Does Meaning of Sound influence Loudness Judgements?

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Abstract

In former experiments, we compared consecutive loudness judgments based on the time sequence of a long-term traffic noise with two synthesized versions of this noise, one realized with help of FTT-based procedure, the other with the conventional procedure using a pink noise multiplied with the temporal envelope of the original sound. We found that meaning had no significant influence on loudness judgements when loudness is high or very high but at low levels (lower than 70 dB) it may enhance loudness judgments corresponding to effects in the order of 5 dB. It was, however, criticized that one could detect the meaning just on the base of temporal structure even if the sounds are meaning-neutralized. In the experiments reported here, however, we were able to replicate the former results by using the same sounds which were, however, partitioned into short-time sections and presented in a random order. It is assumed that such a mixed-up sequence of the traffic noise scene makes detecting of meaning more difficult, particularly in the synthesized versions of the noise.

1. Introduction

Loudness is a crucial psychoacoustic factor in subjective sound evaluation, and has a substantial effect on annoyance. In some cases, however, the meaning of sound is believed to influence the subjective evaluation. To eliminate the meaning of a sound Fastl has proposed a new procedure based on Fourier-Time-Transform (FTT) (cf. Fastl, 2001). Consequently, using this procedure a sound is synthesized with the same temporal structure and the same loudness-time function. In order to study the effect of meaning of sound on loudness, it is necessary to compare subjective loudness evaluations of meaningful sounds with those of sounds which have the same loudness but no meaning. In a former experiment [1], we compared consecutive loudness judgments of 15s lasting noise intervals based on the time sequence of a long-term traffic noise with two synthesized versions of this noise. One was realized with help of a procedure based on Fourier-Time-Transform (FTT) which was developed by Fastl [2], the other with the conventional procedure using a pink noise multiplied with the temporal envelope extracted from the original noise. Using the FTT-procedure a sound is synthesized with the same temporal structure and the same loudness-time function. By the conventional Pink-noise procedure, however, a sound is generated which has the same temporal structure as the original one but may differ remarkably by loudness. That is because loudness depends not only on sound intensity but also on bandwidth.
Additionally, the overall loudness of the traffic noise scene as well of the synthesized noises was judged.
The results were clear-cut. First, there was practically no significant difference between the mean overall loudness judgments. Second, the correlation between the consecutive loudness judgments of 15s-intervals of the original sound and those of the FTT-processed sound is considerably higher than the correlation between respective loudness judgments of the original sound and the pink noise sound. Furthermore, one could clearly see that loudness judgments between original sound and FTT-processed sound differ systematically. At low intensity levels FTT-processed sounds were judged to be softer than the respective original sounds. The pink noise

shows the same tendency, but, due the higher scattering of the data not as clearly.

The high correlation between FTT-processed sounds and original sounds indicates that the FTT method reflects the psychoacoustic parameters of the original sound very faithfully, at least with regard to loudness judgments. By contrast, the pink-noise procedure is apparently less reliable.

It was, however, criticized that one could detect the meaning just on the base of temporal structure even if the sounds are synthesized by FTT- or pink-noise based procedure. Therefore, we have carried out a further experiment which is reported in the following. In the experiment reported here we mixed up the sequence of the short noise intervals randomly, and compared the respective loudness judgements with those of the former experiment where the noise intervals were presented in natural order. We assume that such a mixed-up sequence of the traffic noise scene makes detecting of meaning more difficult, particularly in the synthesized versions of the noise. If loudness judgements of random-order noise-sequence do not significantly differ from those of natural-order noise-sequence then the former results would be supported.

2. Method

2.1 Stimuli and scaling method

The original sound we used was a traffic noise scene (20 min. in duration), recorded near a village on a main road at a gated level crossing. The railway crossing involved was very busy. The trains that passed were goods trains, regional and Intercity trains. Cars and lorries regularly queued up in front of the closed gate at the crossing and most of the drivers switched off their engines in accordance with a sign near the crossing. After a train had passed and the gate had been opened, the noise-situation was dominated by engines starting up and vehicles pulling away. Once the gate was open vehicles drove past one by one at a speed suited to the railway crossing. The background noise consisted of moderate wind noise, rustling leaves, occasional birdsong, and sounds associated with the rural environment and proximity of the village.

The noise scene was recorded with artificial-head technique (HeadAcoustic HRS II.2) and played back with 2 loudspeakers (Canton Ergo 92 DC) in the unechoic chamber of the Bavarian Environmental Protection Agency in Augsburg (Germany). Sound pressure level was calibrated by measuring a calibration broadband noise at the position of subject's head. The mean energy level of the 20-minute noise was L_{Aeq} = 76.3 dB [1, 3].

2.2 Scaling method

We used the Category Subdivision Scale (CS Scale) which has proven successful for continuous loudness scaling of traffic noise [3]. The CS Scale is a combination of category scale and number allocation. It comprises five verbally distinguished categories. Each category contains ten steps allowing the observer to make fine gradings: 1-10 ("very quiet"), 11-20 ("quiet"), 21-30 ("medium"), 31-40 ("loud"), and 41-50 ("very loud"). The scale allows the possibility of going beyond 50 to express noise perceived as painfully loud.

CS-scaling is a direct scaling procedure based on categorical judgements which has been used thus far predominantly for loudness scaling in audiometry and hearing-aid fitting, but which is not limited in its application to these procedures. It could also prove advantageous in noise assessment. Unlike other procedures of direct scaling which are based solely on number allocation, verbal categorisation provides additional information, such as which noise level is neither soft nor loud, and thus "medium loud". This type of information is very useful if one wants to know how people feel and speak about the noise [3].

2.3 Procedure

As in the former experiment the noise was interrupted by 5s-pauses every 15 s. In each pause the subjects were required to judge the loudness of the respective 15s-noise interval. In total, eighty 15s-noise intervals were consecutively judged. In contrast to the former experiment, however, the eighty noise intervals were presented in a random order, not in the natural order.

2.4 Experimental conditions and subjects

In total, 30 subjects participated in the experiment. None of them was experienced in loudness scaling. All subjects reported normal hearing abilities. In Table 1 the experimental conditions are described for the present experiment (random order) and the former experiment (natural order) as well. The results of the present experiment are compared with those of the former experiment.

Table 1: Experimental Conditions

	Original Sound	Neutralized Sound by FTT Method	Neutralized Sound by Pink-Noise Method
Natural Order (former experiment)	12 Subjects average mean age: 39	11 Subjects average age: mean age: 44	10 Subjects average age: mean age: 39
Random Order (present experiment)	10 Subjects mean age: 38	10 Subjects average age: mean age: 41	10 Subjects average age: mean age: 38

3. Results

In the Figures 2 and 3 we can see that there is no remarkable systematic difference between CS-loudness judgements of noise intervals presented in natural order and those presented in randomized order, at least if sounds are synthesized. As expected, due to bandwidth, pink noise shows higher loudness in sone than FTT processed sound and the original sound as well.
The data displayed in Figure 1 however tend towards a difference between loudness judgments of randomly presented sounds and naturally presented sounds, in such a way as we found in the former experiment: In the natural context, at low intensity level loudness judgments are slightly higher than in artificial context (random order).

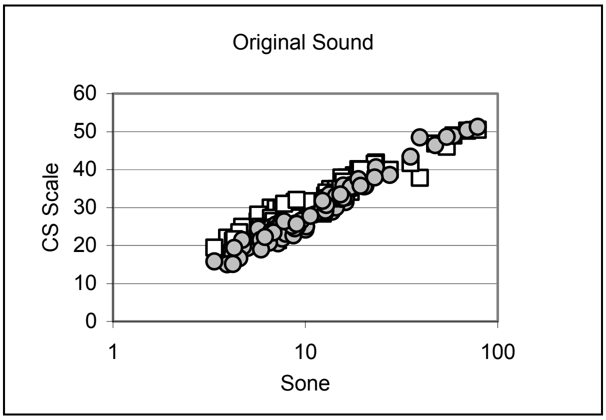

Fig. 1. CS loudness judgments of original sound intervals presented in natural order (open squares) on the one hand and presented in random order (filled circles) on the other hand.

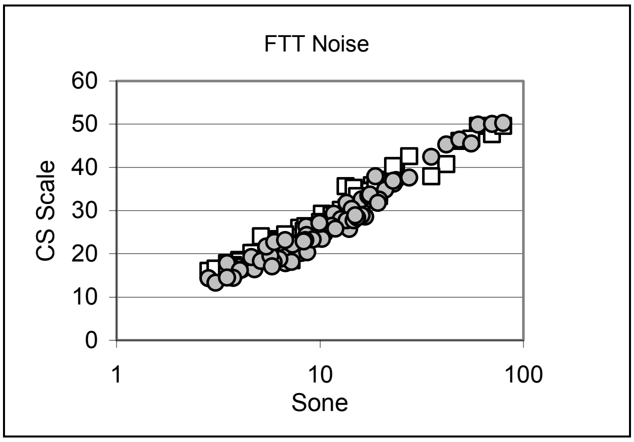

Fig. 2. CS loudness judgments of FTT processed sound intervals presented in natural order (open squares) on the one hand and presented in random order (filled circles) on the other hand.

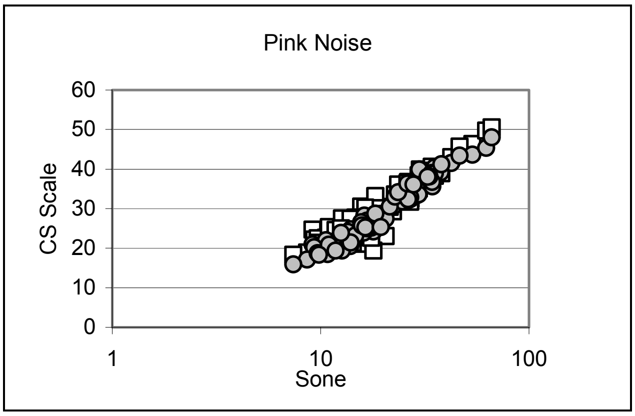

Fig. 3. CS loudness judgments of Pink-noise processed sound intervals presented in natural order (open squares) on the one hand and presented in random order (filled circles) on the other hand.

4. Discussion

The order of presentation has no effect on loudness judgments provided that sounds are neutralized in meaning. If sound sources are recognizable then natural sequence leads to higher loudness judgments at least at low intensity levels. That means that context may influence loudness judgments. The results of the present experiment confirm the former experiment. As formerly outlined, our conclusion is that the recognition of sound sources sharpens attention by separating such sounds from the background, and that therefore, such sounds appear to be louder. This might be the case especially at low intensity levels, while at high levels loudness dominates all other factors. Thus, our results might reflect effects of selective attention in hearing. Auditory attention plays an important role in detection and discrimination of stimulus attributes, in the frequency domain and in the intensity domain as well. This has been shown in several experiments carried out by Scharf and co-workers as well as other researchers (for an overview cf. [4]).

Furthermore, the conclusion can be drawn that the conventional method to eliminate meaning by using pink noise multiplied with the envelope of original noise should be avoided in favour of FTT-based method. The FTT method proposed by Fastl [2] reflects the psychoacoustic parameters of the original sound much more faithfully than the conventional pink-noise method.

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6. References

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