# #54 Somatic Modulation of Tinnitus II: Prevalence and Properties in Non-Clinical Subjects

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## 1 Introduction

It has long been known, almost as a curiosity, that some people can modulate their tinnitus somatically. Møller et al. (1992) showed that median nerve stimulation could modulate tinnitus in close to 40% of subjects. 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. When interviewed, ~20% of our clinic patients report they can somatically modulate their tinnitus. For the past two years we have systematically examined all patients seen in our tinnitus clinic and found that 75% can somatically modulate their tinnitus (Levine, 1999b). However, the significance of this finding is uncertain, since there have been no reports of the effects of muscle contraction upon auditory perception in non-clinical subjects.

## 2 Objective

To understand the significance of somatic modulation in our tinnitus clinic patients, we studied the effect of somatic contractions upon spontaneous auditory perceptions in a non-clinical population. Our results support the view that somatic modulation is more than a curiosity restricted to tinnitus patients, and may be a fundamental property of the human auditory system.

## 3 Methods

- Subjects: 60 adults from personal contacts participated in this study (38 males, 22 females, ages 18 to 74, mean age = 41).
- **Questions:**

Prior to somatic testing, the following questions were asked:
1. Do you have tinnitus?
2. Do you have normal hearing?
3. Do your ears ever ring after a loud sound?
4. Do you ever have a brief ring in one ear, lasting a minute or less?

- **Procedure:** 25 brief, forceful contractions were made by each patient in a low-noise room. Duration of contractions was only a few seconds -- just enough time for the subject to judge his/her auditory perceptions.
  - 10 involved **jaw**
  - 10 involved **head and neck**
  - 5 involved **extremities**

**Jaw contractions**

1) clench the teeth together forcefully
2,3) maximally open mouth, with and without restorative pressure
4,5) maximally protrude jaw, with and without restorative pressure
6,7) maximally slide jaw to left, with and without restorative pressure
8,9) maximally slide jaw to right, with and without restorative pressure
10) maximally retract jaw

**Head and Neck contractions**

With the head in the neutral position, contractions were made to resist maximal pressure applied by the examiner to:

11) occiput
12) forehead
13) vertex
14) mandible (upward)
15) right temple
16) left temple

17) with the head turned to the right, maximally resist the tortional force on the right zygoma
18) with the head turned to the left, maximally resist the tortional force on the left zygoma
19) with the head turned to the right and tilted to the left, maximally resist force applied to the left temple (left sternocleidomastoid)
20) with the head turned to the left and tilted to the right, maximally resist force applied to the right temple (right sternocleidomastoid)

**Extremity contractions**

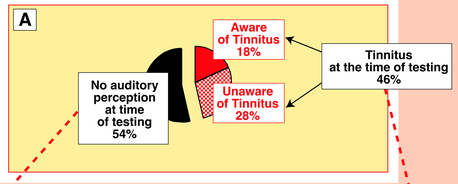
21) locking the fingers of the 2 hands together and pulling as hard as possible

Resisting maximal pressure to:
22) right shoulder abduction
23) left shoulder abduction
24) right hip flexion
25) left hip flexion

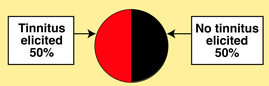
## 4 Results

### All Non-Clinical Subjects (N=60)

1. 18% reported tinnitus; another 28% became aware of tinnitus in the low-noise testing room
2. 85% reported normal hearing; 15% reported mild hearing loss
3. 73% reported an occasional brief ringing in one ear




### B Somatic testing elicited tinnitus in 50% of Non-Clinical subjects initially without tinnitus.




Example:
Subject 1. Head and neck contractions elicit auditory perceptions in a subject without tinnitus.

This 26 year old woman reported normal hearing and was unaware of any tinnitus. She had noticed transient tinnitus following exposure to intense sounds, and occasionally would hear a brief ring in one ear. In the quiet testing room prior to any somatic maneuvers she described no auditory perceptions.

**Somatic Testing**

| Condition* | Right Ear Tinnitus | Left Ear Tinnitus |
|---|---|---|
| **Baseline (0 - 10 Scale)** | 0 | 0 |
| 11. Occipital Pressure | 1 | 1 |
| 12. Forehead Pressure | 2 | 2 |
| 13. Vertex Pressure | 2 | 2 |
| 14. Mandibular Pressure | 2 | 2 |
| 16. Left Temple Pressure | 0 | 2 |
| 19. Left Sternocleidomastoid | 0 | 2 |

*Only maneuvers that modulated her auditory perceptions are shown.
Her elicited tinnitus was described as a "very high pitch ring".

### C Somatic testing changed tinnitus in 75% of Non-Clinical subjects who had ongoing tinnitus at the time of testing.

### Head & Neck contractions changed tinnitus more effectively than Extremity contractions

- **In all cases where Extremity contractions modulated or elicited tinnitus, Head & Neck contractions also did, but the reverse was not always true.**
- **Twice as many subjects could modify or elicit their tinnitus with Head & Neck contractions as with Extremity contractions.**
- **Loudness changes due to Extremity contractions were always weaker than or equal to changes due to Head & Neck contractions.**
- **Whenever an Extremity contraction increased tinnitus loudness, a Head & Neck contraction also increased tinnitus loudness.**
- **Whenever an Extremity contraction decreased tinnitus loudness, a Head & Neck contraction also decreased tinnitus loudness.**

### The effect of somatic manipulations was sometimes prolonged

Example:
Subject 2. Subject with unilateral tinnitus of which he had never been aware. His tinnitus is suppressed with somatic modulation and the suppression is prolonged.

This 61 year old man reported a mild hearing impairment for 10 years (see audiogram below). He was uncertain whether he had ever experienced tinnitus following exposure to intense soulds, or an occasional brief ring of one ear. While he was unaware of any tinnitus, in a quiet room prior to somatic testing he perceived in his right ear a sound "like waves hitting the shore."

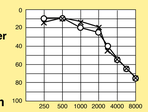
**Somatic Testing**

| Condition* | Right Ear Tinnitus | Left Ear Tinnitus |
|---|---|---|
| **Baseline (0 - 10 Scale)** | 3 | 0 |
| 1. Clenching | 4 | 0 |
| 15. Right Temple Pressure | 1 | 0 |
| 17. Right Head Rotation | 0 | 0 |
| 22. Right Shoulder Abduction | 4 | 0 |

*Only maneuvers that modulated his tinnitus are shown.

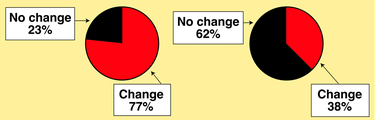
**With completion of the somatic maneuver of turning the head to the right against resistance, his tinnitus remained imperceptible for more than 3 minutes following release of resistance.**

**Audiogram**




### E 52% of all Non-Clinical subjects reported experiencing transient tinnitus after an intense sound

**With somatic testing, those who report tinnitus after an intense sound were much more likely (p<.02) to experience a change in spontaneous auditory perception than those who do not.**




Compare

### Clinical Subjects (N=128) (see Levine, 2000)

### D Somatic testing changed tinnitus in 76% of clinical tinnitus subjects

**Changes in loudness, pitch, and location were similar in Non-Clinical and Clinical Subjects**

## 5 Discussion

**1. Somatic modulation of tinnitus is common,** whether or not it is a clinical problem, and even whether or not people are aware that they have tinnitus. (Panels B, C and D)

This study demonstrates that somatic modulation is widespread and is not restricted to clinical patients. The ability to somatically modulate is therefore not what makes tinnitus a clinical problem.

**2. Some cases of clinical tinnitus may be due to activation of latent somatic-auditory interactions.**

Because in half of all subjects who hear nothing in the quiet, somatic testing can elicit an auditory perception (tinnitus) (Panel B), activation of such interactions could account for some cases of clinical tinnitus such as the somatic tinnitus syndrome (including the tinnitus associated with the temporomandibular joint syndrome or whiplash).(Levine, 1999a)

Example:
**Subject 3. Tinnitus Clinic patient with quiescent unilateral tinnitus reactivated by ipsilateral sternocleidomastoid contraction**

This 29 year old woman had been highly distressed for 7 months due to RIGHT ear tinnitus, which had resolved 2 months prior to her clinic visit. Audiometry was normal. At the time of testing she was no longer distressed but did hear slight constant ringing of both ears (1 on a scale of 10), which was much fainter than her previous right ear tinnitus. The tinnitus elicited by Somatic Testing was identical to her previous right ear tinnitus.

**Somatic Testing**

| Condition* | RIGHT Ear Tinnitus | Left Ear Tinnitus |
|---|---|---|
| **Baseline (0 - 10 Scale)** | 1 | 1 |
| 12. Forehead Pressure | 4 | 1 |
| 14. Mandibular Pressure | 4 | 1 |
| 20. Right Sternocleidomastoid | 4 | 1 |

*Only maneuvers that modulated her tinnitus are shown.

**3. Tinnitus appears to be a threshold phenomenon.** Consistent with this hypothesis are the following two results.

**a) The incidence of change in auditory perception with somatic testing is significantly lower in subjects with no tinnitus than in subjects with tinnitus** (Panels B and C or D)

From our observations of clinical and non-clinical tinnitus subjects, it is clear that somatic testing can increase and/or decrease tinnitus loudness and pitch. If such changes in auditory perception are happening for all subjects, then one would expect the incidence of a change in auditory perception to be less in people without tinnitus than in those who have an ongoing auditory perception (tinnitus) for at least two reasons:

i) If somatic modulation DECREASES the loudness of auditory perception, then this would not be detected in the non-tinnitus subjects; similarly for any change of PITCH.

ii) If somatic testing causes only a small degree of change in the level of activity in the auditory system, then subjects without tinnitus might raise the overall activity in the auditory pathway, but yet NOT SUFFICIENTLY to cross the threshold of auditory perception.

**b) The ability to develop tinnitus following an intense sound CORRELATES with the ability to somatically modulate spontaneous auditory perception** (Panel E).

If both somatic testing and exposure to intense sound shift the tinnitus generator closer toward its threshold of tinnitus perception, then the two phenomena would be expected to covary.

Both may affect the site of tinnitus generation but through different mechanisms.

- intense sound through the otic pathway (Kaltenbach, 1996)
- somatic testing through the somatic pathway (Levine, 1999)

**4. What is the underlying mechanism for changes in auditory perception with Somatic Testing?**

Are acoustic sounds being generated by **muscle contractions?** This study has excluded from consideration sounds that have been elicited described with such terms as "wind" or "snow storm" since these are highly likely to be generated by tensor tympani and/or pharyngeal muscle contractions (Rock, 1995).

Are some of the auditory perceptions elicited due to sounds generated by other types of muscle contractions? Even though a case has been described of "continuous high-frequency unilateral [objective] tinnitus" that disappeared with sectioning of the stapedius and tensor tympani tendons, for this study we have considered an auditory perception as having a non-acoustic source when it is described as a high-pitched ring (Bento, 1998). Clearly, subjects who can decrease the loudness of their tinnitus with somatic testing are highly unlikely to be doing so with muscular generation of an acoustic sound.

Are the changes in auditory perception due to changes in **otoacoustic emissions** (OAEs)? We cannot totally exclude this possibility, but some subjects with known spontaneous OAEs heard nothing in the quiet and it is well established that the vast majority of subjects with spontaneous OAEs never hear them.

We have initiated a study of somatic testing in the **profoundly deaf** to answer some of these questions more definitively. Of the four such subjects tested, one with no ongoing tinnitus developed a "hum" in his right ear when opening his jaw against resistance. In another, her unilateral tinnitus disappeared with widely opening her jaw.

**Are the changes in auditory perceptions due to NEURAL somatosensory-auditory interactions?**

- **Inferior Colliculus** The inferior colliculus is a possible site of somato-auditory interactions and is known to exhibit tinnitus-related abnormalities (Melcher et al., 2000). It receives somatic inputs and experimentally, the firing of all units in the cat central nucleus of the inferior colliculus can be somatically modulated (Davis, 1999).
- **Dorsal Cochlear Nucleus** appears to be critical when tinnitus is due to ear disorders (Kaltenback & McCaslin, 1996). We have previously described the somatic tinnitus syndrome and proposed a model with dorsal cochlear nucleus playing a pivotal role (Levine, 1999a).

If the auditory perception is unilateral, then the cochlear nucleus becomes a highly likely site for its generation, as we have proposed previously to explain the unilateral tinnitus of the somatic tinnitus syndrome. Non-lateralized tinnitus suggests either bilateral cochlear nucleus or some higher center such as the inferior colliculus.

## 6 Conclusions

**1) Somatic modulation is as common in the non-clinical tinnitus subjects as in clinical tinnitus subjects.**

**2) Somatic influences upon auditory perception are not limited to tinnitus subjects but are a fundamental property of the auditory system.**

**3) Somatosensory - auditory interactions are critical not only for understanding clinical tinnitus, but also for auditory perception in general.**

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## Acknowledgements

**Supported by grants from NIH, Tinnitus Research Consortium, Royal National Institute for Deafness, and American Tinnitus Association**

**Website where papers are available: www.LevineTinnitus.org**