

# A NEW RESEARCH ENVIRONMENT FOR SPEECH TESTING USING HEARING-DEVICE PROCESSING ALGORITHMS

Nicolas N. Ellaham<sup>\*1</sup>, Christian Giguère<sup>†2</sup>, and Wail Gueaieb<sup>‡1</sup>

<sup>1</sup> School of Electrical Engineering and Computer Science, University of Ottawa, 800 King Edward av., ON, Canada K1N6N5

<sup>2</sup> School of Rehabilitation Sciences, University of Ottawa, 451 Smith rd., Ottawa, ON K1H8M5

## 1 Introduction

A common complaint among subjects with hearing loss is the difficulty of understanding speech in the presence of background noise. Speech testing is an integral part of a clinical assessment of hearing loss, complementing the pure tone audiogram and providing useful information regarding speech tolerance and recognition ability as well as helpful cues for hearing-aid fitting [1]. Among other indicators, speech tests are used to determine the speech reception threshold (SRT) defined as the lowest level at which speech can be correctly identified at least 50 percent of the time. The use of such tests is very popular in research as it allows an experimental manipulation of listening conditions in order to study their effects on speech perception with respect to a baseline condition.

In this work, we present a new software-based speech testing environment for research in speech perception. The system is designed to permit the measurement of SRTs under a wide range of listening and processing conditions. This paper briefly describes the conception of the program, outlining its useful features, important design components, and requirements, as well as possible applications.

## 2 Conceptual design

### 2.1 Overview

The system is designed to run a speech test using an *adaptive up-down* testing procedure such as the Hearing In Noise Test (HINT) [2]. The program's main graphical user interface provides a set of parameters to specify a listener's hearing profile, listening and processing conditions, and the controls needed to run the test (Figure 1). The software is implemented in Matlab and offers the ability to process sounds through external signal-processing routines prior to presentation to the listener. This functionality is provided by the hearing-device simulator described in Section 2.3. The system's architecture includes a number of Excel files that store important settings, calibration values, hearing-device and test parameters which are easy to modify from within or outside the application. Similarly, test results for a given experiment are exported into an excel spreadsheet to permit analysis as needed.

### 2.2 Feature set

The program has been conceived in order to permit testing with a range of experimental conditions. Its implementation is not limited to the HINT, which allows future extensions

to include additional speech or noise material, languages, and processing conditions. To date, the application includes the following features:

- Testing in quiet as well as in continuous or intermittent speech-shaped noise.
- Testing with the American English or French Canadian HINT sentences (requires permission to use the HINT practice and test sentence lists).
- Testing in monaural or binaural listening conditions.
- Ability to specify arbitrary speech and masker locations (including two preset diffuse-masking specifications).
- A set of simulated programmable hearing devices with the ability to define new ones.
- Three testing paradigms: (1) fixed speech level with an adaptive masker level, (2) fixed masker level with an adaptive speech level, and (3) fixed speech and masker levels with an adaptive distortion threshold.
- Ability to define multiple experiments with independent testing conditions and populations.
- Ability to calibrate the system's sound output using a dedicated Calibration screen.

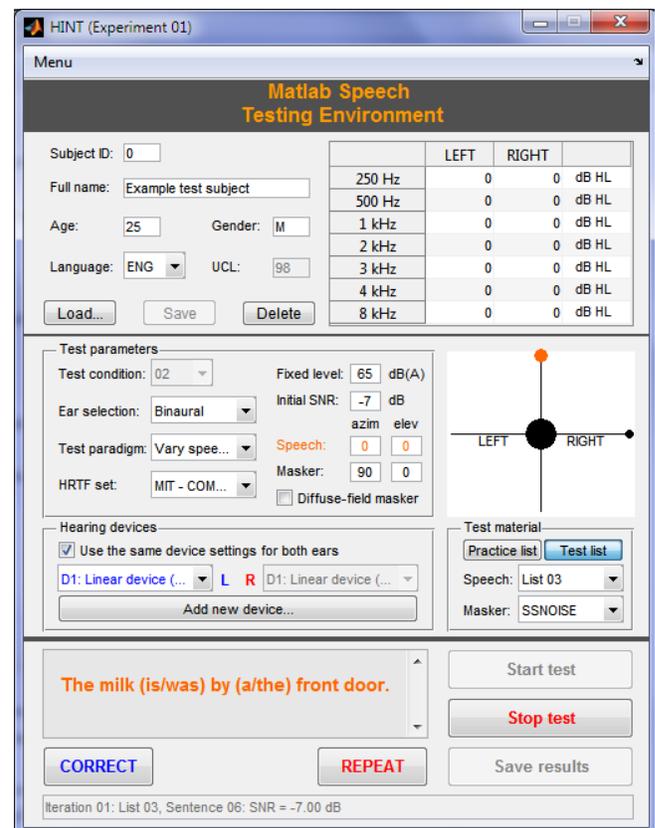


Figure 1: User interface of the Matlab speech testing environment.

\* nellaham@ieee.org

† cgiguere@uottawa.ca

‡ wgueaieb@eecs.uottawa.ca

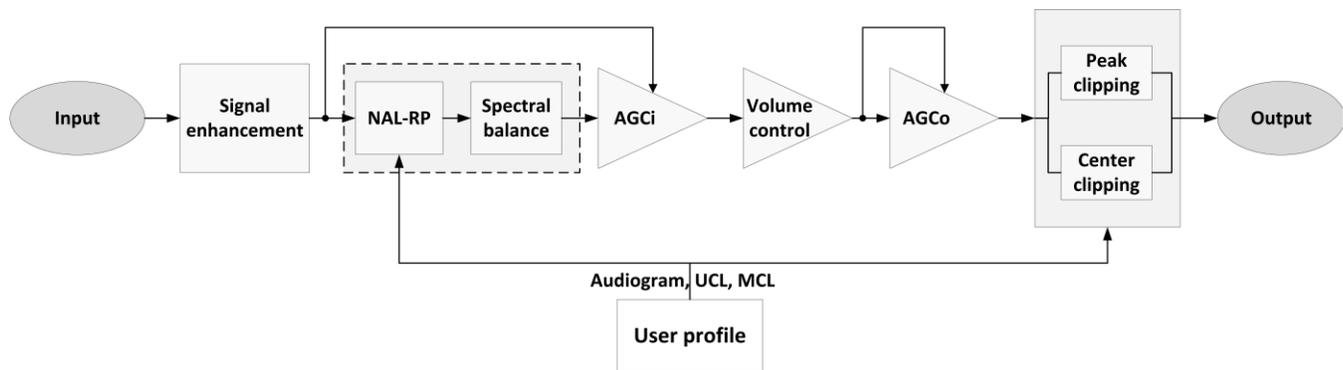


Figure 2: Schematic diagram of the hearing-device simulator

### 2.3 The hearing-device simulator

A software simulator, implemented in Matlab, provides a set of typical functions commonly performed in real hearing devices. Figure 2 shows the architecture of the hearing-device simulator, which includes the following functions:

- A signal-enhancement module that includes a variety of single-channel noise-reduction algorithms. A complete list of algorithms included to date can be found in [3].
- The NAL-RP linear hearing-loss prescription [4] based on a subject's audiogram.
- A spectral balance function to emphasize low or high frequencies using a spectral tilt with different slopes.
- An amplitude compression algorithm implementing an input-controlled automatic gain control (AGC) system.
- A volume control to specify an overall amplification or attenuation in dB.
- An amplitude compression algorithm implementing an output-controlled AGC system.
- A selection of two algorithms that perform symmetric peak or center clipping.

The hearing-device simulator has been packaged as a standalone toolbox. The Matlab speech testing environment provides a graphical interface to access the simulator and create new devices.

### 2.4 Spatial listening simulation

The Matlab speech testing environment has been initially designed for testing under headphone listening conditions. The system makes use of a set of head-related transfer functions (HRTFs) to simulate different spatial listening configurations. Two sets of HRTFs (full and compact) from the MIT media lab [5] are included. Additional sets may be integrated into the system if the proper Matlab routines are provided to read the HRTFs. It is possible to perform testing in the sound-field by omitting the HRTFs, and using a set of speakers to achieve the desired spatial configuration.

### 2.5 System requirements

The software is written for Matlab R2012b for Microsoft Windows systems. Earlier releases of Matlab do not include important functions used in the code (*e.g.* audioread.m). Moreover, the signal processing toolbox is required for the

overall system, while some of the algorithms included in the signal-enhancement module require access to the Wavelet toolbox. Finally, in order to carry out speech testing, it is assumed that access to an audiometric room is available along with standard audio equipment to perform calibration.

## 3 Applications

The speech testing environment presented in this work is intended for use in research environments where Matlab is frequently used as a prototyping platform in the early stages of the development of signal-processing algorithms. It has been employed in a recent study using the HINT speech material to measure subjective SRTs under various spatial configurations and different processing conditions typically encountered with hearing devices [3]. Future extensions of the system being considered include additional test material, such as the Test de Mots dans le Bruit [6].

### Acknowledgments

This work was supported in part by the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Queen Elizabeth II Graduate Scholarship in Science and Technology (QEIGSST).

### References

- [1] G. Lawson, and M. Peterson, *Speech Audiometry*, Plural Publishing Inc., San Diego, 2011.
- [2] M. Nilson, S.D. Soli, and J.A. Sullivan, Development of the hearing in noise test for measurement of speech reception thresholds in quiet and in noise, *J. Acoust. Soc. Am.*, 95(2), 1085–1099, 1994.
- [3] N. Ellaham, *Binaural speech intelligibility prediction and nonlinear hearing devices*, University of Ottawa (PhD thesis), 2014.
- [4] D. Byrne, A. Parkinson and P. Newall, Hearing aid gain and frequency response requirements for the severely/profoundly hearing impaired. *Ear & Hearing*, 11, 40–49, 1990.
- [5] W.G. Gardner, and K.D. Martin, HRTF measurements of a KEMAR, *J. Acoust. Soc. Am.*, 96(6), 3907–3908, 1995.
- [6] J. Lagacé, Développement du Test de mots dans le Bruit: mesure de l'équivalence des listes et données préliminaires sur l'effet d'âge, *Canadian Acoustics*, 38, 19-30, 2010.