

SPEECH ACOUSTICS IN A NOISY ENVIRONMENT

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1. INTRODUCTION

This paper reports on one aspect of the Acoustic Ecology project of the UBC Institute for Hearing Accessibility Research. We examined the effect of a noisy environment on speech communication, with the aim of testing our hypothesis that a noisy room is a hearing-impairing room (Jamieson et al., in prep.). We predicted that the speech characteristics of normal-hearing people in a noisy environment will be similar to those of hearing-impaired people in non-noisy environments. Extensive video, audio, and dosimeter data were evaluated in an examination of discourse productions and shifts of attention.

The speech characteristics of hearing-impaired people include: raised f_0 ; reduced pitch range; reduced or excessive pitch variation; non-normal pitch contours, lack of terminal rise; lack of normal pitch declination; lack of normal pitch rhythm, i.e., distinction between stressed vs. unstressed units; breathy phonation; vocal tension/harshness; non-normal phoneme duration; inappropriate pausing; nasality; and lowered vowel formants. (See Bench 1992, Chen 1995, Higgins et al. 1994, Itoh & Horaii 1985, Kato 2001, Kotby et al. 1996, McGarr & Whitehead 1992, O'Halpin 2001 and references therein, Pisani 1982, Whitehead & Whitehead 1985, Wirz 1988, Youdelman et al. 1989.)

Our research question is: *Does the speech of normal-hearing people in a noisy environment show the characteristics listed above?*

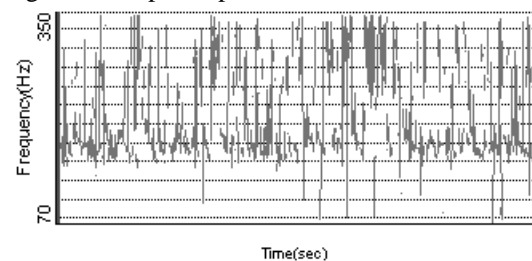
2. METHOD

The subjects were normal-hearing adults aged 24 to 57 ($n = 12$) and children aged 7½ to 13 ($n = 24$) of both genders. Their speech was recorded in naturalistic noisy environments, a real restaurant setting for the adults and real classrooms (grades 1-3, 5, and 7) for the children. Background noise levels were up to 70 dB (average A-weighted Leq). The noisy environment speech was recorded as received by listeners' ears at binaural ear-level

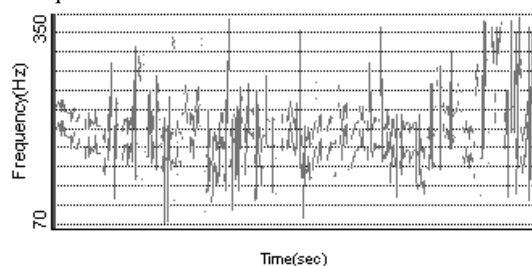
microphone sets, since listeners' ears are the site of any interactionally functional signals. The participants' speech was also recorded with a unidirectional microphone in a soundbooth. The DAT recordings were then loaded onto computer and the speech signals were acoustically analysed using Kay's Multi-Speech 3700®. The acoustic characteristics of the speech in the two environments were compared to identify any of the characteristics of hearing-impaired speech which might be found in the participants' noisy environment speech but not their speech in the soundbooth. Where they are robust, we attribute such characteristics to the noisy environment.

3. SOME RESULTS AND ANTICIPATIONS

Preliminary results indicate that the answer to our research question is 'yes' in several cases. For example, Figure 1 illustrates reduced pitch variation in the noisy environment (sd: 51.05 vs. 65.40 in the quiet environment) for Meg, an adult participant.



a. quiet environment



b. noisy environment

Fig. 1. Pitch contours illustrating reduced pitch variation in noisy environment adult speech.

The full results of our study will be reported. We anticipate that the preliminary results will hold for the full dataset, in support of our hypothesis. This would raise several further issues: 1. to what extent are there similarities between the characteristics for which our findings are 'yes' and the Lombard Effect (Lombard 1911, Junqua 1996), such that the Lombard Effect might be alternatively labelled 'hearing-impaired speech by normal-hearing people'; 2. does the 'hearing-impaired speech by normal-hearing people' effect cast doubt on physical or developmental explanations applied to the hearing impairment (Most & Frank 1994); 3. what potential further support exists for our hypothesis from people's adjustment of their speech to accommodate their listeners' hearing impairment (Imaizumi & Hayashi 1995), if we consider that the normal listeners effectively experience hearing loss in adverse listening conditions; 4. when and why is temporary hearing impairment in a noisy environment interpreted or not interpreted as a signal of cognitive impairment (Pichora-Fuller & Kirson 1994, McKellin 1994); 5. what are the implications of such acoustic ecology issues for environmental design and evaluation.

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