Somatic Modulation Appears To Be A Fundamental Attribute Of Tinnitus

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Abstract

It is well known that an occasional patient can change her/his tinnitus with a head or neck maneuver. However, it is unknown how widespread this attribute of tinnitus is. This study was undertaken to answer this question. We physically examined 70 consecutive patients seen in our tinnitus clinic for their ability to modify their tinnitus with 16 brief but forceful extremity or head and neck isometric contractions. Regardless of etiology or audiometry, more than two-thirds of all subjects could modulate the loudness of their tinnitus with one or more of these maneuvers. As compared to extremity manipulations, head and neck manipulations were about twice as likely to modulate tinnitus, never were weaker in their effect, and always produced the same type of changes (i.e. louder or softer). These maneuvers sometimes resulted in prolonged effects and could alter pitch as well as laterality of the tinnitus percept. Decreased tinnitus loudness was far more likely to occur for subjects with monaural tinnitus than binaural tinnitus. These results suggest that somatic modulation may be a fundamental attribute of tinnitus on a par with the auditory and affective attributes of tinnitus.

Introduction

Tinnitus remains a puzzling symptom. Many fundamental questions regarding tinnitus are still enigmatic, such as (1) why some patients develop tinnitus and others do not despite an otherwise identical hearing disorder, (2) what determines when patients with a chronic progressive hearing loss develop tinnitus, or (3) why patients with symmetric hearing can develop tinnitus in only one ear. We have recently suggested that a somatic component of tinnitus mediated by auditory - somatic interactions within the brainstem may explain many of these mismatches between hearing loss and tinnitus [1] . At present, however, little is known about this putative somatic component of tinnitus.

Numerous reports have detailed the acoustic (e.g., pitch, loudness, masking properties, duration, or lateralization) and affective properties (e.g. emotional distress, sleep disturbance, distracting effect) of tinnitus; the somatic properties, however, have received much less attention. It has long been known, almost as a curiosity, that some people can modulate their tinnitus somatically. Møller et al. (1992) suggested that "some forms of tinnitus may involve the extralemniscal auditory pathway" and showed that median nerve stimulation could modulate tinnitus in close to 40% of subjects (15% louder, and 23% quieter) [2] . Rubinstein et al. (1993) found that about a third of their subjects could influence their tinnitus with jaw movements or pressure on the temporomandibular joint [3] . However there have been no reports in which patients were systematically examined for somatic modulation of tinnitus.

In this report we (a) describe our initial findings from systematic physical examinations of patients for somatic modulation of their tinnitus and (b) interpret these results in terms of the role of somatic-auditory interactions in tinnitus. Our results support the view that somatic modulation is more than a curiosity, and may be a fundamental component of tinnitus on a par with the auditory and affective components.

Methods

Seventy patients (21 F, 49 M; ages 18 to 87) seen consecutively at the Tinnitus Clinic of the Massachusetts Eye and Ear Infirmary between February and August 1999 were first interviewed and then examined for somatic modulation of tinnitus. First each patient was specifically asked whether pushing on the head, turning the head or eyes, clenching the teeth, or anything else could change her/his tinnitus. The patient also rated the loudness of her/his tinnitus on a zero to ten scale. Then, while sitting, different forceful contractions were performed by the patient; with each, the patient rated her/his tinnitus loudness and described any change in pitch or lateralization. Nine head and neck contractions were performed by the first 45 patients and an additional seven extremity contractions were performed by the last 25 patients (9 F, 16 M).

Contractions were made for a few seconds - just enough time for the patient to judge their tinnitus. For the head and neck the contractions were as follows: (1) clenching the teeth forcefully; with the head in the neutral position, maximally resisting pressure applied by the examiner to the (2) occiput, (3) forehead, (4) vertex, (5) mandible (upward), (6) right temple and (7) left temple; (8) with the head turned to the right maximally resisting torsional force on the right zygoma; and (9) as in (8), except on the left. The extremity contractions involved (10) locking the fingers of the two hands together and pulling as hard as possible, or resisting maximal pressure to (11) right shoulder abduction, (12) left shoulder abduction, (13) right hip flexion, (14) left hip flexion, (15) abduction or (16) adduction of both hips.

Results

Sixty-eight percent of all subjects could modulate their tinnitus with at least one of the 16 maneuvers. However, prior to the examination, most patients were unaware that any somatic maneuver could effect their tinnitus. Only sixteen of the seventy patients initially reported that that they could somatically modulate their tinnitus. The tinnitus of all but one of these subjects could be modulated on physical examination. No subjects were initially aware of any tinnitus modulation with trunk or extremity contraction.

The various maneuvers most commonly produced changes in tinnitus loudness. With head and neck manipulations, forty-one percent of subjects could only increase their tinnitus, seventeen percent could only decrease tinnitus loudness and ten percent could either increase or decrease tinnitus loudness depending upon the maneuver (Table 1). With extremity manipulations, nine subjects could increase their tinnitus loudness, only one could decrease it, and no subject could both increase and decrease it. Loudness changes produced by head and neck maneuvers were always greater than or equal to those produced by extremity maneuvers. Subjects who could modulate tinnitus loudness with extremity maneuvers could always modulate loudness with head and neck maneuvers, but the converse was not true. Whenever an extremity maneuver increased or decreased tinnitus loudness, head and neck maneuvers did the same. Nineteen percent of subjects could increase tinnitus loudness with head and neck maneuvers but not with extremity maneuvers. Seven percent could decrease tinnitus loudness with head and neck maneuvers but not with extremity maneuvers.

	Increase	Decrease	Increase & Decrease	None
EXTREMITY Modulation(N=27)	9 (33%)	1 (4%)	0 (0%)	17 (63%)
HEAD & NECK Modulation(N=70)	29 (41%)	12 (17%)	7 (10%)	22 (31%)

Table 1: Effect of somatic maneuvers involving the extremities (27 subjects) or head and neck (70 subjects) on tinnitus loudness.

In general if modulation occurred in subjects with binaural tinnitus, it affected the tinnitus for both ears similarly. However, there were some exceptions. One subject with binaural tinnitus reported that pressure applied to the occiput, forehead, or right temple increased tinnitus loudness from 5/10 to 8/10, in the right ear only. Another man described that his monaural right tinnitus disappeared with left temple pressure only to have tinnitus emerge in his left ear. A third subject with binaural tinnitus reported that pressure on either temple caused her tinnitus to shift its location toward the opposite ear. A fourth patient described that her tinnitus was in both ears but worse on the right; with pressure on either temple or turning to either side, her tinnitus became slightly louder on the right and softer on the left.

In five patients, changes in tinnitus loudness persisted long after the series of brief maneuvers had been completed. This was most pronounced for two subjects. For one, loudness increased from 5/10 to 10/10 after right temple pressure and remained elevated for about 10 minutes. In another patient, loudness decreased from 10/10 to 3.5/10 and her tinnitus changed from binaural to monaural; tinnitus loudness and location stayed in this altered state for the remainder of the visit.

Maneuvers also produced changes in tinnitus pitch. Twelve patients described such changes. Ten of these twelve reported changes in loudness as well. Of the seven who described the change in pitch as a "simple," six reported an increase in pitch and one described his tinnitus as being "less shrill." Of all sixteen maneuvers, clenching the teeth most commonly affected pitch. As for loudness, changes in pitch were more common for head and neck maneuvers than for extremities maneuvers. Of the 25 subjects tested with extremity maneuvers, six reported pitch changes with head and neck maneuvers while only one reported them for an extremity maneuver.

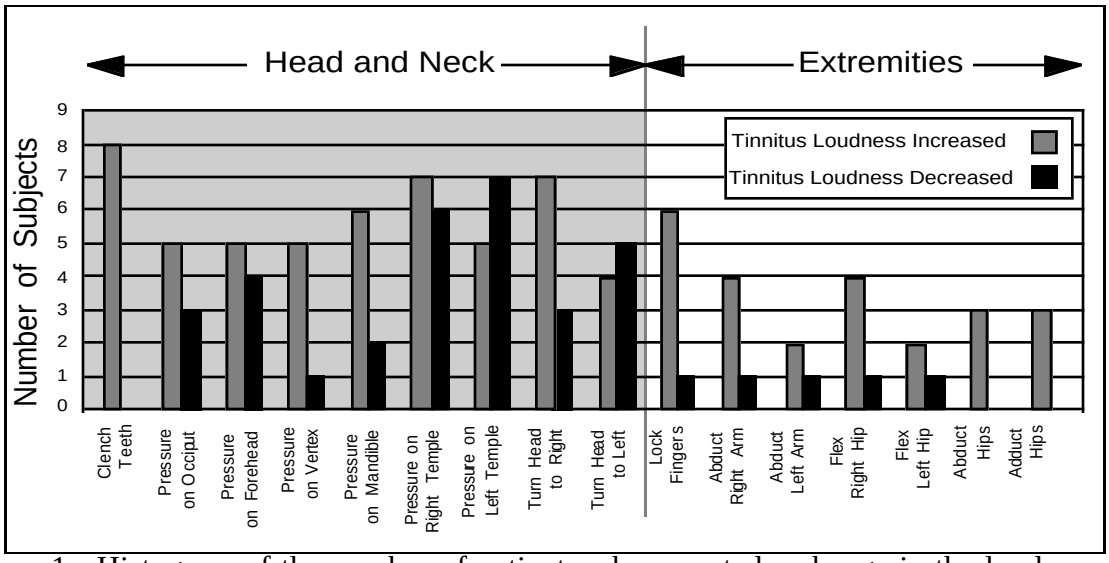

Figure 1: Histogram of the number of patients who reported a change in the loudness of their tinnitus for each of the sixteen somatic maneuvers (x-axis) that formed the basis of the physical examination. Only the patients with both head and neck and extremity maneuvers are included. Of these 25 patients, 17 could modulate their tinnitus loudness with at least one of the maneuvers.

Of the 25 subjects tested with both head and neck and extremity maneuvers, the number whose tinnitus loudness could be modified with each of the 16 maneuvers is shown in figure 1. The pattern of modulation was highly variable. Some subjects could modulate for only one of the sixteen maneuvers, while others could modulate for several of them. Clenching the teeth only increased tinnitus loudness, but every other maneuver could produce either an increase or a decrease depending upon the patient. Similar findings were obtained for the other 45 subjects who had only head and neck testing, except one subject reported her tinnitus decreased with clenching. Of all subjects who were tested with clenching, 28% reported an increase and 1% a decrease in tinnitus loudness.

No relationship between the pattern of somatic modulation and tinnitus etiology or audiometric findings was apparent. The patients who could be modulated carried the following diagnoses: Meniere's disease, unilateral acoustic neuroma surgery with deafness, noise-induced hearing loss, multiple sclerosis, ototoxicity, head trauma, presbycusis, familial hearing loss or idiopathic. Clearly tinnitus can be modulated in patients with a wide range of etiologies.

There was a striking relationship between decrease in tinnitus loudness and tinnitus laterality. Of the twelve subjects whose tinnitus loudness only decreased with somatic modulation, 67% described their tinnitus as monaural and yet monaural tinnitus subjects only accounted for 36% of all subjects tested (Table 2). Moreover, the four subjects with the largest decreases in tinnitus loudness (between 6.5/10 and 4/10) all had monaural tinnitus. By the z-test, this difference in the incidence of decreased tinnitus loudness for these two groups is statistically significant at the $p<0.05$ confidence level.

	Increase	Decrease	Increase & Decrease	None
MONAURAL Tinnitus(N=25)	8 (32%)	8 (32%)	2 (8%)	7 (28%)
BINAURAL Tinnitus(N=45)	21 (47%)	4 (9%)	5 (11%)	15 (33%)

Table 2 (near here): Effects of somatic maneuvers on tinnitus loudness in subjects with monaural (25 subjects) and binaural (45 subjects) tinnitus

Discussion and Conclusions

Our systematic physical examination of 70 unselected consecutive patients showed that somatic manipulations could alter tinnitus in about two-thirds of all subjects regardless of etiology or audiometry. The fact that such a substantial fraction of the patients seen in our clinic showed somatic modulation suggests that somatic modulation is a more common property of tinnitus than has been previously recognized and as reported in two earlier studies [2, 3] . This observation raises other questions. For example we have a patient who normally has no tinnitus but can induce tinnitus with a somatic maneuver of the head. Our findings in this report raise the possibility that, with systematic testing, such phenomena may be found to occur commonly in subjects who do not report having tinnitus. If somatic maneuvers can alter the perception of phantom sounds, another issue is whether they can alter the perception of an externally presented sound as has been reported for electrical stimulation of the median nerve [2].

While more than two-thirds of all patients could somatically modulate their tinnitus, nearly one-third could not. One possible reason for the lack of modulation is that the appropriate muscles were not activated by the maneuvers used, but might have been with other maneuvers. Consider, for example, the fact that two patients could only be modulated by one of the 16 maneuvers. If that one maneuver had not been performed these two patients would have been considered as non-responders. Another possibility is that, in some subjects, certain somatic maneuvers activate muscle groups that increase tinnitus loudness and others that decrease tinnitus loudness, so that the net result is no modulation of tinnitus. A third possibility is that some forms of tinnitus may simply lack a "somatic component." If so, then somatic modulation would provide a basis for distinguishing subpopulations of tinnitus subjects just as acoustic properties (pitch, loudness, masking properties, or lateralization) have been used to classify subpopulations of tinnitus patients [4, 5] .

The lesser effectiveness of extremity manipulations as compared to head and neck manipulations suggests that inputs to the auditory pathway from the cranial nerves and upper cervical region of the spinal cord play a greater role in the somatic modulation of tinnitus than inputs from the more caudal spinal cord. It is even conceivable that the influence of the extremities is artifactually high in our data, as would be the case if the extremity effects were not due to the extremity muscle contractions per se, but were instead a consequence of accessory contractions of head and neck muscles. Reasons for this suspicion are that (a) many subjects showed modulation only with manipulation of the head and neck, (b) no subject showed modulation with extremity manipulation without also showing modulation with head and neck manipulation, and (c) extremity modulation always produced the same type of loudness modulation (i.e. louder or softer) as head and neck modulation. Thus, it is possible that lower regions of the spinal cord actually play little or no role in the somatic modulation of tinnitus.

The greater involvement of upper rather than lower spinal cord regions in somatic modulation fits with our previous observations concerning somatic insults and tinnitus. We noted a correlation in some patients between the onset of tinnitus and such somatic insults as a dental abscess, or an upper cervical nerve root block - insults that specifically involve the head and upper neck and, thereby, the cranial nerves and upper cervical spinal cord [1] . These observations, combined with those of the present study, suggest that the neural circuitry mediating the onset of tinnitus after a somatic injury may also subserve somatic modulation of tinnitus.

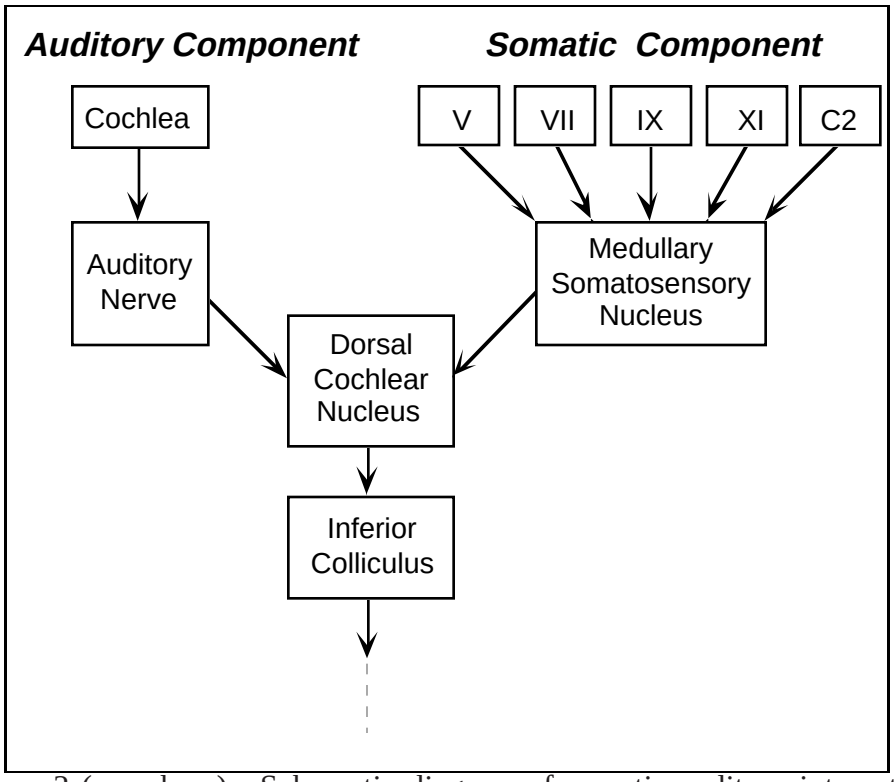

Figure 2 (near here): Schematic diagram of somatic-auditory interactions at the level of the dorsal cochlear nucleus. The dorsal cochlear nucleus receives ipsilateral auditory and somatic inputs (via the medullary somatosensory nucleus [6]). Our hypothesis is that the interaction between these two classes of inputs (a) determines whether or not tinnitus develops and (b) accounts for somatic modulation of tinnitus. A decrease in the somatic or auditory input to the dorsal cochlear nucleus is disinhibiting [7] and results in increased dorsal cochlear nucleus output to the inferior colliculus and higher centers, which ultimately leads to phantom sound perception (tinnitus). Presumably such tinnitus would be monaural because it arises from one cochlear nucleus. Roman numerals refer to the cranial nerves that that are known to converge on the medullary somatosensory nucleus [8] . C2 refers to the second cervical dorsal root.

Our finding that monaural tinnitus patients were far more likely to show a decrease in tinnitus loudness with somatic modulation than were binaural tinnitus patients is interesting in light of our recent proposal concerning the neural circuitry that may underlie the somatic component of monaural tinnitus [1]. We specifically suggested a neurological pathway that could account for a group of normal hearing patients with monaural tinnitus closely coupled to a somatic event. We proposed that, through a (known) multisynaptic pathway, head and neck somatic inputs ultimately disinhibit the output of the ipsilateral dorsal cochlear nucleus, resulting in tinnitus (figure 2). We speculate that decreases in loudness in response to somatic manuevers in patients with monaural tinnitus may occur because (1) the somatic pathway to the dorsal cochlear nucleus is activated, (2) inhibition of the dorsal cochlear nucleus is restored, and, consequently, (3) tinnitus loudness decreases.

A somatic component to tinnitus may provide the “missing link” needed to explain many unresolved issues in the tinnitus field. For example, it may account for the occurence of tinnitus in instances where there is no auditory insult [1] . Likewise, it may explain why some patients develop tinnitus and others do not despite an otherwise identical hearing disorder. Somatic modulation may also account for reports of controlling tinnitus with physical methods such as acupuncture, manipulation, or scalp electrical stimulation [9-11] . The patients who respond to these therapies may be those (a) whose tinnitus loudness decreases with somatic maneuvers and (b) in whom a brief maneuver can result in a prolonged effect.

We conclude that, rather than being an oddity, somatic modulation may be a fundamental property of tinnitus which can provide insights into understanding some of the basic mechanisms of tinnitus, can be the basis for distinguishing subpopulations of tinnitus subjects, and may be the basis for past successes in treating tinnitus. If this tinnitus factor can be better understood, it may be possible to use it as a treatment for tinnitus on a large scale.

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