post") and six months after therapy ("follow-up FU"). The main outcome criteria were the absolute scores of

[1] With SE = standard error of the Mini-TQ (SE = SD*√(1- rtt) and SD = standard deviation of the norming sample = 17.6 and rtt = 0.94.

the German version of the tinnitus questionnaire ("Tinnitus-Fragebogen", abbreviated "TQ") by Goebel and Hiller[26] as well as the relative decrease in TQ scores.

Apart from statistical significance, individual changes were assessed according to the concept of clinical significance[27]. This method allows for calculating a reliable change index, i.e. a criterion level above which changes are unlikely to be due to simple measurement unreliability. The formula for criterion level RC is RC = 1.96*√2*SE[1]. Based on this formula, the RC for the Mini-TQ is estimated to 5.8 raw score points. Any patient who has scores differing for more than 5.8 points between two measurement points has achieved a clinically relevant change - either a reliable amelioration (reduction by more than 5.8 points) or a reliable deterioration (increase by more than 5.8 points). All patients having scores differing between -5.8 and +5.8 points have not achieved a reliable change in the Mini-TQ. Patients with a reliable reduction in TQA scores are called "responders".

Evaluation of therapeutic elements

At discharge all patients of the music therapy groups had the opportunity to rate their subjective therapy satisfaction. They had to answer three specific questions a) "Was your tinnitus percept changed by the music therapy?" (Answers: worsened - unaffected - improved) and b) "Which elements from therapy did you consider helpful?" (open question).

Statistical analysis

Statistical analysis of the data was performed using parametrical and non-parametrical tests in SPSS 16 (SPSS Inc. Headquarters, 233 S. Wacker Drive, 11th floor, Chicago, Illinois 60606). Group differences of sociodemographic data and audiometric tinnitus characteristics were analyzed with the c^2-test or univariate analysis of variance (ANOVA). Therapy outcome as assessed by the TQ and the CPT were evaluated using univariate analysis of variance (ANOVA) for repeated measure procedures.

In order to predict parameters possibly influencing therapy outcome, a logistic regression model (CATREG, SPSS 16.0) was calculated using TQ-score immediately after therapy as an indicator for therapy success as a dependent variable. Independent variables were demographic factors (gender, age) and tinnitus related factors (hearing deficit (dB), time since tinnitus onset, tinnitus pitch and tinnitus masking level (dB SL), high frequency hearing loss (yes/no) and initial TQ-score).

The level of significance was $p < .05$, adjusted for multiple testing by the Bonferroni method (Table 2).

RESULTS

Tinnitus outcome measures (overall TQ scores)

Analysis of TQ scores revealed a highly statistically significant reduction pre-post ($p < .000$) which remained unchanged until FU ($p = .913$). Outcome differed between intervention groups ($p < .05$) as the PT-group did not equally benefit from the therapy as the music therapy groups ST and CT.

The overall reduction in the music therapy groups can be explained by significant changes in distinct sub-scales of the TQ, especially of "E = emotional problems" ($p < .000$), "C = cognitive problems" ($p < .005$), "E + C = psychological problems" ($p < .000$) und "I = intrusiveness" ($p < .000$). There is no group difference between CT and ST on any scale (all $p > .05$).

Individual changes in TQ

According to the concept of „clinical significance", more than 80% of the patients the music therapy groups (ST and CT) achieved a reliable reduction in their tinnitus scores from admission to discharge and could thus be categorized as "responder". In the PT-group 44% achieved this relief. The responder rates remained nearly unchanged at follow-up six months later.

Evaluation of therapeutic elements

On a subjective level, 67% of the patients treated with music therapy regarded their symptoms as "better", 22% observed no change and 11% stated to be worse off. There was no statistical difference between ST and CT ($c^2(1) = 0{,}99$, $p = .680$.

As most beneficial the patients specified the therapy elements *Resonance Training* (53% positive feedback) and relaxation/deconditioning (49%). *Neuroauditive Cortex Training* was mentioned by 22%, "Counseling" by 27%.

Moderator variables

Apart from immediate therapy-related effects, there could be other factors influencing therapy outcome ("moderator variables"). In the logistic regression demographic, therapy and tinnitus related factors were entered in the model to define those factors that are associated with tinnitus and may therefore contribute to therapy success. The regression analy-

Table 2. Socio-demographic data and Tinnitus-Characteristics.

	Standard Therapy	Compact Therapy	Psychological Control Group
Subject characteristics/group			
N [all (female)]	53 (17)	66 (22)	8 (8)
Age in years [mean (SEM)]	47.1 (9.9)	46.8 (12.5)	56.8 ± 14.4
Tinnitus onset [years (SEM)]	7.0 (5.1)	6.7 (4.7)	
Psychoacoustics			
Tinnitus location:N [LE/BE/RE]	13/26/14	18/37/11	
Tinnitus frequency [kHz (SEM)]	5.1 (2.3)	4.9 (2.3)	
Tinnitus minimum masking level [dBHL]	10.9 (4.5)	7.3 (3.9)	
Tinnitus minimum masking level [dB]	50.2 (21.8)	45.8 (22.5)	
RE hearing loss dB HL [LE/RE/BE] (SEM)	34(21)/35(18)/41(23)	50(28)/29(19)/33(22)	normal hearing
LE hearing loss dB HL [LE/RE/BE] (SEM)	32(23)/45(28)/44(24)	38(23)/39(24)/38(25)	normal hearing
High frequency hearing loss [non/unilateral/bilateral] (N)	13/10/30	25/10/31	normal hearing
Low/mid frequency hearing loss [non/unilateral/bilateral] (N)	34/6/13	40/10/16	normal hearing

sis reveals a highly significant relationship between the tinnitus score and the independent variables ($p < .01$, with $R^2 = 0.43$). It revealed that there were no influential demographic factors (all $p > .100$) but it could identify two influential tinnitus related factors: initial TQ-score ($p = .000$) and tinnitus masking level (dB SL) ($p = .055$) (Table 3-5).

DISCUSSION/CONCLUSION

Tinnitus is a very common symptom yet difficult to treat. Therefore there is an urge for a short term therapy with preferably minimal effort but long lasting effect. The proposed therapy concept "Heidelberg Model of Neuro-Music Therapy" seems to be a poten-

Table 3. TQ scores - absolute values, differences (before therapy - after therapy - six month follow-up).

			Pre	Post	FU	Relative Change Pre-Post	Relative Change Pre-FU
Value	Standard-Therapy (n = 53)		41.2 ± 10.5	24.3 ± 10.8	22.9 ± 11.5	41.0%	44.4%
	Compact-Therapy (n = 66)		39.5 ± 10.6	27.2 ± 10.8	24.4 ± 12.2	31.1%	38.5%
	Psycholocial Therapy		40.8 ± 10.4	37.7 ± 9.9	35.3 ± 11.9	7.6%	13.4%
ANOVA	Main effect time		F[2, 133] = 24.83; $p = .000$			F[1, 134] = 0.50; $p = .484$	
	Scheffé post-hoc	Pre	Post	.000	Pre	Post	.000
		Pre	FU	.000	Pre	FU	.000
		Post	FU	.913	Post	FU	.913
	Main effect "therapy group"	F [2, 134] = 0.1; $p = .760$			F [1, 134] = 0.26; $p = .612$		
	Scheffé post-hoc	ST	CT	.999			
		PT	ST	.045			
		PT	CT	.049			
	Interaction "time x therapy group"	F [2, 268] = 0.19; $p = .829$			F [1, 134] = 0.15; $p = .701$		

Pre: Before Therapy = Admission. Post: After Therapy = Discharge. FU: Follow-up six months after the end of therapy.

tial completion of the therapy spectrum. About 80% of the patients accomplished a reliable decrease of tinnitus pathology in the course of music therapy and about two thirds of the patients describe their tinnitus symptoms as "improved" after therapy. This effect was independent of the patient's treatment allocation to standard therapy or compact therapy. According to the results from the regression analysis, there was - apart from tinnitus masking level - no influence of tinnitus characteristics or otological co-symptoms on

Table 4. Individual changes in Tinnitus-Questionnaire Scores according to the concept of "clinical significance".

	Pre - Post			Pre - Follow-up		
	Standard--Therapy	Compact--Therapy	Psycho. Therapy	Standard--Therapy	Compact--Therapy	Psycho. Therapy
"Responder" = reliable improvement (more than - 5.8 TQ-points)	85% (n = 45)	85% (n = 56)	44% (n = 7)	85% (n = 45)	83% (n = 55)	44% (n = 7)
"Non-Responder" = no change (less than ± 5.8 TQ-points)	15% (n = 8)	12% (n = 8)	19% (n = 3)	13% (n = 7)	14% (n = 9)	25% (n = 4)
"Negative Responder" = reliable deterioration (more than + 5.8 TQ-points)	0% (n = 0)	3% (n = 2)	38% (n = 6)	2% (n = 1)	3% (n = 2)	31% (n = 5)
c^2 -Test	$c^2(2) = 30.23$, $p = .000$			$c^2(2) = 21.63$, $p = .001$		

Table 5. Regression analysis - moderator variables.

		Beta	Partial correlation	F	*p*
Tinnitus related factors	Initial TQ-Score	0.41	0.42	18.47	.000
	Tinnitus masking level (dB SL)	0.20	0.21	3.79	.055
	Tinnitus Pitch (Hz)	-0.13	-0.16	2.10	.151
	Hearing impairment (dB)	0.13	0.13	1.39	.242
	Time since Tinnitus onset (years)	-0.11	-0.12	1.24	.268
	High frequency hearing loss (yes/no)	-0.11	-0.10	0.78	.379
Demographic factors	Sex	-0.15	-0.18	2.66	.107
	Age	-0.07	-0.07	0.41	.524

therapy success. Most influential is the initial tinnitus score. Higher initial tinnitus strains led to a larger absolute decline in TQ scores. Nevertheless, the relative reduction and the individual improvement (reliable change index) were independent from the basic TQ--value - therefore also patients with comparatively lower strains still benefit from the therapy in equal measure. Compared to internationally established interventions, the effect size d'[28] of the "Heidelberg Model of Neuro-Music Therapy" is as high as d' = 1.6, i.e. a very large, reliable effect. The results remained stable over a time course of at least six months.

In order to set the results in the context of existing therapies, a psychologically based treatment group was used as control group. In terms of treatment outcome this group was target underperforming since just less than half of the patients achieved the desired symptom reduction. Given that this group received also placebo music therapeutic elements (active listening to preselected musical pieces) and an individual counseling, it seems reasonable to argue that the positive and long lasting effect of the music therapy according to the "Heidelberg Model of Neuro-Music Therapy" is due to the far more specific and active musical training aiming directly at the individual tinnitus sound.

Animal models[29] as well as results from research on tinnitus treatments[30] suggest the use of very specific stimuli, i.e. tonal ones, in order to reorganize the cortical representation of tinnitus-like aversive events[13]. There exists a variety of procedures using a combination of counseling and acoustic stimulation. Often the musical stimuli are spectrally modulated in order to account for hearing impairments[31,32] and are incorporated as a passive means patients have to listen to for rather lengthy intervals (months up to years).

The "Heidelberg Model of Neuro-Music Therapy" on the other hand integrates some well known psychological techniques and strategies in order to reduce the tinnitus sensitivity by means of an immediate exploration of the tinnitus sounds by the patient. At the core of the "Heidelberg Model of Neuro-Music Therapy", the patients are actively "confronted" with their individual tinnitus sounds and are told to deal with their tinnitus explicitly instead of trying to take no notice of the tinnitus. In doing so, the duration of the therapy does not exceed ten weeks (standard therapy) and can even be compacted to five days (compact therapy). The main parts of the therapy consist of active music therapy modules; hence there is no need and no purpose for spectrally changing the music used.

Especially the *Resonance Training* and the *Tinnitus Reconditioning* were rated as helpful. These modules enhance the self-determination and the control beliefs of the patients since they learn techniques in order to actively influence their tinnitus.

The rather low positive feedback rate of the *Neuroauditive Cortex Training* (only about a quarter of the patients rated this module as helpful) might have been due to the wording during the therapy. The patients possibly did not know the scientific label of the intervention thus the answers in the feedback-sheet were blurred because the patients could not label this intervention. Many patients stated though that they would enjoy singing or listening to music subsequent to the therapy. Improved enjoyment of pleasant acoustic stimulation (e.g. listening to music) is a feature already known to be promotive for lasting tinnitus relief[33].

The rather high impact of the Neuro Music Therapy might be rooted in specific working factors:

Proposed working factors of Module 1: Counseling

A comprehensive education is part of any approved tinnitus therapy. One specific of the "Heidelberg Model of Neuro-Music Therapy" is the establishment of a tinnitus-equivalent sound. This intervention has a therapeutic impact in itself[34]. Patients are enabled to externalize their "ear sounds". Additionally, a tinnitus--equivalent sound provides the possibility to deal with the symptoms in an immediate and direct way.

Proposed working factors of Module 2: Resonance Training

The *Resonance Training* is a purely vocal exercise that stimulates the auditory pathway by means of somatosensory innervations and enables the patients to control their tinnitus perception.

It is known that there are manifold cross-modalities in processing somatosensory and auditory stimuli[35]. Many patients can voluntarily change the percept of their tinnitus by for example teeth clenching, pressure on the occiput, forehead, vertex and temples, head turning and shoulder abductions[36]. Levine[37] proposed interactions between auditory perception and somatosensory input at the dorsal cochlear nucleus. Somatosensory stimulation seems to be effective in alleviating tinnitus symptoms[38,39]. Therefore an activation of cranio-cervical and cranio-facial muscles and nerves by means of the *Resonance Training* might correct the auditory pathway by means of indirect stimulation of the joint "relay-station" cochlear nucleus[36].

Proposed working factors of Module 3: Neuroauditive Cortex Training

The *Neuroauditive Cortex Training* contains a detailed "intonation-training" with purpose-built musical stimuli, based on the individual tinnitus frequency in order to increase the patients' discriminative abilities and enhance their attentive skills.

In chronic tinnitus characteristic auditory cortical reorganizations are traceable, which seem to be frequency specific[40,41]. Frequency discrimination training may interrupt the cortical representations that are generating tinnitus[42,43]. Experimental data indicate that it is more efficient to train at normal hearing frequencies rather than in the region of hearing loss or tinnitus frequency[44,45]. We therefore propose that it is possible to alter the internal tinnitus spectrum by means of the *Neuroauditive Cortex Training*, which represents a specific perceptual training within the normal hearing frequencies. Furthermore it is very important to ensure the training regime is intrinsically motivating. Active music therapy guarantees the lasting co-operation of the patients.

Proposed working factors of Module 4: Tinnitus Reconditioning

*Tinnitus Reconditioning*has distinct features in that it combines musical distractors with psychophysiological relaxation and imagination of mental well--being. This module increases the auditory filtering and supports a modified emotional processing of the tinnitus sound.

Since the application of the "well-being image" is linked to acoustic stimuli (relaxation music, tinnitus equivalent sound), the connection "well-being image - relaxation - tinnitus reduction" can be explained in terms of classical conditioning[46].

The neurological basis seems to be in an endogenous system located in the medial temporal lobe system (MTLS)[6] and the reticular formation (RF)[47]. The MTLS is suspected to be responsible for the establishment of a "tinnitus memory" similar to the pain memory. The use of the tinnitus sound aims at the extinction of this paradoxical memory path. RF neurons coordinate sensory and motor functions and influence cortical activity via the thalamus. Stress is considered to potentiate the severity of tinnitus due to the proposed accompanying reduction and alteration in auditory masking[6]. A deliberate regulation of emotional responses towards the tinnitus sounds might enhance gate control mechanisms and restore misdirected "filter functions" of thalamic and limbic areas.

Preliminary MRI data[48] support the working factor hypotheses. Further studies are needed in order to evaluate which elements of the music therapy contribute most to the overall effect and to scrutinize the proposed working factors of the modules.

Limitations of the music therapy are that it is suitable only for a subgroup of tinnitus sufferers: the musical exercises will only be tolerated if the patients do not present severe hyperacusis and/or hearing loss > 60 dB - though hyperacusis and hearing loss are very common symptoms in tinnitus[49]. The treatment of tinnitus related psychological distress is part of the music therapy concept, though the duration is very short and music therapy presents a focal therapy and no in-depth psychotherapy will be possible. Therefore patients are not eligible if they suffer from severe psychiatric co-morbidities.

On the whole, music therapy is a method with short duration, fast onset and long lasting effect for patients with “tonal” tinnitus and light to moderate tinnitus severity (Figure 1 and 2).

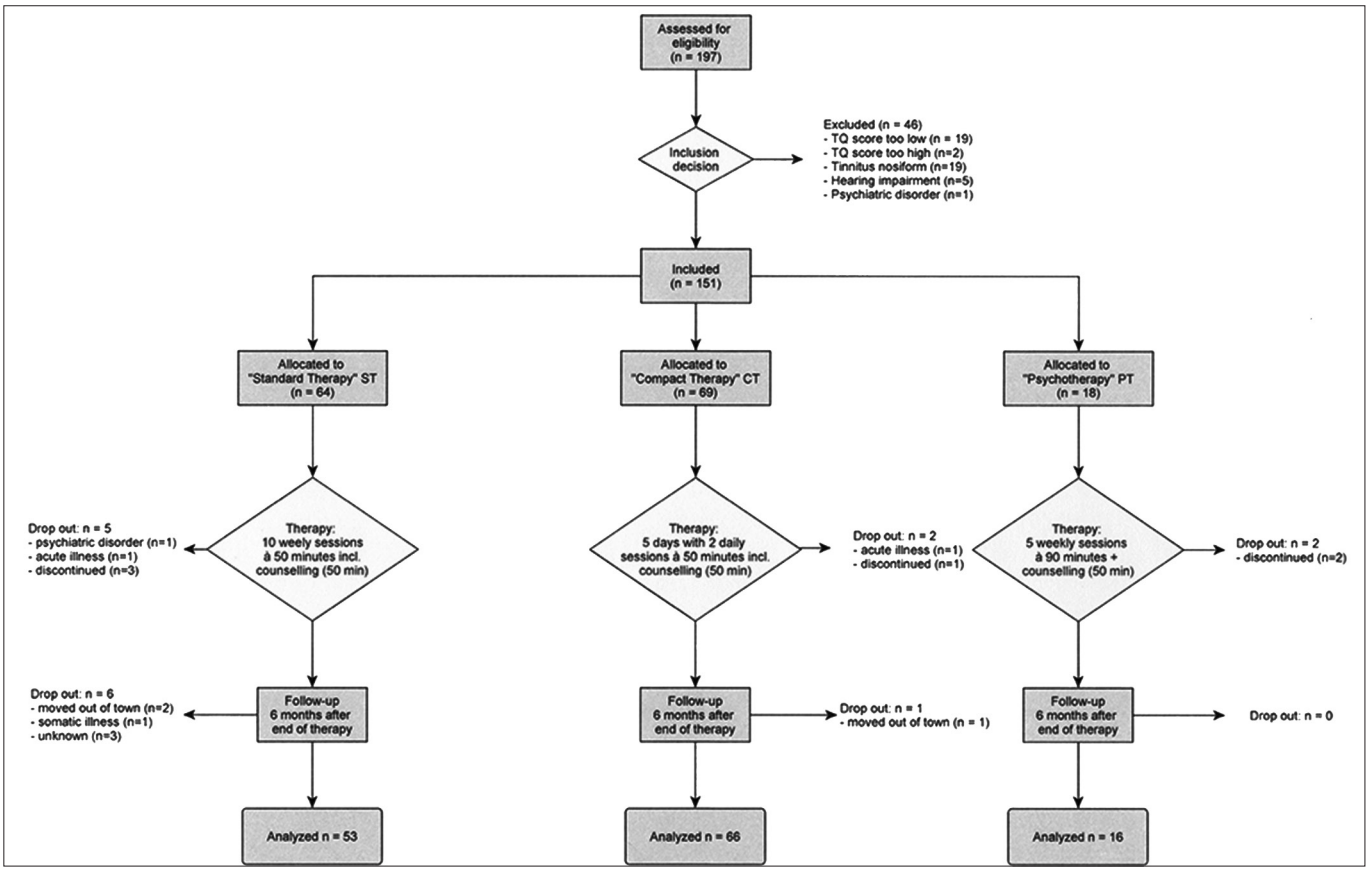

Figure 1. Flow-chart of patients. Group allocation to neuro music therapy groups (ST: Standard Therapy, lasting for 10 consecutive weeks with one weekly therapy session; CT: Compact Therapy, lasting for 5 consecutive days with two daily therapy sessions) and reasons for drop out. TQ: Tinnitus Questionnaire.

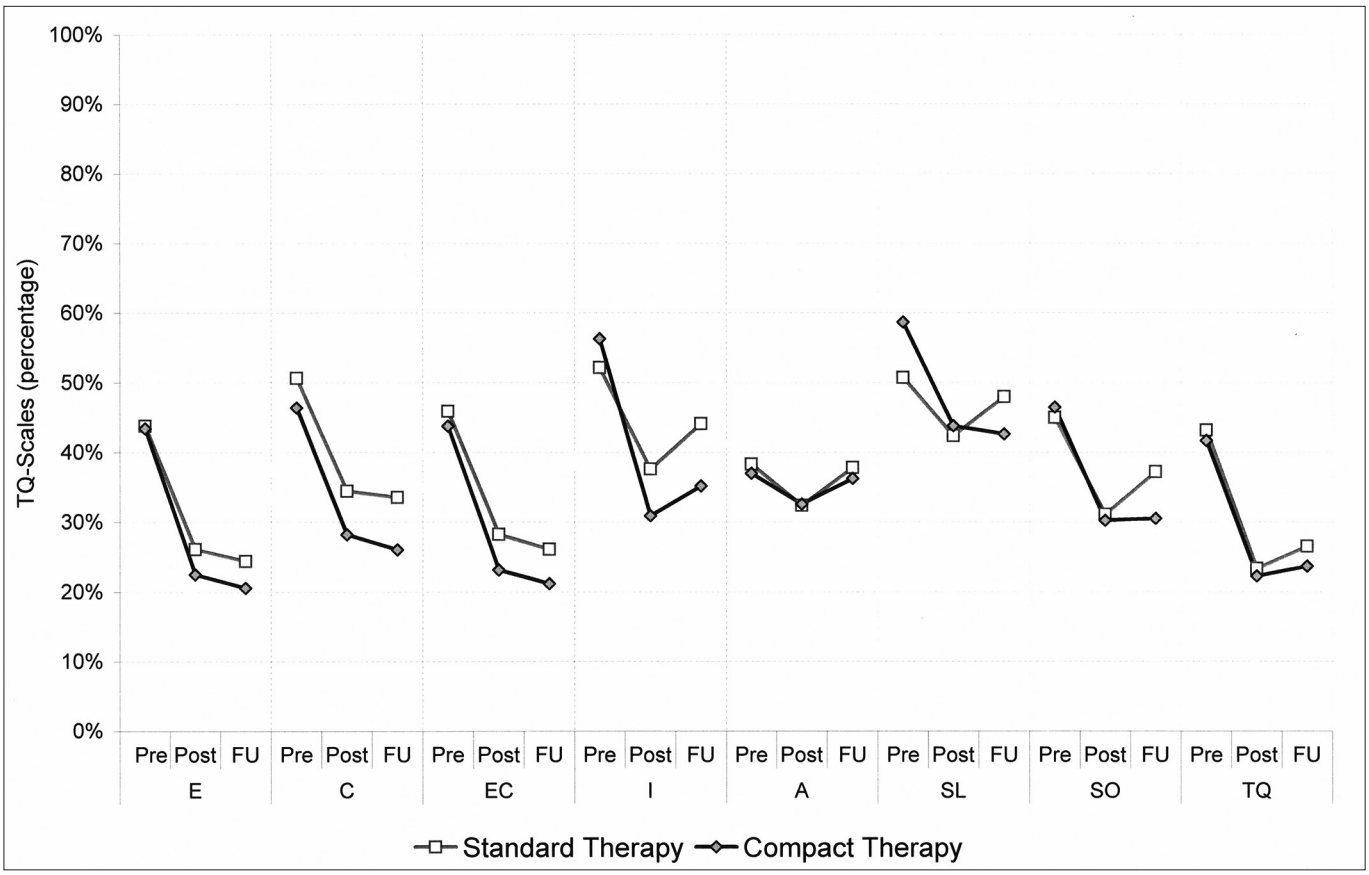

Figure 2. Subscales of the Tinnitus-Questionnaire (percentage). E: Emotional distress; C: Cognitive distress; E: Psychological distress; I: Intrusiveness; A: auditory perceptional difficulties; SL: Sleep disturbances; SO: Somatic complaints; Pre: admission to therapie; Post: discharge from therapy; FU: follow-up six months after therapy.

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