ORIGINAL ARTICLE

Flight or fight tinnitus? Tinnitus coping over time and psychophysiological reactions

Andrea Crocetti [1], Umberto Ambrosetti [2], Luca Del Bo [1]

[1] Tinnitus Clinic, Milan,Italy; [2] Università degli Studi of Milan, Clinical and Community Science Department. IRCCS Ca' Granda Ospedale Maggiore Policlinico Foundation. Audiology UOSD, Milan,Italy.

Correspondence to: Andrea Crocetti, PsyD; Tinnitus Clinic, Via Santa Sofia 29, 20122 Milan, Italy; tel. +39 3386272952; e-mail: andrea.crocetti78@gmail.com

Submitted: 2018-09-28 Accepted: 2018-10-31 Published online: 2018-11-03

Key words: **tinnitus; psychophysiology; tinnitus retraining therapy; cognitive - behavioral therapy; psychological disease**

Act Nerv Super Rediviva 2018; **60**(2): 49–54 ANSR600218A03

Abstract

OBJECTIVES: Tinnitus affects 10 to 15% of population. 0 to 5% develops significant influence on life quality, perceiving tinnitus as intrusive. It often causes restless state, sometimes coming up to a psychological disease. Researches show controversial data about correlation between tinnitus disease and psychophysiological arousal.

AIMS: Here we want to measure psychological disease and psychophysiological stress profile in tinnitus patients attending Tinnitus Retraining Therapy supported by cognitive – behavioural tools, and to measure time trend of the disease caused by tinnitus.

METHODS: A sample of 92 subjects underwent pre treatment assessment composed of psychometric questionnaires and for a subgroup psychophysiological stress profile. Then, follow up after three months with questionnaires were administered. We also re-tested psychophysiological stress profile after six months in order to look for some time-condition changing.

RESULTS: Results show correlations between disease given by tinnitus and psychological disease. The treatment protocol gives after three months significant improvement on tinnitus disease and also on the related psychological side. About psychophysiology, we have found that tinnitus perception does not improve arousal.

CONCLUSIONS: This study supports the efficacy of reconditioning methods on tinnitus perception and the subsequent disease on psychological sphere. Our data does not show psychophysiological arousal during tinnitus perception.

Abbreviations:
tinnitus retraining therapy (TRT), cognitive - behavioral therapy (CBT), central nervous system (CNS), autonomous nervous system (ANS), pre treatment term (T0), re test at three months (T1), Tinnitus Handicap Inventory (THI), Cognitive Behavioral Assessment Outcome Evaluation (CBA - OE), frontal muscle contraction (EMG), peripheral temperature (T), galvanic skin response (GSR), heart rate (HR), microvolt (μV), microSiemens (μS), Celsius degrees (°C), beats per minute (bpm), eta squared ($p\eta 2$).

Introduction

Tinnitus is a sound perceived into the ear or head without an external source. It could be perceived as a pure tone or a composed noise. Tinnitus is a symptom, often not representing an organic pathology. It involves auditive systems, from the ear to the peripheral nervous system and up to the CNS (Eggermont & Roberts 2004). Neurophysiological evidences show anomalous activation of the auditory system (Weisz *et al* 2007) and CNS (Schmidt *et al* 2017). Among the most frequent etiology, we find cochlear damaging, represented tonotopically in the auditory cortex (Norena *et al* 2002), where an alteration of the spatial representation of the auditory frequencies has also been observed (Mulnichel *et al* 1998). Perceptional paths involve cognitive aspects (Kandel 2012), besides structures active for the emotional reaction. Tinnitus stimulus firstly generates an automatic activation and then it could become a topic important to be perceptually and cognitively evaluated. A synthetic model to describe tinnitus neurophysiological pattern is offered by Jastreboff (Jastreboff *et al* 1996). Interesting to note McKenna (McKenna *et al* 2014) model, where tinnitus is a trigger of dysfunctional automatic thoughts, possible expression of a negative stress coping style (Heinecke *et al* 2008). It promotes distress and drives attention to a selection of stimuli, like tinnitus and often external sounds that could appear amplified to the subject consciousness and sometimes feared. A similar process can be seen in chronic pain (Moller 2007), where an objective somatic damage and a subjective reaction modulate the pain amount.

Tinnitus is perceived by 10 to 15% of the population. 0 to 5% develops significant influence on life quality, perceiving tinnitus as intrusive (Davis & El Rafaie 2000; Baguley *et al* 2013; Gallus *et al* 2014). People suffering for tinnitus fail to adaptively process this signal. *Flight* strategy as commonly intended – escape – is not possible because of tinnitus internal features. *Fight* strategy is applied in different ways: from the naïf ones independently elaborated by patients to specific treatment protocols. A common fight strategy could be translated in the willingness to erase tinnitus. Attending failings, many, and often frustrating, attempts can be repeated (Heinecke *et al* 2008). Increasing stress condition and sometimes psychological disease result. Tinnitus perception and reaction increase each other. This loop could be associated to obsessive – compulsive pattern: intrusive stimulus calls for behaviors aimed to control it, attention is fixed on it and consequently it appears as amplified. Obsessive-compulsive trait is associated with a worse coping of tinnitus (Sahlsten *et al* 2017).

TRT sees a counseling for the patient's education on tinnitus physiology and possible cognitive and emotional consequences; then a personalized sound enrichment aimed to associate tinnitus with a new neutral answer is applied.

Looking at studies about ANS, some psychophysiological experiences evidenced a sympathetic activation in tinnitus patients (Olderog *et al* 2004). Literature not offers many studies about psychophysiology and tinnitus and fewer about how tinnitus stimulates ANS activation comparing it to other stimuli activation power. Therefore, here we have planned a psychophysiological stress profile with different stressful stimuli. The measure is recorded before the treatment. We have repeated the measurement after six months of treatment.

The other goal of this study was to measure treatment effects, so we administered questionnaires pre treatment and after three months looking for the efficacy in a considerable short time.

Tab. 1. Subjects sociodemographic characteristics.

	TO sample		**T1 sample**	
	N=92		**N=61**	
	N(%)	**M (SD)**	**N(%)**	**M (SD)**
age	91	51.8 (13.7)	60	52.4 (14.7)
schooling	89	13.6 (3.5)	61	13.1 (3.2)
male	63 (68.5%)		45 (73.8%)	
married	55 (59.8%)		36 (59%)	
cohabitants	4 (4.3%)		2 (3.3%)	
divorced	11 (12%)		8 (13.1%)	
single	20 (21.7%)		13 (21.3%)	
widower	2 (2.2%)		2 (3.3%)	
personalized TRT device	87 (94.6%)		49 (80.3%)	
positive psychopathological diagnosis	33 (35.9%)		23 (37.7%)	

Methods

Participants

We included in the study Caucasian people affected by tinnitus for six months at least, inner ear etiology, adult, male and female. People with other tinnitus treatment in progress, tinnitus originated in the middle ear, subjects with neurological pathology, psychosis or dementia were excluded, sending them to specific treatments of the case.

Our study for tinnitus improvement evaluation involved n.92 subjects at T0. N.61 participated to re test at T1. Table 1 shows sociodemographic features. Males at T0 are 68.5%. Mean age of the whole sample 51.8 (SD 13.7). Males were 73.8% at T1. Total mean age at T1 52.4 (SD 14.7). T-test and chi-square test showed no significant differences comparing subjects who completed the follow up to drop out subjects. At T0, 35.9% of the sample presents psychological disease.

N.21 subjects participated at psychophysiological measures at T0 and n.18 at sixth month follow up.

Procedure

We have developed a perspective study at Tinnitus Clinic in Milan, recruiting during 20 months subjects who started the treatment. ORL physician firstly evaluated the audiological aspect, defining tinnitus etiology. Then assessment sees questionnaires administration: THI (Newmann *et al* 1996) for tinnitus disease measure, CBA – OE (Michielin *et al* 2008) to assess level of anxiety, depression, subjective well being, perception of change, general discomfort. Psychophysiological stress profile were administered using a device made by Satem. Channels recorded were: frontal muscle contraction, peripheral temperature, skin conductance, heart rate. Psychophysiological stress profile is composed by no task periods alternated with stressful stimuli periods. Stressors were cognitive, emotional and attention focused on tinnitus.

TRT devices were personalized sound generator for 94.6% of the sample at T0 and 80.3% at T1; the other part used environmental sound enrichment.

Specific interview were administered to evaluate the presence of psychological disease.

Questionnaires were administered pre treatment and after three months.

Psychophysiological stress profile was recorded pre treatment and after six months.

Materials

THI is composed by 25 items, multiple choice, with three possible answers on Likert scale, score range 0–100. It has good internal consistency (Cronbach α=0.93).

CBA – OE is composed by 80 items multiple choice with five possible answers on Likert scale scoring from 0 to 4. In this study, Cronbach α at T0: anxiety 0.89; subjective well being 0.93; perception of change 0.75; depression 0.91; general discomfort 0.82. Cronbach α at T1: anxiety 0.90; subjective well being 0.93; perception of change 0.77; depression 0.89; general discomfort 0.82.

Anxiety is considered moderate if score is from 26 to 35, severe anxiety scoring above 36. Subjective well being moderate with scores from 19 to 11, severe if lower (or equal) than 9. Moderate perception of change with scores from 18 to 12, severe if score is 10 or lower. Moderate depression with score from 33 to 42, severe above 45. General disease: moderate from 27 to 41, severe above (or equal) 43.

Biofeedback instrument used for psychophysiological measure has an EMG sensitivity of 0.01 μV, 0.01 °C for peripheral temperature, 0.01 μS for skin conductance, 0.1 bpm for heart rate.

TRT was calibrated with sound enrichment devices, assessed considering patient's auditive condition, or environmental device.

During treatment, clinical session and technical controls for the devices were planned at T0, after one month, at T1 and after six months. Clinical sessions were aimed to thoughts restructuring about tinnitus, physiology education about auditive perception, knowledge and skills development about alert reaction, homework for attention focus. Suspecting related psychopathology, deepening assessment and suggestions about specific treatments to be added were suggested to the patient.

Data analysis

The Statistical Package for Social Sciences (SPSS 23.0) was used in data analysis. After data screening, descriptive statistics were computed to report participants' sociodemographic characteristics and study variables. Independent samples *t*-tests and chi-square tests were performed to examine differences between the participants dropping out after T0 (n=31) and those completing the study at T1 (n=61). Since the literature identifies a potential relationship between a diagnosis of psychopathology and tinnitus perception (Salviati *et al* 2014), Pearson's correlations were further computed to determine the strength of this relationship. Diagnosis was coded as a dummy variable (0=absence of psychopathology; 1=presence of psychopathology). At both times, correlations were significant for diagnosis with psychological variables. Therefore, diagnosis was entered as covariate in subsequent one-way repeated ANOVAs, which were performed to evaluate change in our outcome variables over time, from T0 before treatment to T1 after three months of treatment. If the omnibus tests were significant, pairwise comparisons with Bonferroni adjustment were finally performed between times. The strength of effect sizes was evaluated through partial $p\eta^2$ with 0.01 indicating a small, 0.06 a moderate, and 0.14 a large effect (Cohen 1988).

Tab. 2. Pearson's correlations between positive psychopathological diagnosis, tinnitus disease (THI) and psychometric measures. Below the diagonal values at T0, above at T1.

	1	2	3	4	5	6	7
1 THI	–	0.691***	–0.607***	–0.617**	0.703***	0.624***	0.382**
2 Anxiety	0.351**	–	–0.66**	–0.642**	0.744***	0.646***	0.306*
3 Subjective well being	–0.403**	–0.589**	–	0.900***	–0.718**	–609**	–0.233
4 Positive changing	–0.344**	–0.512**	0.832***	–	–0.775**	–0.57**	–0.21
5 Depression	0.455***	0.801***	–0.727**	–0.724**	–	0.797***	0.453***
6 General psychological disease	0.424***	0.764***	–0.522**	–0.538**	0.808***	–	0.427***
7 Psychopatological diagnosis	0.297**	0.302**	–0.338**	–0.291**	0.443**	0.374**	–

Tab. 3. Mean THI and CBA - OE scores at T0 and T1.

	TOTAL M	SD
THI TO	49.674	19.6
THIT1	30.131	18.6
CBA OE anxiety TO	18.53	9.1
CBAOE anxiety T1	14.12	8.7
CBA OE depression TO	19.63	11.9
CBA OE depression T1	15.4	10.3
CBA OE general psychological disease TO	13.88	8.4
CBA OE general psychological disease T1	10.84	7
CBA OE positive changing TO	22.91	5.5
CBA OE positive changing T1	24.07	6.4
CBA OE subjective well being TO	26.59	9.9
CBA OE subjective well being T1	30.98	10.2

Tab. 4. Psychophysiological values at T0 and at six months follow up.

	TO	6 months follow up
EMG cognitive stressor	6.25	7
EMG emotional stressor	8.5	6.98
EMG tinnitus perception	3.3	4.6
GSR cognitive stressor	9.33	7.6
GSR emotional stressor	10.21	9.43
GSR tinnitus perception	8.54	7.26
T cognitive stressor	33.12	33.39
T emotional stressor	33.22	33.39
T tinnitus perception	33.06	33.53
HR cognitive stressor	73.84	73.74
HR emotional stressor	71.04	70.94
HR tinnitus perception	65.71	69.71

Results

Table 2 shows correlations between tinnitus disease, psychological disease and diagnosis of psychopathology, at T0 and T1. Correlations are almost always significant at T0 and at T1. In detail, at T0 tinnitus disease correlates with psychological disease and specifically with anxiety, depression, general disease levels and inversely with subjective well being and changing perception levels. At T1 correlations panorama is quite the same. Tinnitus disease becomes worse when psychological status is disturbed.

We have evaluated temporal trend of THI and CBA – OE scores. Psychopathology was considered as covariate. Table 3 synthetizes questionnaires scores at T0 and T1. Mean THI score is 49.67 (SD 19.6) at T0 and 30.13 (SD18.6) at T1. Scores decreases significantly in time [F(1.59)=43.93, $p<0.01$; pη^2 0.427]. Specifically, score decreases from 45.36 to 24.63 at T1 (SD 15.0) if psychopathology is not diagnosed, and from 57.39 to 39.2 (SD 20.8) if present (Figure 1). Psychopathological disease gives a significant contribution on tinnitus disease severity ($p=0.002$; pη^2 0.156).

After three months of treatment, anxiety gets better [F(1.54)=7.38, $p<0.01$; pη^2 0.120]. Significant the psychopathological diagnosis contribution on anxiety level ($p=0.02$; pη^2 0.098). Significant the mood tone increasing [F(1.56)=10.24, $p<0.01$; pη^2 0.155], with contribution of psychopathological diagnosis on it ($p<0.01$; pη^2 0.227). General discomfort improves [F(1.55)=6.22, $p=0.02$; pη^2 0.102), with contribution of psychopathological diagnosis on its severity ($p<0.01$; pη^2 0.197). Patients do not seem to perceive significant change of their general condition [F(1.56)=1.32, $p=0.26$; pη^2 0.023], and also here psychopathological diagnosis affects this variable ($p=0.04$; pη^2 0.071). Subjective well being improves [F(1.50)=5.72, $p=0.02$; pη^2 0.103]; psychopathological diagnosis influences ($p<0.01$; pη^2 0.131) this variable amount.

Table 4 describes mean psychophysiological values during stressors terms of the profile at T0 and after six months. Generally, attention focus on tinnitus does not seem to produce sympathetic activation. In detail, at T0 the difference is significant between cognitive stressor *vs* attention on tinnitus about muscle contraction ($p=0.007$) and heart rate ($p=0.003$). Emotional stressor

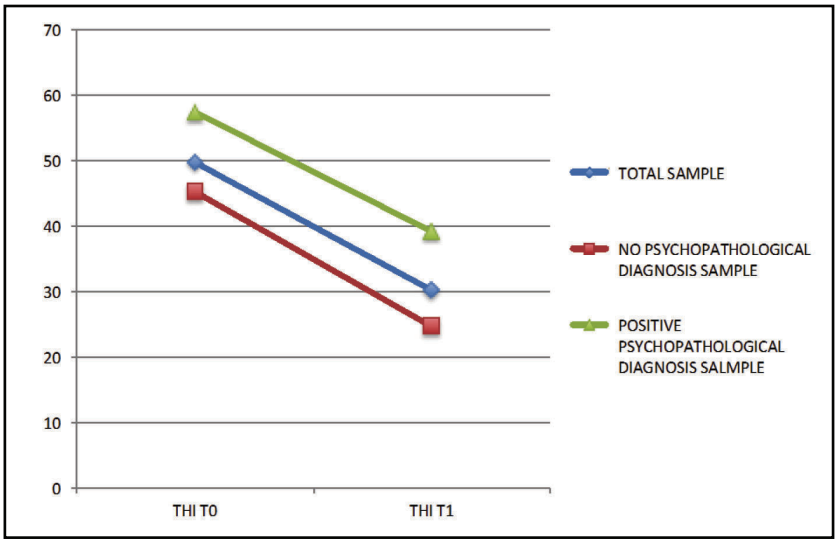

Fig. 1. THI time trend at T0 and T1.

and attention on tinnitus are different about skin conductance channel (p=0.005) and heart rate (p=0.003). Temperature does not show considerable changes.

At sixth month follow up, cognitive stressor and attention on tinnitus are different about muscle contraction (p=0.006) and about heart rate (p=0.009). P=0.052 skin conductance difference between emotional and cognitive stressors. No significant changes about temperature.

We do not record significant change of reaction during time to cognitive and emotional stimuli.

We added an observation about questionnaires scores at six months: THI decreases for the whole sample to 25.65. So the fastest part of the improvement is in the first three months.

Discussion

This study describes time trend tinnitus disease and shows psychophysiological condition according to a specific stress profile recording. Fragile psychological condition or overt psychological disease correlates with a more difficult tinnitus coping. Patients show good improvements after three months. Our model, adding to TRT sessions based on cognitive behavioral concepts, allows to reach these improvements in few months. Also the related psychological disease gets better, even if our observations suggest to deep the assessment and to specify treatment when the psychological pattern is complicated. Our model aim is to offer a powerful help to tinnitus patients. A different frequency of sessions, above all for patients with significant disease, could be an interesting development: we could measure if tinnitus disease decreases in a bigger amount and if general psychological disease, seen as related, does the same and which could be its trend during time. The two topics, tinnitus and psychological disease, have to be considered clearly and not completely overlapped. Benefits could be reached from an evidence-based contribution, with a team engaged to the parts involved in tinnitus disease, as already neurophysiology data suggest us (Eggermont & Roberts 2012), and as principal tinnitus models describe. According to it, where clear psychopathological disease is evaluated, specific support and parallel treatments should be planned. The team and the patient share each specific contribution, useful to the complex frame that tinnitus involves.

Psychophysiological data of this study were against our expectation of tinnitus contribution on sympathetic activation. Focusing attention on tinnitus during the psychophysiological profile recording was not activating. Some data (Heinecke *et al* 2008) specify that coping strain is not correlated with psychophysiological condition, but to a dysfunctional process during stress condition. The authors suggest that the first aim should be to develop suitable coping skills. Our data settle on this direction. During psychophysiological stress pro-

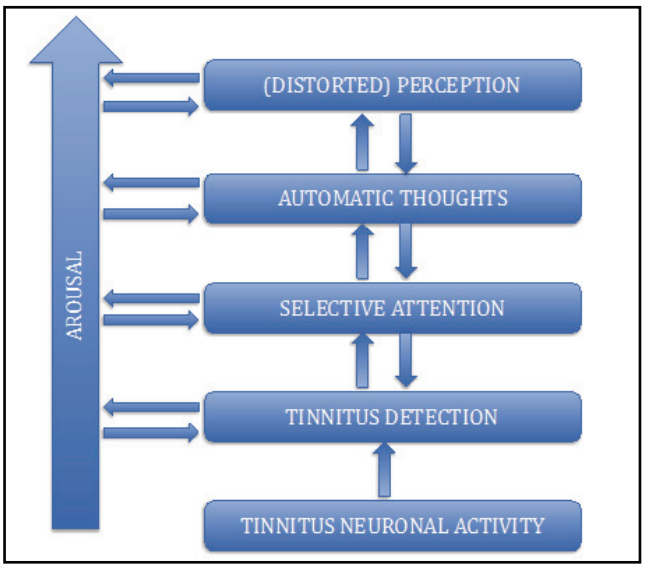

Fig. 2. The model describing a possible loop that tinnitus starts.

file, the operator told patients to listen to tinnitus. We think that this instruction could put the subjects into an unaware acceptance attitude of tinnitus, bypassing the automatic *fight or flight* strategies. One of the targets of treatments could be the development of a third way of reaction, with tools aimed to acceptance, with tinnitus newly conditioned to a reaction of quietness. A hypothesis could be that an interesting coping style is composed by the skill to disassociate tinnitus from the automatic reaction of distress it calls. Patients who realize it tell tinnitus becomes a stimulus without emotional and cognitive meanings, without its stimulus function, not eliciting a significant reaction. The model represented in Figure 2 can describe a possible loop that tinnitus starts, and it could stimulate areas of treatment.

Limits in this study are the intra subject control, not with a group not attending to any treatment, and the drop out amount, even if it does not change sample features during time. Then, one development could be a methodology with a waiting list control group. Useful to plan precise steps of supportive treatments based on disease assessment, preferably administered during the first patient access.

Notes. *THI Cronbach α of our study was not possible to be calculated because the digital version of the test directly gave total score.*

REFERENCES

1 Baguley D, McFerran D, Hall D (2013). Tinnitus. *Lancet.* **382** (9904): 1600–1607.
2 Cohen J (1988). Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale NJ: Lawrence Earlbaum Associates. ISBN 0-8058-0283-5.
3 Davis A & El Rafaie A (2000). Epidemoiology of tinnitus. In: Tyler RS, ed. *The handbook of tinnitus.* San Diego: Singular. ISBN 1565939220. pp. 1–23.
4 Eggermont JJ & Roberts LE (2004). The neuroscience of tinnitus. *Trends Neurosci.* **27**: 676–682.
5 Eggermont JJ & Roberts LE (2012). The neuroscience of tinnitus: understanding abnormal and normal auditory perception. *Front Syst Neurosci.* **6**: 53.
6 Gallus S, Lugo A, Garavello W, Bosetti C, Santoro E, Colombo P Perin P, La Vecchia C, Langguth B (2014). Prevalence and determination of tinnitus in the italian adult population. *Neuroepidemiology.* **45** (1): 12–19.
7 Heinecke K, Weise C, Schwarz K, Rief W (2008). Physiological and psychological stress reactivity in chronic tinnitus. *J Behav Med.* **31** (3): 179–188.
8 Jastreboff PJ, Hazell JW, Graham RL (1996). Neurophysiological approach to tinnitus patients. *Am J Otol.* **17** (2): 236–240.
9 Kandel ER (2012). The age of insight. New York: Random House. ISBN 978-1-4000-6871-5.
10 McKenna L, Handscomb L, Hoare DJ, Hall DA (2014). A scientific cognitive behavioral model of tinnitus: novel conceptualizations of tinnitus distress. *Front Neurol.* **6** (5): 196.
11 Michielin P, Vidotto G, Altoè G, Colombari M, Sartori L, Bertolotti G, Sanavio E, Zotti AM (2008). New questionnaire to evaluate psychological treatment effects. *G Ital Med Lav Ergon.* **30** (A): 98–104.
12 Moller AR (2007).Tinnitus and pain. *Prog Brain Res.* 166: 47–53.
13 Mulnichel W, Elbert T, Taub E, Flor H (1998). Reorganization of auditory cortex in tinnitus. *Proc Natl Acad Sci USA.* **95** (17): 10340–10343.
14 Newman CW, Jacobson GP, Spitzer JB (1996). Development of the Tinnitus Handicap Inventory. *Arch Otolaryngol Head Neck Surg.* **122** (2): 143–148.
15 Norena A, Micheyl C, Chery-Croze S, Collet L (2002). Psychoacoustic characterization of the tinnitus spectrum: implications for the under- lying mechanisms of tinnitus. *Audiol Neurootol.* **7**: 358–369.
16 Olderog M, Langenbach M, Michel O, Brusis T, Khole K (2004). Predictors and mechanisms of tinnitus distress – a longitudinal analysis. *Laryngorhinootologie.* **83** (1): 5–13.
17 Schmidt SA, Carpenter-Thompson J, Husain FT (2017). Connectivity of precuneus to the default mode and dorsal attention network: a possible invariant marker of long-term tinnitus. *Neuroimage Clin.* **22** (16): 196–204.
18 Sahlsten H, Taiminen T, Karukivi M, Sjosten N, Nikkila J, Virtanen J, Paavola J, Jousta J, Niinivirta-Jousta K, Takala M, Holm A, Rauhala E, Loyttyniemi E, Johansson R, Jaaskelainen SK (2017). Psychiatric (Axis I) and personality (Axis II) disorders and subjective psychiatric symptoms in chronic tinnitus. *Int J Audiol.* **30**: 1–11.
19 Salviati M, Bersani FS, Terlizzi S, Melcore C, Panico R, Romano GF, Valeriani G, Macrì F, Altissimi G, Mazzei F, Testugini V, Latini L, Delle Chiaie R, Biondi M, Cianfrone G (2014). Tinnitus: clinical experience of the psychosomatic connection. *Neuropsychiatr Dis Treat.* **10**: 267–275.
20 Weisz N, Dohrmann K, Elbert T (2007). The relevance of spontaneous activity for the coding of the tinnitus sensation. *Prog Brain Res.* **166**: 61–70.