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Original article

Speech audiometry in noise: Development of the French-language VRB (*vocale rapide dans le bruit*) test

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ABSTRACT

Introduction: Understanding speech in noise is a major challenge for most hearing-impaired subjects, with or without hearing aids. To overcome the weaknesses of French-language speech-in-noise tests, we developed a new instrument, with a balanced mix of difficulty of the speech material.
Material and methods: The speech material comprised 127 sentences taken from the "Marginal Benefit from Acoustic Amplification" (MBAA) corpus, each including 3 keywords. The noise was created using the "*onde vocale globale*" (global vocal wave: OVG), described by Dodelé. The 127 speech/noise pairs were recorded individually after root-mean-square equalization. The first experiment, on 10 normal-hearing adults, determined the signal-to-noise ratio (SNR) associated with 50% correct keyword identification in each sentence (SNR-50), using an ascending method with noise level set at 73 dB SPL. Relative levels between sentences and noise were then adjusted sentence by sentence to achieve an SNR-50 of 0 dB. The second experiment, with 12 normal-hearing adults, validated the equalization of sentence difficulty.
Results: Mean SNR-50 was −6.64 dB ($\sigma = 1.47$). Mean adjusted SNR-50 was 0.08 dB ($\sigma = 0.55$). Mean psychometric curve slope was 19.3%/dB, with low standard deviations, testifying to the sensitivity of the speech material.
Conclusion: The VRB (*vocale rapide dans le bruit*: rapid speech in noise) test is based on sentences from the MBAA corpus with background noise based on the OVG at different signal-to-noise ratios. The test is feasible and able to detect slight variations in speech-in-noise performance between subjects.

1. Introduction

As early as 1970, Carhart and Tillman argued that hearing difficulty should be assessed more ecologically than by pure-tone and speech audiometry in silence, which needs supplementing by testing speech perception in noise. Many authors, including among others Killion and Niquette (2000), Taylor (2003) and Wilson, McArdle and Smith (2007), reiterated this recommendation [1–3]. In France, however, speech-in-noise audiometry (SNA) is still not widely used.

Difficulty in understanding speech in noise is often one of patients' main complaints. Good practice should systematically search for relevant information to objectify and quantify this complaint.

SNA has many advantages for hearing-aid adjustment, in selecting the device, assessing the usefulness of stereophonic aids, the efficacy of speech-processing algorithms and of directional systems and the contribution of associating an FM system [2]. In hearing-aid follow-up, SNA can also monitor performance resulting from hearing-aid fitting.

As there are few standardized French-language SNA tests, the present study aimed to develop a new one, the "*vocale rapide dans le bruit*" (rapid speech in noise: VRB), with homogeneous difficulty for normal-hearers, using a methodology similar to that of the American QuickSIN™ [4].

The SIN test [5] was at the origin of the QuickSIN. It was developed to assess speech intelligibility in noise with and without hearing aids. The speech material was taken from the IEEE (Institute of Electrical and Electronics Engineers) sentence list, each sentence having 5 keywords that are not highly predictable from context. The noise was of the multitalker type (3 female and 1 male voice). The lists comprise 40 sentences testing 4 SNRs, from +15 dB to 0 dB by 5 dB steps. In each list, 20 sentences are presented at a fixed level

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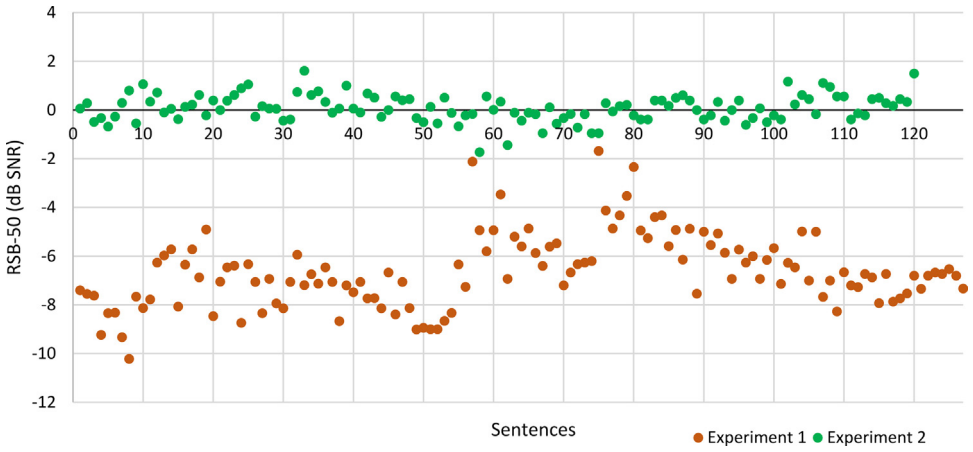

Fig. 1. SNR-50 distributions in the two experiments.

of 70 dB HL and the others at 40 dB HL. The drawbacks of the SIN are:

- long administration time (>10 min);
- 40 dB HL level too low for hearing-impaired subjects;
- lists not mutually equivalent.

QuickSIN™ [4,6] is an improved version, giving a quick estimate of the 50% correct-response SNR, on a descending method from least to most difficult. The lists comprise 6 IEEE sentences, of equivalent difficulty. Within each list, 6 SNRs are tested, from +25 dB to 0 dB by 5 dB steps. The Spearman-Kärber equation determines the 50% correct-response SNR (SNR-50), using a non-parametric method to calculate the 50% level of a psychometric function (here, intensity/SNA performance). It is an alternative to adaptive audiometric techniques.

The aim of the present study was thus to develop French-language speech material of homogeneous difficulty, to be used to develop an SNA test. The methodology consisted in:

- selecting a set of sentences and a noise meeting certain criteria;
- measuring the SNR-50 for each sentence;
- equalizing difficulty across sentences;
- validating difficulty equivalence for the speech/noise pairs;
- and creating three VRB test-lists and testing them in clinical practice.

2. Material and methods

2.1. Speech material and noise

The test sentences were taken from the Marginal Benefit from Acoustic Amplification (MBAA) corpus of 540 sentences, typical of everyday conversation; length varies greatly, from 3 to 15 words, and they are of all forms: affirmative, negative, interrogative and exclamatory. The speaker was a female speech-therapist, speaking French at normal speed without regional accent.

One-hundred-and-twenty-seven sentences were selected on the following criteria:

- short enough to be easily repeated [7]: only 7-11 syllables;
- not highly predictable from context, so as to limit mental compensation [4];
- not liable to create confusion: interrogative and exclamatory sentences in the MBAA corpus were not used [7];
- and containing at least three 1-, 2- or 3-syllable keywords for grading purposes; these could be of any type except prepositions, articles, pronouns, conjunctions or proper names [8].

The noise comprised an 8-second loop taken from the "*onde vocale globale*" (global vocal wave: OVG). This consists of 4-speaker noise composed from recordings of two couples, one French- and one English-speaking, in conversation [9]. The idea of pairing exactly the same noise with all sentences came from the WIN test [10,11], and was intended to reduce variability and facilitate synchronization between speech and noise in processing the data files.

2.2. Subjects

Sampling was performed on a predefined population. An upper age limit reduced age-related intelligibility bias, and a limit on age and educational level ensured adequate knowledge of French.

Participant inclusion criteria comprised:

- native French speaker;
- hearing thresholds $\leq$ 20 dB HL at all octaves between 125 and 8000 Hz in both ears (Interacoustics AC-40 audiometer and TDH-39 headphones in soundproof booth);
- and normal otoscopy with no otologic history.

Experiment 1, determining SNR-50 for the sentences, included 10 normal-hearing French adults, 5 male and 5 female, aged 21–37 years ($\bar{X}$ = 27.7 years; σ = 4.95).

Experiment 2, confirming homogeneous sentence difficulty, included a new sample of 12 normal-hearing French adults, 8 male and 4 female, aged 19–39 years ($\bar{X}$ = 26.33 years; σ = 6.73).

VRB test feasibility in clinical practice was assessed in 29 hearing-impaired subjects aged 42–90 years ($\bar{X}$ = 67.72 years; σ = 15.02) and 6 normal hearing subjects aged 25–33 years ($\bar{X}$ = 30.17 years; σ = 3.97), using 3 lists of 9 sentences. No exclusion criteria were applied.

2.3. Protocol

Subjects were tested in a soundproof booth with TDH-39 headphones, with binaural diotic listening. Noise was set at 73 dB SPL, measured on a Brüel and Kjær 2270 sonometer-analyzer and Brüel and Kjær 4152 artificial ear. This level was chosen to represent noise levels generally encountered in social gatherings, which typically range between 65 and 85 dB SPL [4].

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