

## Tinnitus severity measured by a subjective scale, audiometry and clinical judgement

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### Abstract

Tinnitus is discussed, with particular reference to the problem of assessing severity. The authors argue that tinnitus severity can only usefully be determined by measuring the impact of tinnitus on an individual, and therefore propose a scale to estimate severity in these terms. Data presented on 112 members of a tinnitus self-help group, demonstrated the reliability of a Subjective Tinnitus Severity Scale (S.T.S.S.), with a coefficient alpha of 0.84. This indicates a high degree of internal consistency, *i.e.*: statistically this scale is measuring aspects of a single dimension. The validity was established in a separate sample of 30 clinic attenders, where mean S.T.S.S. scores were found to correlate highly with two independent clinical ratings of severity ( $r^2 = 0.76$ ,  $p < 0.001$ , and  $r^2 = 0.73$ ,  $p < 0.001$ ). Additionally, in these patients S.T.S.S. scores were significantly associated with several audiometric variables, although the correlations were of low magnitude.

### Introduction

Tinnitus is a problem which is not just confined to the ENT clinic. Patients with tinnitus make contact with professionals right across the medical spectrum. This can either be directly, due to the diverse aetiology of tinnitus (MRC Institute of Hearing Research, 1987) or indirectly through the large number of pharmacological products that can result in transient or permanent tinnitus (Brown *et al.*, 1981). Often the presenting complaint, can additionally be complicated by the presence of psychological problems associated with this condition (Reich and Johnson, 1983; Tyler and Baker, 1983; Hallam *et al.*, 1984; Jakes *et al.*, 1985; Stephens and Hallam, 1985).

Estimates of the incidence of tinnitus of a severity likely to lead to medical consultation range from two per cent to seven per cent of the adult population (Office of Population Censuses and Survey's, 1981; Smith and Coles, 1987). For certain individuals their tinnitus is a major handicap; for others a trivial concern. Tinnitus like pain, is a subjective state and trying to objectively assess the severity is problematic. Audiological techniques to match subjective loudness to a machine produced noise may offer little help, in that sound intensity matches can bear little correspondence to subjective complaint (Meikle and Taylor-Walsh, 1984).

Such a seemingly intangible dimension may provide problems in classification for the clinician and researcher alike. In practice the clinician makes a global evaluation of severity, the validity of which will depend upon their knowledge of tinnitus, and the time available for examination. The researcher has tended to use individual questions relating to loudness or tolerance, with a line to mark or a set of alternative responses to choose from. Basing assessments on single questions can be unre-

liable; and the patient is as likely as the specialist to find difficulty in expressing their tinnitus in *absolute terms*, as they have no other tinnitus with which to compare it but their own.

Our long-term objective is to establish a simple questionnaire that can legitimately classify tinnitus severity. This paper presents the preliminary findings relating to the statistical reliability of a proposed scale administered to a large tinnitus self-help group. We also report on validity data gained in a small clinic sample. The Subjective Tinnitus Severity Scale (S.T.S.S.) comprises sixteen items. It aims to measure tinnitus severity according to how intrusive, prominent, and distressing is the tinnitus. The total score is designed to reflect both tinnitus loudness and emotional reaction, together with the degree of handicap involved. The rationale behind this being, that tinnitus severity can only be usefully defined with regard to the impact it has on an individual, and his/her life.

Tinnitus is a multi-faceted phenomenon, resulting in a myriad of complaints from sleep disturbance to problems in concentration. A factor analytic approach has demonstrated sub-classifications within a range of tinnitus complaints (Jakes *et al.*, 1985). However our objective was to develop a straightforward scale, which yielded a single severity score. To test whether we are justified in regarding the severity we are measuring as a unitary concept. Cronbach's coefficient alpha (Nunnally, 1970) was employed. This is a reliability coefficient that measures the internal consistency of a scale; *ie*: the extent to which the different properties of a scale all relate to the same underlying dimension. To test the *validity*, we compared S.T.S.S. scores to independent clinical ratings of severity. The relationship was also examined between clinical ratings, scale score's and audiometric loudness matching techniques.

Accepted for publication: 8 November 1990.

## Method

### *Self-Help Group Survey (Reliability)*

**Subjects:** 112 members of a local tinnitus self-help group replied anonymously to a postal approach, via group officials. This represented a response-rate of 75 per cent. There were 64 females, 44 males (four sex unknown). The mean age was 61.9 years. Most were long-term tinnitus sufferers; 82 per cent having had tinnitus for four years or more. Only 2.8 per cent ( $n = 3$ ) had developed tinnitus in the last year.

**Analyses:** Coefficient alpha was used as a measure of reliability; it indicates the internal consistency of a scale. A value of '0' demonstrates that the separate items (questions) in a scale are completely independent of each other. '1' indicates perfect congruity. A split-half correlation between the odd and even items of the scale, was also employed to measure internal consistency. Item-remainder correlations were computed on postal S.T.S.S. data, primarily to test the value of each question. This entails a correlation between each item and the total obtained from the remainder of items (ie: the total less the comparison item). The extent to which all the items correlate with the total score, also reflects internal consistency. All correlations given in this study are standard Pearson product—moment coefficients.

As an estimation of the clinical relevance of actual scores, we used the responses to three individual questions, to examine mean differences in total score. We considered that a negative response to question 16 ('Would you say that, you would have a much more enjoyable life, if you did not have tinnitus'), suggested that the tinnitus was not having a significant effect on the quality of life. Responses to two questions were considered indicative of particularly intrusive tinnitus (YES to 3: 'Do you find that your tinnitus bothers you, when you are doing something physical, like dressing or gardening'; and NO to 10: 'When you are busy, do you quite often forget about your tinnitus'). We regarded those scoring on either item as 'intrusive-respondents'. T-tests were employed to assess the significance of mean differences in total score.

### *Clinic Study (Validity)*

**Subjects:** 30 volunteers for a controlled tinnitus drug trial, who were attending the Hospital for full audiometric assessment, were also used to evaluate the validity of the Subjective Tinnitus Severity Scale (S.T.S.S.). There were 18 males and 12 females. The mean age was 53.5 years. Most were chronic tinnitus sufferers; 60% having had tinnitus for five years or more. However, 16.7% ( $n = 5$ ) had developed tinnitus within the last year.

Subjects were recruited, mainly by direct approaches to organizations. A large minority were members of tinnitus self-help groups; but volunteers came from such diverse sources as a college of music, and a rifle association. They included both those motivated by the need for help (or a possible future need), and altruistically orientated individuals such as members of the Hospital staff. Thus the degree of severity was varied.

**Clinical ratings:** A scale of 1–3 was used with 1 scored for mild severity, 2: intermediate and 3: severe. Rating was on the basis of clinical notes, audiometry and audio-

metric tinnitus assessment. Two assessors made independent evaluations on this data, unaware of the patient's S.T.S.S. score.

**Tinnitus audiometry:** The loudness of the tinnitus was matched in dBHL using an OB 822 Madsen Clinical Audiometer. At 1 kHz, thresholds and tinnitus loudness matches were determined using 5 dB steps. At the tinnitus frequency these levels were assessed employing 1 dB steps. The dBSL loudness level was also recorded (i.e. level of tinnitus loudness above threshold). The ascending method of loudness matching was employed. This entails increasing the audiometers loudness in small increments from threshold, until the subject identifies the matching loudness. This was then increased to check the confidence of the subject in the match. In the event of the subject only being certain that their tinnitus came within a range of values, the median was recorded.

**Analyses:** The relationship between S.T.S.S. scores, clinical ratings and audiometric variables was investigated using a correlation matrix. A three-level one-way analysis of variance was used to assess the degree of association, between each raters assessment, and mean S.T.S.S. scores. Coefficient alpha and the split-half correlation, were also determined for the clinic group.

### *Subjective Tinnitus Severity Scale (S.T.S.S.)*

Tinnitus severity was measured by a sixteen item binary response (yes/no) scale. Ten items gain a score by a 'yes' response; six by a 'no'. The potential score range being 0–16.

## Results

### *Reliability: Postal Survey*

In the tinnitus self-help group sample, the Subjective Tinnitus Severity Scale (S.T.S.S.) proved highly reliable with a coefficient alpha of 0.84. The eight odd items also correlated with the eight even items ( $r^2 = 0.72$   $p < .001$ ). From Table I, it can be seen that with the exception of question 15, each of the individual items correlates significantly with the total S.T.S.S. score. These correlations are high for binary data. The significant association between the total score and all but one of the items, is indicative of both internal consistency and the utility of individual items.

### *Estimated Clinical Relevance of S.T.S.S. Scores: Postal Survey*

An individual's response to question 16, showed that those who do not perceive their enjoyment of life much impaired by tinnitus, have lower total S.T.S.S. scores than those who do; a mean of 5 versus 10.5, respectively ( $p < 0.001$ ).

Those who were still bothered by tinnitus when actively engaged ('intrusive respondents') showed markedly elevated S.T.S.S. scores. Mean S.T.S.S. scores for those still bothered by tinnitus when doing something physical (question 3), versus those not bothered were 12.7 and 8 accordingly ( $p < 0.001$ ). Likewise those who do not forget their tinnitus even when busy have higher S.T.S.S. scores (question 10: 12.9 versus 8.7,  $p < 0.001$ ).

TABLE I

SHOWS EACH ITEM IN THE S.T.S.S. WITH THE RESPONSE (YES/NO) THAT GAINS A SCORE. CORRELATIONS ARE GIVEN BETWEEN EACH ITEM AND THE TOTAL SCORE (EXCLUDING THE COMPARISON ITEM). PERCENTAGES REPRESENT THE PROPORTION OF SUBJECTS OBTAINING A SCORE ON EACH ITEM. \*p<0.01 \*\*p<0.001 N.S. = NON-SIGNIFICANT

Subjective Tinnitus Severity Scale (S.T.S.S.) Items	r <sup>2</sup>	% scores
1. Does your tinnitus sometimes make it difficult for you to concentrate? (yes)	0.47**	67%
2. Are you almost always aware of you tinnitus? (yes)	0.46**	73%
3. Do you find that your tinnitus bothers you, when you are doing something physical, like dressing or gardening? (yes)	0.49**	31%
4. Does your tinnitus cause you problems in getting off to sleep? (yes)	0.47**	52%
5. Would you say that generally your tinnitus does not bother you? (no)	0.63**	61%
6. Do you sometimes go for hours without noticing your tinnitus? (no)	0.52**	35%
7. Is your tinnitus very noisy? (yes)	0.65**	68%
8. Does your tinnitus frequently upset you? (yes)	0.66**	53%
9. Do you often have a day or more completely free from tinnitus? (no)	0.22*	88%
10. When you are busy, do you quite often forget about your tinnitus? (no)	0.36**	20%
11. Is you tinnitus present for at least part of every day? (yes)	0.25*	97%
12. Does your tinnitus often interfere with you ability to relax? (yes)	0.50**	72%
13. Would you say, that although your tinnitus can be irritating, it does not get you down? (no)	0.48**	45%
14. Do you often talk about the problems your tinnitus causes to others? (yes)	0.29**	43%
15. Is it unusual for your tinnitus to annoy you, when you are trying to read or watch television? (no)	0.20 n.s.	46%
16. Would you say that, you would have a much more enjoyable life, if you did not have tinnitus? (yes)	0.48**	80%

Validity and audiometry: Clinic study

As can be seen from Table II the S.T.S.S. was shown to be a valid measure of severity, correlating significantly with two independent clinical ratings of severity (r<sup>2</sup> = 0.76, p<0.001 and r<sup>2</sup> = 0.73, p<0.001).

At 1 kHz, the S.T.S.S. also significantly correlated with the tinnitus loudness match and with tinnitus sensation level, but not with the threshold value. Whereas at the tinnitus frequency it was the threshold and loudness match that correlated with the S.T.S.S. while the tinnitus sensation level did not. It should be noted that even the significant correlation were of low magnitude.

The interrelationships between most of the audiometric variables are affected by artefactual processes (see discussion). Not in this category: is the significant correlation between the loudness match at 1 kHz and tinnitus sensation level at 1 kHz.

Indicative of a greater consistency between dBHL loudness values than dBSL values, is the moderately high correlation between the loudness matches at 1 kHz and at the tinnitus frequency (r<sup>2</sup> = 0.61, p<0.01), while the corresponding two sensation level measures were poorly related (r<sup>2</sup> = 0.18 ns).

Significant relationships are shown between the two assessors and most audiometric variables, but it must be remembered that in making a severity judgement they did have access to this data (whereas they did not have access to S.T.S.S. data).

Specific clinical ratings and S.T.S.S. scores: Clinic study

Table III illustrates how S.T.S.S. scores were in agreement with the clinical assessments of both assessors. S.T.S.S. scores are low for the mild severity classification, near to overall mean for the intermediate group, and high for the severely classified cases for both assessors. Mean differences in S.T.S.S. scores according to clinical classification were highly significant for both assessors, on analysis of variance (p<.001, for both calculations).

Reliability: Clinic sample

The S.T.S.S. revealed high reliability in the clinic sample with a coefficient alpha of 0.90. The split-half (odd-even item) correlation was r<sup>2</sup> = 0.75 (p<0.001).

TABLE II

SHOWS CLINIC SAMPLE CORRELATIONS BETWEEN THE S.T.S.S., TWO INDEPENDENT CLINICAL RATERS (RATER 1 AND RATER 2), AND THE AUDIOMETRIC VARIABLES

	S.T.S.S.	Rater 1	Rater 2	TH/1K	LM/1K	SL/1K	TH/TF	LM/TF	SL/TF
S.T.S.S.	—	0.76**	0.73**	0.31	0.48*	0.36+	0.39+	0.41+	0.02
Rater 1	0.76**	—	0.71**	0.54*	0.65**	0.29	0.55*	0.59**	0.09
Rater 2	0.73**	0.71**	—	0.50*	0.74**	0.52*	0.39+	0.45*	0.18
TH/1K	0.31	0.55*	0.50*	—	0.83**	-0.13	0.47+	0.55*	0.01
LM/1K	0.48*	0.65**	0.74**	0.83**	—	0.45*	0.56*	0.61*	0.16
SL/1K	0.36+	0.29	0.52*	-0.13	0.45*	—	0.16	0.22	0.18
TH/TF	0.39+	0.55*	0.39+	0.47+	0.56*	0.16	—	0.98**	-0.30
LM/TF	0.41+	0.59**	0.45*	0.55*	0.61*	0.22	0.98**	—	-0.09
SL/TF	0.02	0.09	0.18	0.01	0.16	0.18	-0.30	-0.09	—

Key to audiometric variables (all dBHL unless stated otherwise): TH/1K: threshold at 1 kHz; LM/1K: loudness match at 1 kHz; SL/1K: sensation level at 1 kHz; TH/TF: threshold at tinnitus frequency; LM/TF: loudness match at tinnitus frequency; SL/TF: sensation level at tinnitus frequency. For most of the values N = 26 because of missing data. N = 22 for correlations between certain data (TH/1K and TH/TF, LM/1K and LM/TF, SL/1K and SL/TF), to exclude the four subjects whose tinnitus matched at 1 kHz.

\*p<0.05 \*p<0.01 \*\*p<0.001 (one-tailed probabilities).

TABLE III

DISPLAYS MEAN SUBJECTIVE TINNITUS SEVERITY SCALE SCORES FOR THE CLINIC SAMPLE, ACCORDING TO WHETHER TWO INDEPENDENT RATERS, ASSIGNED PATIENTS TO MILD, INTERMEDIATE OR SEVERE, TINNITUS GROUPS (NUMBERS ASSIGNED IN BRACKETS)

	Mild Severity	Intermediate Severity	Severe
Assessor 1:	4.4 (n = 12)	8.6 (n = 9)	12.6 (n = 9)
Assessor 2:	4.9 (n = 14)	8.5 (n = 6)	12.3 (n = 10)

### Hearing loss: Clinic sample

The average hearing threshold at 1 kHz was 18.7 dBHL (standard deviation: 19.9). The average threshold at the tinnitus frequency match was 46.3 dBHL (standard deviation: 30.6).

### Descriptive Data: Postal and Clinic sample

Means for the S.T.S.S. were 9.6 for the self-help group and 8.1 for the clinic sample. The quartiles for the self-help group were: 25%: 7, 50%: 10 and 75%: 12.8. For the clinic sample the quartiles were: 25%: 3.8, 50%: 8.5 and 75%: 12.2. This reflects a higher proportion of low S.T.S.S. scorers in the clinic sample. Examination of Table III indicates that a large minority of the clinic sample were rated as having mild severity tinnitus (this converts to 40% for Assessor One; 46% for Assessor Two).

### Discussion

The S.T.S.S. proved a reliable means of quantifying tinnitus severity, when applied to a large tinnitus self-help group and a small clinic sample. The high coefficient alpha for both samples justifies our grouping these different items together, and presenting a single total score. Fifteen of the sixteen S.T.S.S. items appear to be measuring aspects of what we term 'tinnitus severity', by correlating with the total score (less comparison item). This also demonstrates that although tinnitus is of manifold nature in its range of interference with life, one can still use the term of 'severity' in a global sense.

It appears legitimate to regard the S.T.S.S. as a measure of subjective tinnitus severity, as there was a high correlation between clinical ratings of severity, and S.T.S.S. scores.

On such a small clinic sample one cannot as yet offer to translate specific S.T.S.S. score values, into precise severity classifications. However, we do ourselves find the S.T.S.S. useful in the clinic as an approximation of severity. Currently, although not necessarily explicitly, otolaryngologists are making severity judgements, which they use in deciding patient management. In developing a simple scale such as the S.T.S.S. our object is not to displace measured clinical judgement, but to express severity in a standard quantifiable form.

Clearly our next objective must be to gather more widespread data on persons with tinnitus in ENT and non-ENT settings to offer norms, so that we can say with more confidence how actual S.T.S.S. scores relate to different levels of severity. The clinic sample possessed a reasonable range of severity including a large minority

of patients with mild tinnitus. Our self help-group was naturally biased toward those expressing a more severe form of complaint. Our priority is to test the performance of the S.T.S.S. on a sample which includes a substantial proportion of sub-clinical tinnitus subjects. This will inform us at what level an S.T.S.S. score can be considered indicative of sub-clinical tinnitus.

Although one should be cautious in over-interpreting responses to individual questions, it is relevant to examine the relationship between *certain* questions, and total S.T.S.S. score. Within the postal study, those subjects who did not consider that their life would be very much more enjoyable without tinnitus were relatively low S.T.S.S. scorers. The two questions we regarded as indicative of intrusive tinnitus, whereby tinnitus was still troublesome even when busily engaged in an activity, were associated with high S.T.S.S. scores. We termed these patients 'intrusive-respondents'. The mean S.T.S.S. score on question 3 (still bothered while engaged in physical activity) was significantly elevated at 12.7; likewise with question 10 the 'intrusive-respondents' (still bothered when busy) S.T.S.S. score was significantly raised at 12.9. These self-help group values were very similar to the clinic sample's mean S.T.S.S. scores for those patients clinically classified as having severe tinnitus (Assessor One: 12.6; Assessor Two: 12.3). This provides a reference point, suggesting that scores close-below 12 or above twelve are indicative of severe tinnitus.

In relation to audiometry the S.T.S.S. showed significant correlations of low magnitude, with the loudness match and sensation level at 1 kHz; and with the threshold and loudness match at the tinnitus frequency. There was a low marginally non-significant correlation between the S.T.S.S. and the threshold at 1 kHz; but nil relationship ( $r^2 = 0.02$ ) between the S.T.S.S. and the tinnitus sensation level at the tinnitus frequency.

Using loudness matches in dBHL provides the highest correlation between the S.T.S.S. and the audiometric variables at either 1 kHz or the tinnitus frequency. It seems likely that these dBHL matches are more closely related to subjective complaint, because dBHL values naturally incorporate an element of hearing loss (or lack of loss) in their expression. This is based on the assumption that the subjective experience of tinnitus will appear worse, with lessened environmental masking in hearing impaired persons. Sensation level values also take no account of recruitment. Tyler and Conrad-Arnes (1983) and Hallam *et al.*, (1985) advocate formulae to convert sensation level matches into units that take into account an individual's perceived loudness range.

The audiometric measures inherently show much inter-relation for two reasons. First, where there is hearing impairment at 1 kHz, there is a likelihood of increasingly raised thresholds at the tinnitus frequency. Second, as the sensation level of tinnitus is close to threshold; the correlation between the dBHL loudness match and threshold will always be extremely high. To a lesser extent the same appears to apply at 1 kHz, where the loudness match is closely related to the threshold.

### Conclusion

Tinnitus although a multi-faceted complaint, can have

its clinical significance estimated, using a short severity questionnaire. The Subjective Tinnitus Severity Scale (S.T.S.S.) proved statistically reliable in a tinnitus self-help group and a clinic sample. The scale's validity was indicated by high correlations with independent evaluation. Severity scores also correlated significantly with several audiometric variables, although the magnitude of the correlations were not high. The S.T.S.S. may prove its usefulness, as a reliable but simple method of assessing tinnitus severity. However, to be able to recommend the S.T.S.S. as an aid to diagnostic classification, more extensive normative data will first have to be acquired.

#### Acknowledgements

The study was supported by the Ian Mactaggart Trust, with facilities provided by the Cromwell Hospital. In addition we would like to thank Dr. Ross Coles, for constructive advice, when this paper was in its final stage of preparation.

We also would like to pay tribute to the late John Brown, and express our thanks to his wife, both of whom helped in gaining data from members of the Basildon Branch of the British Tinnitus Association.

#### References

- Brown, R. D., Penny, J. E., Henley, C. M., Hodgis, K. B., Kupetz, S. A., Glenn, D. W., Jobe, P. C. (1981) Ototoxic drugs and noise. In: Tinnitus: Ciba Foundation Symposium 85. London: Pitman: p 151–171.
- Hallam, R. S., Rachman, S., Hinchcliffe, R. (1984) Psychological aspects of tinnitus. In: Contributions to medical psychology. (Rachman, S. ed.) vol 3. Oxford: Pergamon Press: p 31–50.
- Jakes, S. C., Hallam, R. S., Chambers, C., Hinchcliffe, R. (1985). A factor analytical study of tinnitus complaint behaviour. *Audiology*, **24**: 195–206.
- Meikle, M., Taylor-Walsh, E. (1984). Characteristics of tinnitus and related observations in over 1800 tinnitus clinic patients. In: Proceedings of the second international tinnitus seminar (Shulman, A. ed.). *Journal of Laryngology and Otology*, **Supplement 9**: 17–21.
- MRC Institute of Hearing Research (1987). Epidemiology of tinnitus. In: Tinnitus (Hazell, J. W. P., ed). Edinburgh: Churchill Livingstone: p 46–70.
- Nunnally, J. C., Jnr. (1970). Introduction to Psychological Measurement. Maidenhead: McGraw-Hall.
- Office of Population Censuses and Survey's (1983). General Household Survey. The prevalence of tinnitus 1981. OPCS Monitor GHS 83/1. London: OPCS.
- Reich, G. E., Johnson, R. M. (1984) Personality characteristics of tinnitus patients. In: Proceedings of the second international tinnitus seminar. (Shulman, A. ed). *Journal of Laryngology and Otology*, **Supplement 9**: 228–32.
- Smith, P., Coles, R. (1987) Epidemiology of tinnitus: an update. In: Proceedings of the third international tinnitus seminar. (Feldmann H. ed). Harsch Verlag; Karlsruhe: p 147–153.
- Stephens, R. D. G., Hallam, R. S. (1985) The Crown-Crisp Experiential Index in patients complaining of tinnitus. *British Journal of Audiology*, **19**: 151–158.
- Tyler, R. S., Baker, L. J. (1983) Difficulties experienced by tinnitus sufferers. *Journal of Speech and Hearing Disorders*, **48**: 150–154.
- Tyler, R. S., Conrad-Armes, D. (1983) The determination of tinnitus loudness considering the effects of recruitment. *Journal of Speech and Hearing Research*, **26**: 59–72.

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**Key words:** Tinnitus; Audiometry