

# INVESTIGATING THE INTER-SUBJECT VARIABILITY OF TINNITUS MASKING FROM PSYCHOPHYSICAL TUNING CURVES – STSM REPORT

## 1. Purpose of your mission

The main aim of our mission was to test if it is possible to determine by the means of the Psychophysical Tuning Curves (PTCs) two different tinnitus subgroups – group of people suffering from tinnitus, who could benefit from the sound therapies (masking therapy) and group of tinnitus patients, for whom the different method of treatment could be more suitable. Using PTCs, which are a measure of the frequency selectivity of the auditory system, enables researchers to determine the presence of the *dead regions* in the cochlea. Initially we wanted to test whether the presence of dead regions could prevent the masking of tinnitus. Due to lack of patients with the dead regions however (only results obtained from 1 of 27 patients demonstrated clearly presence of dead regions), we changed our initial focus and decided to examine possible relations between different shapes of the PTCs and the efficiency of tinnitus masking.

We focused on two tinnitus groups – patients with tonal and with noise tinnitus.

## 2. Description of the work carried out during a mission

We tested 27 patients (12 males, 15 females) from the IMERTA Clinic (Dr Paolino) in Marseille. The mean age of participants was 55.75 years (SD=12.36), with the mean duration of tinnitus 8 years (SD=7.27). As demonstrated by the audiological pre-interview, 8 patients had normal hearing (hearing loss <25dB), 17 had hearing loss (two audiograms not included). Twelve patients had unilateral tinnitus, 14 bilateral tinnitus (1 missing data).

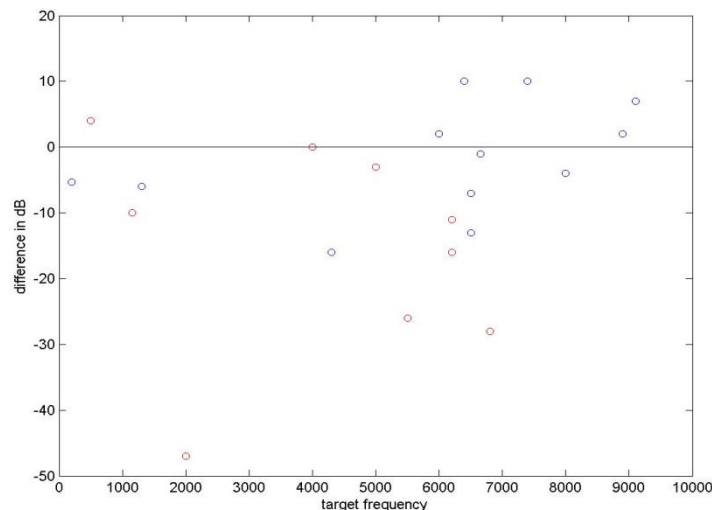
The study consisted of three parts based on custom-made Matlab scripts:

1. Matching tinnitus characteristics – we were presenting a tone with the frequency described in the audiological pre-interview as a tinnitus pitch and by varying its parameters: the frequency, volume and bandwidth (to obtain tonal vs. noise characteristics) we were adjusting computer generated sound to tinnitus perceived and described by patients. The dominant frequency of tinnitus was then used as the target frequency in test 2 (PTC).
2. Determining the PTCs – we determined psychophysical tuning curves for the tone with the frequency of tinnitus (frequency of tone or central frequency of the noise when patients described their tinnitus as noise) obtained in the previous part of a study presented on the level indicated as tinnitus loudness plus 10dB. Three tones were presented (each 100ms in duration with 100ms silence interval, the first one preceded and the last one followed by 250ms of silence) embedded in maskers lasting 1s. We used the masker of bandwidth of 320Hz and tone pip frequency at the following frequency: - 1, -1/2, -1/4, -1/8, 0, +1/8, +1/4, +1/2 octave. The level of masker was raised until the target tone was completely masked. For the target frequency and the two neighboring frequencies (+/- 1/8 octave) we used 3 repetitions.
3. Determining the tinnitus masking curve – we used the same procedure to determine the level of the masker required just to mask tinnitus (there was no tone, just tinnitus). We used the masker of bandwidth of 320Hz and octave steps as follows: - 1, -1/2, -1/4, -1/8, 0, +1/8, +1/4, +1/2 octave. For the target frequency and two neighboring frequencies (+/- 1/8 octave) we used 3 reversals.

We used monaural presentation – the tinnitus ear was stimulated in case of unilateral tinnitus or the ear in which tinnitus is prominent in case of bilateral tinnitus. We had to exclude from further analysis results obtained from 6 patients due to variances in tinnitus perception (for 1 participant tinnitus stopped being audible during the session, for 2 participants with bilateral tinnitus it was impossible to ignore perception of tinnitus in the second ear, for 1 patient the pitch of tinnitus changed during the session) or due to too severe hearing loss (2 participants).

### 3. Description of the main results obtained

We calculated for each participant the mean difference between the PTCs and tinnitus masking curves for the tinnitus target frequency and two neighboring frequencies (target-1/8 octave, target, target+1/8 octave). Negative results indicated tinnitus harder to mask than a tone, positive – tinnitus easier to mask. Figure 1 illustrates obtained results.

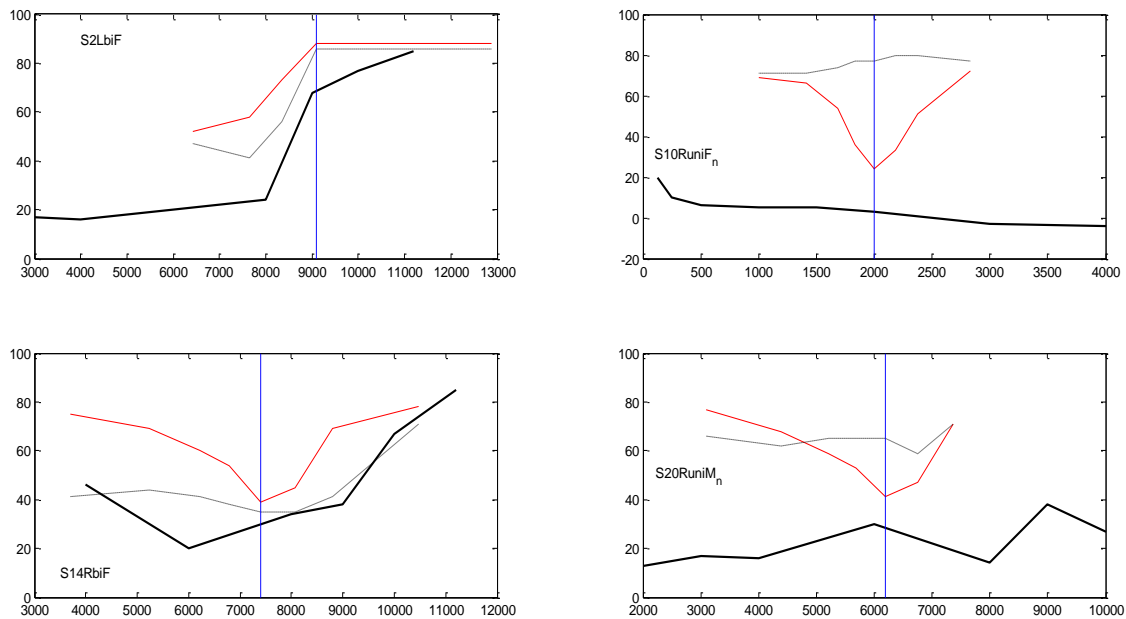


**Figure 1. The mean difference between PTC and tinnitus masking curve for all subjects.** Calculations performed for the target and two neighboring frequencies for patients with tonal tinnitus (blue circles) and noise tinnitus (red circles).

Figure 2 presents results obtained from 4 patients showing differences in the tinnitus masking efficiency – for subject 2 and 14 tinnitus was easy to mask, for subject 10 and 20 difficult to mask. Results of patient S2 revealed the presence of dead regions – the pick of the PTC is slightly shifted to the left. The most efficient masker frequency for this patient was lower (7652 Hz) than his tinnitus frequency (9200 Hz), masking was however possible and easy.

ANOVA test performed in the IBM SPSS Statistics 22 showed significant difference between mean differences obtained for patients with tonal vs. noise tinnitus –  $F(1, 17)=5.811$ ,  $p=0.028$ . The mean difference for results obtained by patients with tonal tinnitus was  $-.133$  ( $SD=8.13$ ), noise tinnitus  $-13.556$  ( $SD=15.420$ ), indicating, that noise tinnitus was more difficult to mask.

We would like to test more patients to further investigate this correlation. It is possible, that patients with tonal tinnitus may benefit more from sound therapies (engaging tinnitus masking). Another possibility is that masking noise tinnitus may require broader frequency band of masking stimuli (in present study we used masker of 320Hz bandwidth).



**Figure 2. Results obtained from patients with tonal tinnitus (on the left) and noise tinnitus (on the right).** S – subject, L/R – left/right, bi/uni – bilateral/unilateral, F/M – female/male, n-noise. Black line indicates hearing thresholds expressed in the dB SPL, red line – PTC, dotted line – tinnitus masking curve, blue vertical line – tinnitus frequency.

#### 4. Future collaboration with the host institution (if applicable)

We hope to continue our collaboration during the second STSM, entitled ‘Investigating the inter-subject variability of tinnitus masking and residual inhibition with amplitude modulated maskers’.

#### 5. Foreseen publications/articles resulting from a mission (if applicable)

We are working on our results in order to prepare an article entitled ‘Investigating the inter-subject variability of tinnitus masking from psychophysical tuning curves’. We would appreciate the possibility to test more tinnitus patients for this publication during the next STSM.

#### 6. Confirmation by the host institution of the successful execution of your mission

Attached to an email.

#### 7. And other comments (if any).

We would like to thank for the possibility to perform this mission.