FEATURES OF NEUTRALIZED SOUNDS FOR LONG TERM EVALUATION

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ABSTRACT

The meaning of a sound may influence its rating significantly. Therefore, a method was proposed, which removes the meaning of sound, keeping the loudness-time function the same. In essence, the sound is analyzed by FTT and, after spectral broadening, resynthesized by IFTT.
Since it is impossible to remove the meaning of a sound, keeping *all* psychoacoustic magnitudes the same, variations are discussed for the sound produced by a noise immission of 20 min duration. For the comparison, loudness, sharpness, fluctuation strength, and roughness are considered as functions of time, and as cumulative distributions. Data for the original sound *with* meaning are compared to data for the neutralized sound *without* meaning. While the loudness-time functions of original and neutralized sound are the same, significant differences can occur with respect to roughness.

INTRODUCTION

For the rating of a sound, in addition to physical magnitudes like level, spectral distribution, temporal structure and so forth, also its meaning may be of influence. For example, at same energy equivalent A-weighted level, immissions from railway noise are preferred to immissions from road traffic noise. This effect frequently is termed “railway bonus” , and was demonstrated in field studies (e.g. Möhler 1988) as well as laboratory studies (Fastl et al. 1996). Part of the railway bonus can be described on the basis of differences in the spectral distribution of typical road traffic noise versus railway noise (e.g. Fastl 1996). Usually, road traffic noise contains more low frequency components than railway noise, which are significantly attenuated by A-weighting, but nevertheless contribute to the impression of loudness. Therefore, when comparing road traffic noise and railway noise at same A-weighted level, the perceived loudness of the road traffic noise is larger than the loudness of the railway noise. This difference, which can amount to some 3 dB, may partly account for the “railway bonus”.
On the other hand, railway noise and road traffic noise can be clearly distinguished and traced back to different noise sources. Therefore, the meaning of a sound may also have an influence on its rating.
In order to get an indication about the magnitude of such possible effects of meaning, a procedure was proposed, by which the meaning of a sound can be largely neutralized (Fastl 2001). It could be shown (Fastl 2001, 2002) that the procedure yields identical loudness-time functions of sounds with meaning versus sounds without meaning. Hence, original and neutralized sounds show the same loudness, but they may differ in other psychoacoustic magnitudes like sharpness, fluctuation strength, or roughness.
In this paper, for an original sound with meaning versus a neutralized sound without meaning, producing the same loudness-time function, the magnitude of possible differences in other hearing sensations is discussed.

MEASUREMENTS AND RESULTS

In figure 1, the time functions of psychoacoustic magnitudes are displayed for a noise immision, i.e. an original sound with meaning (left), and the related neutralized sound without meaning (right). A noise immission from traffic noise of 20 min duration is considered.
The upper panels in figure 1 show the loudness-time function of both sounds. As expected, there is no difference in loudness as a function of time of the original sound with meaning (left) and the neutralized sound without meaning (right).
The following two panels show the dependence of sharpness on time. Again, the sharpness-time functions of the sound with meaning versus the sound without meaning look rather similar, although some minute differences can be detected.
The next panels show the time function of the fluctuation strength. Generally, the time function for the sound with meaning versus the sound without meaning looks similar. However, small differences are easily detected. For example, at 450 sec and in particular at 850 sec, the fluctuation strength of the sound without meaning (right) is definitely larger than the fluctuation strength of the sound with meaning (left).
The bottom panels in figure 1 clearly show systematic differences in roughness. Throughout the whole time history, the roughness values of the sound without meaning are larger than roughnesses of the sound with meaning.

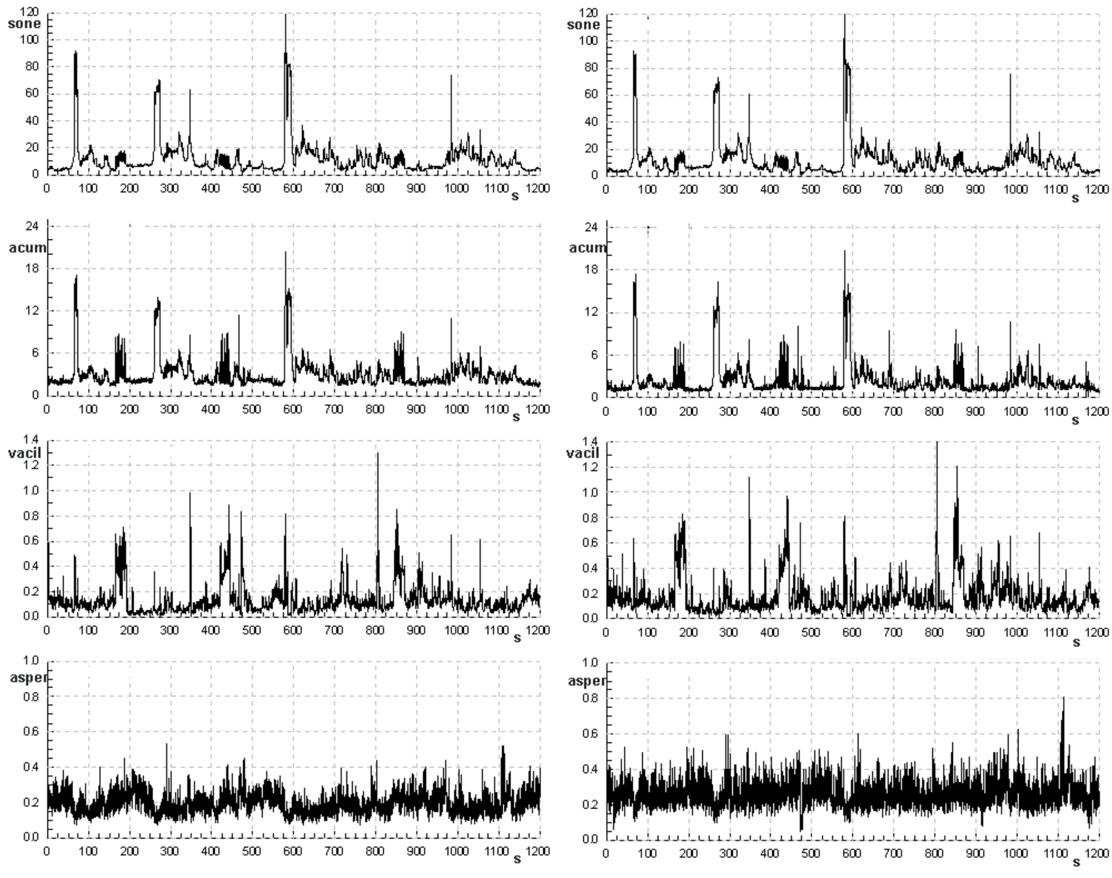

Fig. 1.- Psychoacoustic magnitudes loudness, sharpness, fluctuation strength, and roughness for a traffic noise immission of 20 min duration (left), and for the related neutralized sound without meaning (right), as a function of time.

In order to discuss the differences between sound with meaning versus sound without meaning in more detail, cumulative distributions were calculated. Figure 2 shows the cumulative distributions of loudness, sharpness, fluctuation strength, and roughness for the traffic noise immission (left), and the related neutralized sound without meaning (right).
As expected, the upper panels in figure 2 clearly show that the loudness distributions of original and neutralized sound are identical.

The following panels illustrate that for sharpness, differences amount to some 5 %, and therefore are below the threshold of discriminability.
The next panels show that the differences in cumulative distribution of fluctuation strength amount at maximum values to 12 %, and therefore are just above the threshold.
On the other hand, the cumulative distributions of roughness displayed in the bottom panels of figure 2 reveal that the roughness of the sounds differs by 25 %, a clearly audible difference.

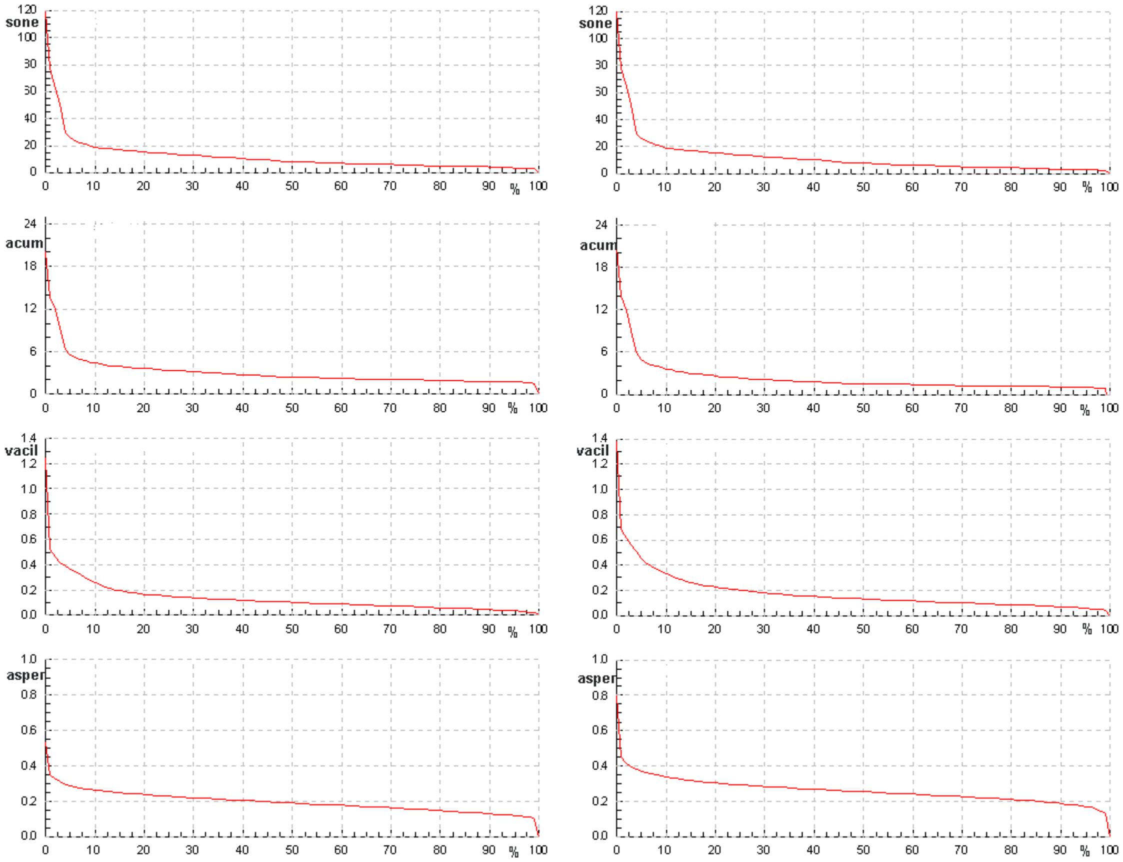

Fig. 2.- Cumulative distributions of loudness, sharpness, fluctuation strength, and roughness for an immission of traffic noise (left), and the related neutralized sound without meaning (right).

DISCUSSION

Since the procedure proposed to neutralize the meaning of sounds (Fastl 2001) aimed at producing the <u>same</u> loudness-time function of sounds with meaning versus sounds without meaning, it is clear that the loudness-time functions as well as the cumulative distributions of loudness for both sounds should be identical. Since sharpness is derived from the loudness patterns, also for this psychoacoustic magnitude only minute differences are expected. On the other hand, the spectral broadening before the re-synthesis of the sounds, definitely leads to differences in fluctuation strength, and in particular in roughness.
For example, at a center frequency of 400 Hz, the width of the critical band is 100 Hz. As described in the literature (Zwicker and Fastl 1999), the effective modulation frequency of a narrow band noise corresponds to 0.64 its bandwidth. Hence, for the example chosen, an effective modulation frequency of 64 Hz is calculated. Since the maximum of the hearing sensation roughness is centered around a modulation frequency of 70 Hz, it becomes clear that the neutralized sound without meaning should produce significant values of roughness.
This means that the original sound with meaning and the neutralized sound without meaning show the same loudness, but different roughness. On the basis of these values of the physically measured psychoacoustic magnitudes, the following predictions on the subjective rating of original versus neutralized sound can be made: If the subjects, when comparing the sound with

meaning and the sound without meaning, evaluate in addition to the loudness the roughness, then the sound without meaning should get a higher rating. If on the other hand, subjects would rate the sound without meaning lower than the sound with meaning, this result is not easily explained on the basis of basic psychoacoustic magnitudes and other, more central effects like attention may play a role. This reasoning is addressed by results from psychoacoustic experiments, reported in a companion paper (Hellbrück et al. 2002).

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