

Fundamentals of Perceptual Audio Encoding

“All maskers are equal, but some are more equal than others.”

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INTRODUCTION

No aspect of auditory psychophysics is more relevant to the design of perceptual auditory coders than masking, since the basic objective of perceptual audio coders is to use the masking properties of sounds to hide quantization noise.

In the spirit of MIT’s motto, *Mens et Manus* or learn by doing, this lab allows you the opportunity to carry out some psychophysical measurements on yourselves and gain some “ear-on” experience with auditory masking. The experiments should be carried out in pairs, so you can take turns running the experiments.

GENERAL INFORMATION

The experiments are to take place in the sound booth in the middle of room.

The entire lab session will take approximately 2-3 hours. The lab session is divided into two parts. In part one, you will be measuring the masking pattern associated with a narrowband noise. In part two, you will be measuring the masking thresholds in the presence of various types of masker.

The waveforms are created on a PC using Matlab. Sound is generated from those waveforms using a 24-bit digital-to-analog converter (DAC) in the PC. The electrical signal is then fed via a headphone buffer (TDT HB6) to the booth. In the booth, the stimuli are presented via Sennheiser HD580 headphones (located in the booth).

- Before you start the experiment, it is very important to make sure that the wiring and the attenuation settings are correct. Make sure the HB6 switch is set to 6 dB.
- Log onto the computer with the user name: **HST723** and with the password: (*provided in class*)
- Start up Matlab.
- On the command line, enter:

➤ `cd M:\Experiments\Perceptual_encoding`

- There should be a handheld voltage meter outside the booth. Use this to verify the voltage at the headphone amplifier left output. To check the voltage enter:

➤ `calibrate('mid',+6,'1')`

This tells the system that you have +6 dB attenuation in the path (from the headphone amplifier) and that you are testing the left channel only ('1').

- On the screen will then appear the voltage you should expect to measure at the output to the headphone buffer. Check that the actual voltage does not differ from the predicted voltage by more than about 10%.

MASKING EXPERIMENTS

Masking refers to the process by which the presence of one sound (*masker*) elevates the threshold (changes the audibility or sensitivity) of another sound (*target*). The hearing threshold in the presence of a masking signal is called the *masked threshold*.

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Figure 1: Masked threshold and threshold in quiet

The *masked threshold* is the threshold intensity of a target signal in the presence of a masking stimulus with a specific intensity (Fig. 1). When the masker intensity is set equal to zero, the masked threshold is just the probe intensity at the hearing threshold in quiet.

Part 1: Masking pattern

Objective

In this part of the lab, you will be measuring your hearing threshold in quiet and the masked threshold associated with a narrowband noise center at 1 kHz. You have the option of measuring your left ear or your right ear, but it is important to stay consistent.

Stimuli

The target stimuli are tones from 200 Hz to 4 kHz, starting at 30dB SPL.

The masker stimulus is a narrowband noise with a bandwidth from 990 to 1010 Hz and a spectrum level of 60 dB SPL.

The experimental parameter is the level of the target tones.

Method

The method of adjustment is used in this part of the lab. This method is also known as the Bekesy method. As the subject, your objective is to *adjust the levels* of the target tones to maintain them at the *just detectable levels*.

To start the experiment, enter the following line in the Matlab command window:

- `cd Mask_pattern;`
- `bsy_main('Mask_pattern','XX_repX','mid','0','1');`

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considerations.

Note that all the arguments are in single quotes and are separated by commas. The first argument is the experiment name; the second is for your initials and the repetition number (e.g., 'js_rep1' for John Smith); the third is the booth name ('mid' in this case), the fourth is the amount of attenuation set on the TDT PA4, and the fifth is the condition under examination ('1' for the threshold in quiet in the left ear, '2' for the threshold in quiet in the right ear, '3' for the masked threshold in the left ear, and '4' for the masked threshold in the right ear).

After enter the above command, a dialog window will appear. You will be instructed to press the space bar to start the experiment session.

If you are measuring your threshold in quiet, you will hear a high pitch tone at the beginning of the experiment session. The level of the target tone should begin at an easily detectable level. By pressing on the *space bar* you slowly lower the level of the target tone. When you release the space bar, the level of the target tone will slowly increase. As the experiment processes, the target tone will sweep slowly from high frequency to low frequency. As the subject, your only task is to maintain the target tone at the *just detectable level*.

If you are measuring your masked threshold, at the beginning of the experiment session you will hear a high pitch tone accompanied by a mid frequency tonal sound. The high pitch tone is the target tone and the mid frequency tonal sound is the masker. Here, as in the case of measuring threshold in quiet, the target tone should also begin at an easily detectable level. By pressing on the *space bar* you slowly lower the level of the target tone. When you release the space bar, the level of the target tone will slowly increase.

However, the masker will not be affected by your actions. As in the above case, you as the subject has the task of maintaining the target tone at the *just detectable level*.

The procedure is not easy to master. I highly recommend going through procedures two or three times. To indicate the multiple experimental runs, you can add a repetition number to the end of your initials.

Data storage

The results from your experiment are stored in the “*Result*” directory, under the file named “*mask_pattern_xx.dat*” (where *xx* should be your initials).

Part 2: Are all maskers equal?

Objective

In this part of the lab, you will be measuring the masking effect of different masker types.

Stimuli

Target	Masker
Narrowband noise	Tone (1 kHz)
Narrowband noise	Narrowband noise
Narrowband noise	Multiplied noise
Narrowband noise	Low-noise noise

The maskers are all presented a 70 dB SPL.

The Narrowband noise was generated by digitally filtering a broadband Gaussian noise with a filter centered at 1 kHz with a bandwidth of 20 Hz.

The Multiplied-noise was generated by multiplying a sinusoid at 1 kHz with a modulator. The modulator consisted of a low-pass Gaussian noise with a cutoff frequency of 10 Hz at an rms value of -10 dB (relative to amplitude 1) to which a dc component of value 1 was added (Dau *et al.*, 1999).

The Low-noise noise is generated in a way described by (Kohlrausch *et al.*, 1997). It represents an efficient way of generating a bandpassed noise with a smoothed temporal envelope. The generation started with a Gaussian noise signal with a rectangular power spectrum. The following steps were iterated ten times: The envelope of the noise was calculated, representing the absolute value of the analytic signal, and the time waveform was divided by this envelope on a sample-by-sample basis and then restricted to its original bandwidth of 20 Hz by zeroing the corresponding components in the power

spectrum. Iteration of the procedure leads to a decreasing amount of spectral splatter after each division by the envelope. The power spectrum within the passband is slightly different from that at the beginning of the iteration (for details, see (Kohlrausch *et al.*, 1997)).

Method

To start this experiment, enter the following line in the Matlab command window:

- `cd ..`
- `cd Mask_threshold;`
- `afc_main('Mask_threshold','xx_rep1','mid','0','1k')`

Note that all the arguments are in single quotes and are separated by commas. The first argument is the experiment name; the second is for your initials (e.g., 'js' for John Smith); the third is the booth name ('mid' in this case), the fourth is the amount of attenuation set on the TDT PA4 (0 because the PA4s are not included in the circuit), and the fifth is the signal frequency.

After entering in the above command, a dialog window will appear to give you instructions about what to do next. **At the end of each run you have the option to start a new run, or to end the session (a total of 8 runs).** If you end or if you interrupt the program (for instance, by closing the dialog window), you can start where you left off simply by re-entering the line given above. The program will know what conditions you still have to do by looking at the control file.

This is a 2-interval, 2-alternative forced-choice procedure. The signal level begins at what should be an easily detectable level and is varied adaptively according to a 2-down 1-up rule, tracking the 70.7% correct point on the psychometric function. The signal level is initially varied in steps of 8 dB. After the first two reversals, the step size is reduced to 4 dB. After a further two reversals, the step size is reduced to its minimum value of 2 dB. Each run is terminated after six more reversals, and the threshold is defined as the mean level at the last six reversals. Two repetitions of each condition will be run. The program randomizes the presentation order of the conditions.

Each trial consists of two 500-ms noise bursts. The task is to decide which of the two intervals also contains the target signal. All the stimuli are gated with 50-ms ramps to avoid spectral "splatter".

If you decide to do a practice run first, you **MUST** indicate the different experimental runs, by adding an indexing number to the end of your initials at the command line.

Data storage

The results from your experiment are stored in a file named "*Mask_threshold_xx_1.dat*", where *xx* should be your initials.

DATA ANALYSIS

Once the data have been collected, you should copy your data file onto a diskette (*not provided*) and complete the analysis elsewhere. Excel or Matlab can read the data. If you are an Athena user, the full version of Matlab is available on Athena. The data analysis may be carried out in pairs. If you have no experience with Matlab, team up with someone who knows how to use the application. If you are having trouble, feel free to email me.

LAB REPORT

Your lab report should describe the experiment, and the results (include plots and tables of the data). Below are some suggestions.

- 1) Plot your hearing threshold in quiet and your masked threshold. If you have data from multiple runs, plot them all.
- 2) Create a table with the hearing thresholds under the different masker types.
- 3) Plots of the different maskers may help you with your discussion of the data.

You should also include a brief discussion of your data, as well as your thoughts on the following questions.

- 4) What are the advantages and disadvantages of the two psychophysical methods?
- 5) Are the masking abilities of tones and noises different? If so, why?
- 6) How can this lab exercise be improved?

The lab report should be done independently. If you asked for help with the analysis, please acknowledge the proper person/people in your report.

Feel free to email or call me for clarifications or assistance on the lab or the lab report.