inter·noise 96
25th Anniversary Congress – Liverpool

INCE: 63.1

JUDGED LOUDNESS OF MOVING SOUND SOURCES

A Hellmann

Department of Psychology, Ruhr-University Bochum & Graduate College Psychoacoustics, Carl-von-Ossietzky-University Oldenburg, Germany

1. Abstract

In the experiment reported here, first attempts are made to study the effect of perceived movement of the source towards the perceiver on judged loudness. The question was whether loudness perception differs between non-moving sound sources with increasing emitted level, and approaching sound sources with constant emitted level.
Sounds with levels increasing constantly over time (simulating stationary sources becoming louder) and sounds with levels increasing exponentially (simulating approaching sound sources with constant velocity) were presented in random order, the subjects' task was to judge their loudness on a five-point scale. The results show no difference between the two types of level increase, the most important factor for judged loudness is the level at the end of presentation.

2. Introduction

Many factors besides its acoustic properties influence the perceived loudness of a heard sound as well as its perceived noisiness and the annoyance caused by it [cp. 12; 6; 2; 2; 15; 16; 4; 5; 13; 14; besides others). Among them are attitudes held by the perceiver towards the sound source or the cause of the noise, and the activity which is performed by the perceiver and disturbed by the noise.
It was shown that (binaural) spatial information about the location of the source in the perceiver's environment is an important factor influencing physiological responses of the listener and psychoacoustic parameters like loudness judgements [1]. Besides the direction of a sounding event, acoustic information about its distance [cp. 9; 10] and about movement of the sound source in the environment are likely to be also important for perceived loudness.

Few studies exist on the loudness perception of time varying sound sources, which may be perceived as approaching or receding. Rosinger et al. [11] presented sound with three different types of linear SPL-change (and also of frequency change): The SPL either increased or decreased linearly, or it remained constant. All sounds had the same average intensity over the signal duration of 15.25 sec. The sounds with SPL-change were intended to represent approaching or receding sound sources. It was measured how annoying the sounds appeared to the subjects. The results showed that sounds with an SPL-increase were more annoying than sounds with an SPL-decrease. "Signals representing an 'approaching' sound were generally judged more annoying than those representing a 'receding' sound" (p.843). Sounds with any type of change were more annoying than sounds with no change at all, but "time-varying *intensity* components appeared to have greater influence on judgements of noisiness than did time-varying *frequency* components" (p.843). Namba [8] found a small effect of the shape of the envelope of impulsive sounds on their perceived loudness. Höger et al. [7] presented sounds that changed over time (54 sec or 7.2 min, respectively) in different ways, all having the same averaged energy equivalent sound level. The subjects judged the loudness of the sounds, using a production method. The results showed that sounds with an SPL-increase at the end were judged louder than those with an SPL-decrease at the end, or those with no SPL-change. The authors interpret the results as a recency effect: The sound events or changes heard more recently in a signal are more important for the judgements than earlier parts of the signal. Also important here is that the SPL-change up to a point in time (in this case: up to the end of the signal) can allow the anticipation and extrapolation of the directly following (development of the) stimulus. The subjects may have anticipated a continued increase or decrease after the end of the signal, which influenced their loudness judgements.

The data presented here are part of a study on the perception of approaching sound sources. When a source with constant emitted sound approaches a perceiver with constant velocity, the spectrum, the relation of direct to reflected sound, and the (immitted) level change at the listener's ears, besides other things. The characteristic exponential change of the level at the listener's ears with distance according to the 6dB-rule is often seen as the most important source of information or cue for auditory distance perception with stationary sources. One of the main questions of the study was the use or importance of the sound pressure level (SPL) change at the listener's ears as source of information for the perception of an approach of the source. A question was whether it is necessary that the

SPL at the listener's ears changes exponentially, or whether a linear (dB/sec) SPL-change is also perceived as an approaching source. Besides these, a question was whether there are differences in loudness judgements between linear and exponential SPL-changes, and between sounds perceived to be approaching and sounds perceived to be stationary.

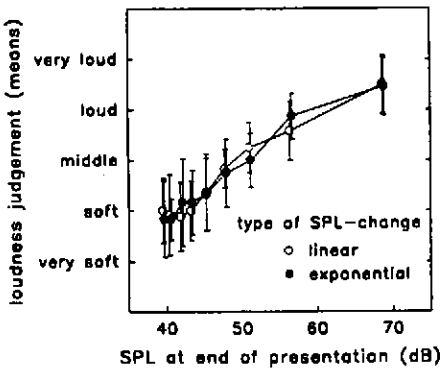
3. Method

6 subjects (3 male and 3 female) participated, all were students of psychology and reported to have normal hearing. Age ranged between 20 and 31 years (median 25.5). The subjects heard two different types of SPL-change: The SPL of the sound increased either linearly or exponentially. From a 9 sec sequence of white noise, the SPL of which increased exponentially over time, thus simulating the approach of the source with constant velocity according to the 6dB-rule, sequences of 1, 2, 3, and 4 sec duration were cut. Matched to each of these exponential SPL-changes, one linear SPL-change was constructed with the SPL changing linearly (dB/sec) from the same start level to the same end level. Thus, 30 exponential and 30 linear SPL-changes were presented to the subjects in random order. The subject's task was to judge the loudness of each sequence on a 5-point scale (very soft, soft, medium, loud, very loud) via key-press.

4. Results

The loudness judgements show no difference between the two types of SPL-change. The higher the SPL at the end of presentation and the greater the SPL-change during presentation, the higher are the loudness judgements (fig. 1). This result was confirmed by similar experiments not reported here with longer stimuli. The loudness judgements are similar to those found in other studies with non-constant sounds [e.g. 17].

Fig. 1: Loudness judgements for the two types of SPL-change.



5. Discussion

The results of other experiments of this study showed that both types of SPL-change are perceived as an approach of the sound source, an exponential SPL-change is not crucial. The subjects are not really able to perceive the difference between the two types of SPL-change. This may explain why there is no difference in the loudness judgements between the two types of SPL-change. The physical difference between exponential and linear SPL-changes was small, and they had the same ranges of start level, end level, SPL-change during presentation, and duration. In further experiments, one option is to increase the difference between the exponential and the linear SPL-changes. Another option is to use identical stimuli, but to vary the perception of movement of the source by other means, to be able to study its effects on perceived loudness.

References

[1] Bodden, M. (1993): The importance of binaural hearing for noise validation. In: August Schick (ed): Contributions to Psychological Acoustics. Results of the Sixth Oldenburg Symposium on Psychological Acoustics. Oldenburg: Bibliotheks- und Informationssystem der Carl von Ossietzky Universität Oldenburg, 537-554.

[2] Guski, R. (1987): Lärm. Wirkungen unerwünschter Geräusche. Bern: Huber.

[3] Guski, R. (1991): Lärmwirkungen aus ökologischer Perspektive. Fortschritte der Akustik, DAGA '91 - Bochum 1991, Teil A, 53-74.

[4] Hellbrück, J. (1991): Loudness scaling: Ratio scales, rating scales, intersubject variability and some other problems. In: Schick, A., Hellbrück, J. & Weber, R. (eds): Contributions to Psychological Acoustics. Results of the 5th Oldenburg Symposium on Psychological Acoustics. Oldenburg: Bibliotheks- und Informationssystem der Universität, 119-133.

[5] Hellbrück, J. (1993): Hören. Physiologie, Psychologie und Pathologie. Göttingen: Hogrefe.

[6] Höger, R. (1986): Lautheitsurteil und akustischer Kontext. Experimentelle Untersuchungen zu einer mehrdimensionalen Bezugssystemtheorie. Dissertation, Ruhr-Universität Bochum.

[7] Höger, R., Matthies, E. & Letzing, E. (1988): Physikalische versus psychologische Reizintegration: Der Mittelungspegel aus wahrnehmungspsychologischer Sicht. Zeitschrift für Lärmbekämpfung 35, 163-167.

[8] Namba, S. (1981): Loudness and noisiness assessments of impulsive sounds. In: Schick, A. (ed): Akustik zwischen Physik und Psychologie. Stuttgart: Klett-Cotta, 33-39.

[9] Paulsen, R. (1995): Zur Entfernungsschätzung von Umweltgeräuschen im Labor. In: W. Arnold & S. Hirsekorn (Hg): Fortschritte der Akustik - DAGA 95. Oldenburg: Deutsche Gesellschaft für Akustik (DEGA), S. 847-850.

[10] Paulsen, R. (1996): Versuchspersonengesteuerte Stimulusfolge bei der Beurteilung von Umweltgeräuschen. In: Fortschritte der Akustik - DAGA 96. Oldenburg: Deutsche Gesellschaft für Akustik (DEGA).

[11] Rosinger, G., Nixon, C.W. & Gierke, H.E. (1970): Quantification of noisiness of 'approaching' and 'receding' sounds. Journal of the Acoustical Society of America 48, 843-853.

[12] Sader, M. (1988): Lautheit und Lärm. Göttingen: Hogrefe, 154 S.

[13] Schick, A. (1990): Schallbewertung. Grundlagen der Lärmforschung. Berlin: Springer.

[14] Schick, A. (1993; ed): Contributions to Psychological Acoustics. Results of the Sixth Oldenburg Symposium on Psychological Acoustics. Oldenburg: Bibliotheks- und Informationssystem der Carl von Ossietzky Universität Oldenburg.

[15] Schulte-Fortkamp, B. (1993): Judging noise in the laboratory. An analysis based on a new method. In: August Schick (ed): Contributions to Psychological Acoustics. Results of the Sixth Oldenburg Symposium on Psychological Acoustics. Oldenburg: Bibliotheks- und Informationssystem der Carl von Ossietzky Universität Oldenburg, 487-504.

[16] Weber, R. & Schulte-Fortkamp, B. (1989): A new approach to the continuous judgment of time-dependent loudness and its correlation with objective measures. 13.International Congress on Acoustics, Belgrade, Yugoslavia.

[17] Weber, R. (1991): The continuous loudness judgment of temporally variable sounds with an "analog" category procedure. In: Schick, A., Hellbrück, J. & Weber, R. (eds): Contributions to Psychological Acoustics. Results of the 5th Oldenburg Symposium on Psychological Acoustics. Oldenburg: Bibliotheks- und Informationssystem der Universität, 267-294.