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Tinnitus and Influencing Comorbidities

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ABSTRACT

Numerous studies show that impairments in chronic tinnitus are closely connected with psychosomatic and other concomitant symptoms. This overview summarizes some of these studies. Beyond hearing loss, individual interactions of medical and psychosocial stress factors as well as resources are of central importance. Tinnitus related distress reflects a large number of intercorrelated, psychosomatic influences – such as personality traits, stress reactivity and depression or anxiety – which can be accompanied by cognitive difficulties and should be conceptualized and assessed within a vulnerability-stress-reaction model. Superordinate factors such as age, gender or education level can increase vulnerability to stress. Therefore, diagnosis and therapy of chronic tinnitus be individualised, multidimensional and interdisciplinary. Multimodal psychosomatic therapy approaches aim to address individually constellated medical, audiological and psychological influences in order to sustainably increase the quality of life of those affected. Counselling in the first contact is also indispensable for diagnosis and therapy.

Contents

1. Introduction

Subjective tinnitus is defined as the "conscious awareness of a tonal or composite noise for which there is no identifiable corresponding external acoustic source" which can be "associated with emotional distress, cognitive dysfunction, and/or autonomic arousal leading to behavioral changes and functional disability" [1].

How the tinnitus symptom impacts upon patients' daily lives is complex and largely determined by associated psychological experiences [2]. For example, it is crucial to distinguish between the "tinnitus sound" as an initial tonal symptom and "tinnitus-related distress" as a multi-layered psychological phenomenon. Current research suggests that reactive tinnitus-related distress is particularly important – as it can significantly facilitate chronification of the often harmless initial symptomatology [2, 3]. Tinnitus-related distress emerges against a background of pre-existing medical, psychological or social vulnerability and can manifest itself in a variety of functional phenomena, such as (1) other functional hearing disorders (e. g. hyperacusis), or (2) anxiety and depression cycles, which, in turn may involve (a) sleep or concentration difficulties, (b) cognitive difficulties, or (c) mood volatility [4].

Tinnitus is a common symptom: at least 14,7 % of the European population are affected at some point in their lives – and about one in a hundred people (1,2 %) reports high emotional distress following its onset [5]. The prevalence of tinnitus significantly increases with age and a deterioration of hearing ability [5]. Worldwide, the treatment of tinnitus causes significant cost, in particular when the symptom is experienced as highly distressing [6, 7].

Often – yet not always [8] – hearing loss or a hearing-related disorder precedes the emergence of the tinnitus sound [9–11]. Other risk factors include neurological (e. g. meningitis), cardiovascular (e. g. hypertension), or metabolic influences (e. g. diabetes mellitus) [12, 13]. Irrespective of potential medical influences, however, tinnitus-related distress has to be understood as a reflection of psychological experience that either reflects pre-existing emotional distress or distress as triggered by the tinnitus sound stimulus [14, 15]. Emotional distress can precede sudden hearing loss [16], facilitate the chronification of tinnitus perception[17], increase muscle tension [18] or, conversely, be triggered or intensified by the tinnitus sound [19, 20]. Interactions between the often harmless tinnitus sound and tinnitus-related distress are crucial for multimodal conceptualization and treatment of chronic tinnitus.

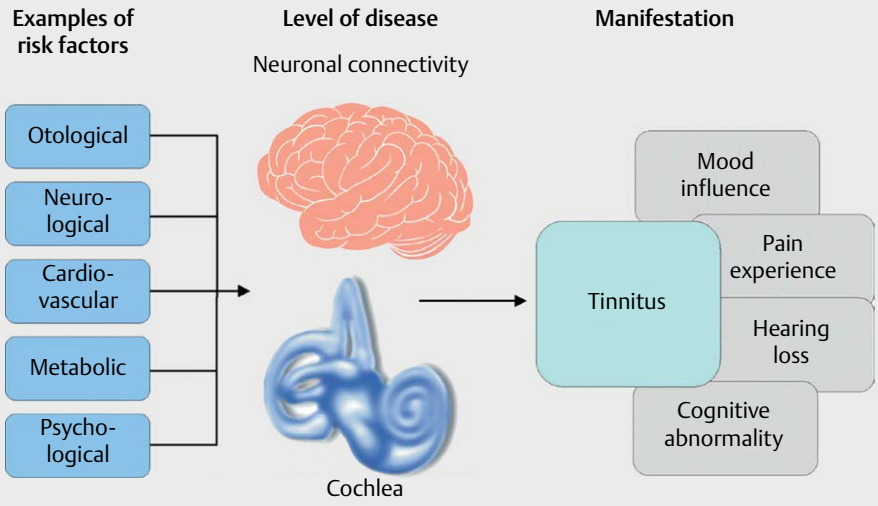
2. Multidimensional character of tinnitus

The current practice of diagnosing isolated index problems and categorically conceptualized 'comorbid' conditions, based on classification systems such as the DSM and ICD, is a hindrance to understanding multidimensional problems and developing effective treatment strategies. Tinnitus-related distress reflects many dimensional, interdependently connected influencing factors: Whilst the tinnitus *sound* can originate from medical risk factors such as hearing loss or vascular conspicuities [12], tinnitus-related *distress* and chronification is caused and maintained by psychological influences that must be individually and holistically formulated within a vulnerability-stress-reaction model [19, 21, 22]. Consequently, therapeutic approaches must be interdisciplinarily conceptualized [23, 24]. In this context, it is particularly relevant to turn to intensified psychosomatic diagnostics and treatment, including psychological vulnerability and concormitant factors – focusing on individual psychological and psychosomatic vulnerability, stress and coping factors [18] (▶ **Fig. 1**).

In a recently published study, Brueggemann et al. [25] demonstrated that tinnitus-related distress was closely associated with depressive experiences, emotional distress and other somatisation tendencies. These associations were more pronounced in people of older age and lower education – general risk factors for psychological distress [26]. While patients often attribute their emotional distress to the tinnitus symptom, pre-existing psychological distress likely extends towards the tinnitus sound as being experienced as more threatening [27]. The tinnitus sound itself can further be experienced as emotionally distressing –often in the context of pre-existing psychological vulnerability [19, 21, 28].

One study of tinnitus patients [21] used the revised Freiburg Personality Inventory (FPI-r) alongside a measure of perceived stress and demonstrated that tinnitus-related distress resulted from individual interactions of psychological vulnerability as reflected in measured personality traits and subjective stress experiences. The authors showed that certain personality traits (e. g. emotional excitability or inhibited aggressivity) interacted with perceived stress experiences in the here-and-now in explaining tinnitus-related distress. The study's particular relevance lies in its emphasis of individual psychological interactions and the importance of thereon-based treatment strategies [21]. A follow-up study demonstrated that psychosomatic and psychotherapeutic treatment of subjective stress experiences and worry lastingly reduced tinnitus-related distress [29]. ▶ **Fig. 2 (a)** illustrates the vulnerability-stress-reaction model and (b) putative psychosomatic associations in chronic tinnitus.

People with chronic tinnitus have a heterogeneous profile and often a complex medical history [30]. To reduce this heterogeneity, a recently published study [31] identified four subgroups of tinnitus patients ("phenotypes"): The first group is characterized by emotional avoidance tendencies and comprised a large proportion of the study sample. Apart from the index symptom "chronic tinnitus", members of this group reported little psychological distress – yet sought treatment in a psychosomatic treatment setting. The authors suggested that, in this group, the tinnitus symptom might be understood as a somatisation phenomenon that occurs within a broader context of emotional avoidance tendencies [32]. The second group comprised 15 % of the study sample and patients reported high psychosomatic burden, as reflected in high levels of tinnitus-related distress, depression, and anxiety alongside low psychological coping abilities such as self-efficacy or optimism and low quality of life. In this group, depressive or anxious symptoms are seen as the basis of the general symptom burden and tinnitus can be placed in a broader context of psychological stress experience. This subgroup included proportionally more women and patients who tended to live alone, seek work, or be less formally qualified. The third group was characterized by physical tension and subjective pain experiences that were highly correlated with emotional- and tinnitus-related distress. The fourth group was characterized by patients that showed strong associations between the tinnitus symptom and high levels of psychological stress – including anxious-depressive mood and related feelings of fatigue or exhaustion



▶ **Fig. 1** Tinnitus as multidimensional phenomenon (source "brain": iStock.com/Bohdan Skrypnyk.

respectively. Members of this group included proportionally more men and tended to be younger and employed. Overall, the study emphasized the importance of emotional distress (and its avoidance) in the maintenance of tinnitus-related distress. Physiological or genetic correlates of these distress experiences are the subject of ongoing psychosomatic research [33–38].

3. Interplay of neuronal networks of the tinnitus experience

It is currently assumed that chronic tinnitus is represented in "central" neural networks [39]. Different neurophysiological approaches that investigate the genesis of the tinnitus sound feature tonotopic reorganisation, neuronal synchronicity, neuronal spontaneous activity, or the limbic processing of auditory information [40, 41]. In addition to auditory cortical regions, extra-auditory areas such as the limbic system (insula and amygdala), the anterior gyrus cinguli, the ventral striatum, and the prefrontal cortex appear to be involved in chronic tinnitus symptomatology [42, 43]. Individuals with hearing loss also show neurophysiological changes in the firing rate of neurons along the central auditory pathway, neuronal synchronicity, and tonotopic organisation. These changes may reflect neuroplastic processes that can also occur as a result of the prolonged attentional focusing of the tinnitus sound [44]. In addition, compared to healthy subjects, patients with chronic tinnitus showed neurophysiological differences in the processing of affectively significant auditory stimuli in the area of the orbitofrontal brain and limbic system [45].

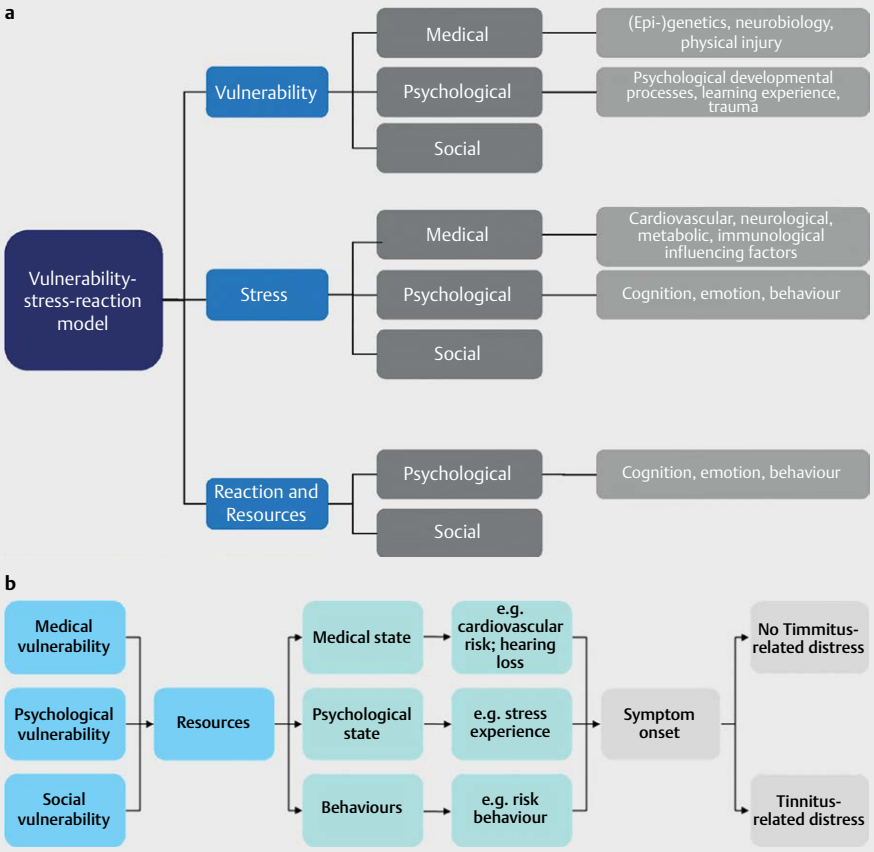
De Ridder et al. [42] describe a working model in which a conscious perception of the tinnitus sound results from increased neuronal activity of the sensory cortex. Herein, the tinnitus sound is considered as salient by means of parallel activated neuronal (self-) attention networks, and is evaluated affectively within a frontal-limbic non-specific distress network (anterior cingulate cortex, anterior insula and amygdala). By means of classical and operant conditioning processes, a coupling of conscious perception of the "tinnitus sound" and "distress experience" occurs both neurophysiologically and psychologically.

4. Comorbidities and influencing factors

Chronic tinnitus can be associated with severe distress. Studies using a categorical comorbidity model report that a large proportion of individuals with chronic tinnitus suffer from 'comorbid disorders'. In particular, anxiety disorders and depression [46–53] are common, as are other somatoform disorders [4, 54]. Studies examining subordinate phenomena further report strong associations between tinnitus-related distress and symptoms such as sleep [55] or concentration [56] difficulties.

4.1 Depression, anxiety, and stress

It appears that tinnitus-related distress is most closely interlinked with depressivity – also owed to strong construct overlap and similarities in psychological stimulus processing [57]. Emotional distress experiences as reflected in anxiety, depressivity or emotional exhaustion alongside associated symptoms such as sleep disturbances are often already present at the time of tinnitus onset. Thus, they are considered crucial for the chronification of the tinnitus sound [2, 3, 18]. Physical and emotional exhaustion can facilitate an increased perception of the tinnitus sound thereby negatively influencing its processing and experience [2]. Due to mutual reinforcement of these factors, the tinnitus sound is the "catalyst" of a vicious cycle between pre-existing vulnerability or reactive emotional experience and perception of the tinnitus sound. For example, one study demonstrated that 52,2 % of a sample of 1490 patients with chronic tinnitus reported depression [58]. Understanding the interaction and construct overlap of tinnitus-related distress and depressivity may improve prevention, assessment, conceptualization and treatment of both symptom groups [29, 59].



▶ **Fig. 2** **a** Vulnerability-stress-reaction model **b** Possible vulnerability-stress interactions in chronic tinnitus

Studies also show a close relationship between stress and tinnitus-related distress [60, 61]. Whilst cause-effect relationships remain unclear as well, chronic stress, which closely resembles anxiety and depression in its physiological effects [62] may reflect an increased vulnerability to tinnitus onset and tinnitus-related distress [63].

4.2 Subjective pain experiences

One strand of research examines similarities between chronic tinnitus and chronic pain experiences, as some chronic tinnitus patients describe co-occurrence of the tinnitus-related distress and pain sensations such as ear-, or headaches [64]. Paralleling models of chronic pain development and maintenance [65, 66], chronification of the tinnitus percept may be related to altered signal processing in the central nervous system alongside closely linked accompanying psychological factors [67]. In particular, interactions between the limbic system and the auditory or somatosensory cortex may play a role to this regard [42, 68]. A recent study investigated the co-occurrence of tinnitus-related distress and affective pain experiences [69]. Both symptom clusters were shaped by psychological factors such as depressiveness, perceived stress experiences, and coping attitudes – the therapeutic addressing of which was able to improve both symptom groups [29].

4.3 Hearing loss

In acoustic processing, sound signals are converted into afferent activity of the auditory nerve, which increases the activity of hierarchically ascending neural networks [70]. The acoustic signal travels through the brainstem, midbrain, and thalamic nuclei to the auditory cortex where it is given meaning by the non-auditory salience network and is consciously perceived [70]. At the same time, connections between the salience network and the limbic system assign emotional meaning to the sound [71].

Medically, hearing loss can often precede the onset of the tinnitus sound [72], and neurophysiological models discuss the effects of hearing loss on the auditory system, from the cochlea to the auditory cortex [73–75]. Hearing loss is often, but not always, associated with chronic tinnitus symptomatology [12, 76, 77] and has sometimes been reported to predict tinnitus-related distress [78].

Epidemiological studies show that tinnitus becomes more common with age, probably due to more frequent or severe hearing loss [11]. Studies have shown that most people with tinnitus show high-frequency hearing loss which is often correlated with high-frequency tinnitus perception [11, 79]. However, hearing loss and tinnitus-related distress are usually uncorrelated – highlighting the crucial importance of psychological third variables. For example, hearing loss can be measured in approximately 90 % of people with

tinnitus; however, most people with hearing loss report not have tinnitus, irrespective of the severity of the hearing loss [41]. It is possible that interactions of older age and hearing loss, cognitive changes, and anxiety or depression may contribute to distressing tinnitus experiences at older ages [80].

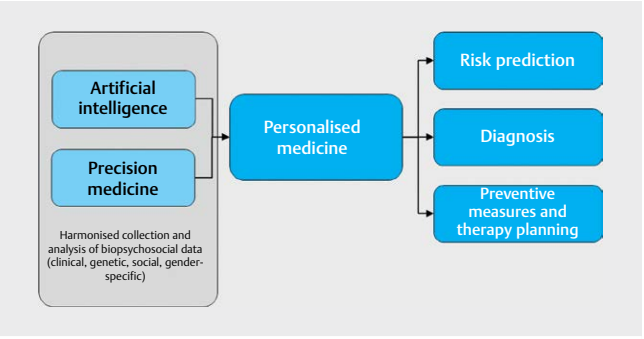
4.4 Cognitive influences

The role of cognitive factors in hearing loss, tinnitus or tinnitus-related distress is currently investigated intensively [81–83]. The term "cognition" denotes the sum of all thought and perception processes which can be conscious or unconscious [84], and many of which decline with age [85]. Clinically, it is noticeable that patients with chronic tinnitus often report difficulties that at least partially suggest cognitive influences – such as concentration or working memory difficulties [56]. However, in context of strong construct overlaps, it must be critically examined whether these difficulties might actually reflect depression-related difficulties that are merely attributed to the tinnitus symptom. Cognitive processes are closely interlinked with affective influences such as anxiety and depression [86, 87], as well as audiological processes [88]. Thus, whilst cognitive processes are relevant to hearing [89], hearing loss may conversely contribute to cognitive difficulties [82, 90, 91] as well as depressive experiences [92].

On a theoretical level, tinnitus may reduce individuals' cognitive capacity and executive control which are needed to perform tasks. Cognitive functions such as attention, concentration, and executive control are prefrontally controlled, and dysfunction of frontal neural processes may thus impede habituation to the tinnitus sound and, in interaction with the limbic system, reflect subjective distress experiences [93, 94]. For example, individuals with chronic tinnitus showed difficulties in attention and memory tests [95–97]. Recent neuropsychological studies [81, 98] further suggest that individuals with chronic tinnitus may exhibit executive difficulties, involving e. g. "stimulus inhibition" (i. e., the ability to suppress automatic responses) or "set-shifting" abilities (i. e., the ability to switch between different stimulus sources). These processes may, in turn, be linked to individuals' hearing ability and listening effort [99]. The "cognitive-perceptual load theory" [100] postulates that continuous perception of the tinnitus sound uses perceptual resources – which are consequently no longer available for other sensory environmental stimuli. Moreover, the tinnitus sound may use central resources such as stimulus discrimination and working memory capacities thus facilitating an increased cognitive load.

Depression research has linked interactions of reduced executive control and its effects on limbic circuits to patients' experiences of emotional excitability and reduced emotion regulation ability [101]. Negative effects of depression on cognitive processes such as working memory are also well established [102]. For chronic tinnitus patients, Neff et al. [83] observed an association between tinnitus-related distress and decreased crystalline intelligence and stimulus processing speed.

Overall, these results once again emphasize that, in addition to careful clarification of otological, audiological and internistic influences, psychological factors – including cognitive factors – ought to be taken into account for assessment and treatment planning.



▶ **Fig. 3** Outlook – personalised medicine.

5. Treatment options

Current guidelines recommend the provision of hearing aids for people with hearing loss and chronic tinnitus alongside psychoeducational "counselling" and psychotherapeutic approaches [103]. Hearing aids may positively influence tinnitus-related distress [104, 105]. For example, a recent randomized cross-over study demonstrated that a specific hearing aid fitting could reduce tinnitus-related distress in individuals with chronic tinnitus and mild-to-moderate hearing loss [106]. Whether hearing aids can also have a positive effect on cognitive difficulties is controversially discussed [80, 107–110]. Psychotherapeutic approaches are is the treatment option of choice for individuals who experience the tinnitus sound as highly distressing [104]. A recent review concluded that cognitive behavioral therapies significantly increased the quality of life of patients with chronic tinnitus [111]. Whilst psychodynamic therapy approaches have not been studied in randomized-controlled trials, effectiveness can still be assumed, as psychodynamically oriented multimodal treatment approaches achieve good results [112, 113]. Regarding mediators of treatment change, Cima et al. [114] reported that reductions in tinnitus-related anxiety significantly predicted treatment success of a special treatment developed by the authors. Another study that investigated mediators of treatment change for a multimodal treatment program identified the psychotherapeutic amelioration of "worry," "depressiveness," and "emotional tension" as mediators of treatment success [29].

6. Conclusion and outlook

The assessment, formulation and treatment of chronic tinnitus ought to be based on otological, audiological, psychosomatic and psychological diagnostics. The latter should apply validated questionnaires which do not apply mere symptom checklists, but which assess dimensions of psychological experiences and stimulus processing (e. g., catastrophizing tendencies, optimism-pessimism, or self-efficacy [115, 116]). Age- or mood-associated cognitive abnormalities should be assessed neuropsychologically, where indicated. Treatment procedures should be derived based on an individual psychosomatic case conceptualization, that links medical, audiological, and psychological aspects of the tinnitus sound within a broader, holistic context [19].

German and European guidelines also recommend a combination of multimodal therapy components that are tailored to individuals' needs [104]. For individuals with hearing loss, hearing aids are the initial treatment option of choice, where applicable. Preliminary evidence suggests that the use of hearing aids can benefit tinnitus-related distress for patients with mild-to-moderate hearing loss [106]. In cases of profound hearing loss, a cochlear implant should be considered [117–119].

The current gold standard for treating tinnitus-related distress are psychotherapeutic approaches that favorably influence tinnitus-related distress, quality of life as well as anxiety and depressivity [111]. Such treatment approaches must be individually formulated [21, 29] and consider sociocultural [120] as well as gender- [121, 122] or age-associated influences [123]. In case of severe emotional distress, day-care or inpatient treatments may be indicated.

In future, the field can expect further improvements in assessment and therapy. Novel research frameworks focus on dimensional (not categorical) conceptualizations of psychological distress [124–126], biomarkers of tinnitus-related distress [33, 35, 127] as well as refined psychotherapeutic treatment frameworks [128]. In addition, the importance of unified data collections [129–131] or methodological advances in big data analysis are of increasing importance [31, 58]. These developments pave the way for personalized medicine approaches across chronic conditions and multidimensional stress experiences (▶ **Fig. 3**).

Conflict of Interest

The authors declare that they have no conflict of interest.

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