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PERCEPTIVE CHARACTERISATION OF THE ACOUSTICAL QUALITY OF REAL COMPLEX SOUNDS - VALIDATION WITH SYNTHESIS

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1. Perceptive categorisation. The search for objective acoustical criteria corresponding to perceived qualities is a concern common to the instrument maker and the engineer of noisy machines: they both try to control and improve in some way the sound produced. In trying to identify the sound characteristics perceived by the auditors, one soon discovers that the use of specific words can hardly be shared among several subjects. Within the conceptual frame of the perceptual categorisation defined by Rosch [1] (basic level, prototype and typicality), two ecological principles have underlined our experimental method: the subjects are put in the context of an activity and must organise their categories according to the purpose of this activity [2].

2. Experiment and results. The experiment is based on a set of vacuum-cleaners sounds [3]. In a first task of free categorisation, the subjects who are instructed to react as if they were using a vacuum cleaner at home, must group stimuli within as many classes as they want, according to their sensation of comfort. The analysis of results with a method sketched by Barthelemy [4] yields two main categories closely related to the SPL in dBA. After an equalisation of the subjective level of sounds and a second test of free categorisation, new groups emerge. Comparative hearing and FFT analysis suggest that three acoustical parameters could explain how sounds are grouped: 1/ A spectral peak between 100 and 1 500 Hz can give a musical pitch to the sound. 2/ A spectral formant in the band 1 500 - 3 000 Hz can give an aggressive and striking impression. 3/ The attenuation slope of the spectrum envelope beyond 1000 Hz. Several sounds chosen for their typicality were modified (software AudioSculpt by IRCAM) by enhancing or eliminating these acoustical features. A new set of sounds (original and transformed) is used in a third test, and we see that transformed sounds are put in different categories, according to what could be predicted.

3. Conclusion. The experimental method has proved to be efficient at pointing out acoustical criteria relevant to the perceived quality of sounds, without *a priori* verbal attributes to the sounds. The phase vocoder technique offers this tremendous advantage of a possible check on the hypotheses made after the acoustical analysis of the categories established on a set of real complex sounds. However, the relevance of the selected acoustical criteria is restricted to one type of sounds, for subjects in a well defined situation.

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[1] E.Rosch (1978) "Principles of Categorisation", in *Cognition and Categorization*, edited by E.Rosch, B.B. Llyod, (L.Erbaum , Hillsdale, N.J.) 27-47.

[2] D.Dubois, D.Fleury, C.Mazet (1993) "Représentations catégorielles : perception et/ou action? contribution à partir d'une analyse des situations routières" in A.Weill Fassina, P.Probardel et D.Dubois (Octares, Toulouse) 79-93.

[3] F.Guyot, B.Fabre, M.Castellengo, C.Piron (1995) "An experimental method for the analysis of the sound quality of ecological sounds", 4th ISMA (Dourdan, France) 582-588

[4] J.P.Barthélemy, A.Guenoche (1988) *Les arbres et les représentations des proximités* (Masson, Paris)

PSYCHOACOUSTICS AND HEARING AIDS

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In terms of signal processing capabilities, modern hearing aids do offer a wide range of possibilities. The question of course is *what* kind of processing schemes should be applied in order to optimally support the hearing impaired. In this respect, psychoacoustics can help to specify the origin of a hearing impairment in functional terms, and may provide useful indications and guidance in making a proper choice on the type of signal processing to be applied. However, it should not be expected that all types of hearing deficits simply can be compensated for by signal processing 'at the outside'. It is more realistic to consider signal processing in the light of adapting or fitting the signal characteristics to the limited capabilities of the impaired ear.

For the purpose of this presentation, we will consider hearing impairment with a degree of residual hearing which suggests the application of an hearing aid. Given the Pure-Tone Audiogram and the Loudness Discomfort Level, it is common practice to adjust the hearing aid's amplification characteristic such that sounds are presented optimally within that dynamic range. In order to achieve this for both weak and loud sounds, it is also commonly understood that some form of automatic gain control (AGC with a time constant of a few hundred ms) can be useful. Still, given this basic type of hearing-aid fitting, it is often the case that there is no complete speech-hearing rehabilitation. An important and very relevant measure in this respect is the Speech Reception Threshold (SRT) in noise. For an individual hearing impaired listener provided with that basic type of hearing aid, the SRT may still deviate substantially from what is found for the normal-hearing population. This situation, the hearing impaired fitted with a basic type of hearing aid (i.e., appropriate amplification and AGC), is the starting point for considering the possible benefits of special signal processing schemes.

We will discus various types of approaches in signal processing. The first type can be labelled *improving the directivity*. Some of the proposed processing schemes are based on models of binaural processing, others are engineering approaches based on multiple-microphone arrays. In many practical situations the SRT may improve considerably. A second type is *(multi-band) compression*. The rationale for this type of processing is to compensate for the often anomalous loudness function in the hearing impaired (recruitment). The effectiveness is a matter of ongoing discussions. Then there are the approaches based on *enhancement of the spectral or temporal envelopes*. These are based on the idea to compensate for the decreased degree of spectral or temporal resolution, as often observed in psychoacoustical measurements on the hearing impaired. No significant positive effects have been reported. Various types of *noise-suppression* schemes have been proposed, and some benefit for the hearing impaired has been observed.

In summary, apart from the straight-forward effect of improving the directivity, the beneficial effects of the above types of signal processing are small. Still, it will be shown that modern psychoacoustics, stressing the importance of across-frequency processing in audition, may motivate other types of signal processing schemes, aiming at enhancing the essential spectro-temporal cues in the speech signal.