Comparison of discomfort caused by two types of backup alarm

Laurent Brocolini, Lucie Léger, Etienne Parizet, Jean-Marie Verlhac, Xavier Carniel

Proceedings of Meetings on Acoustics

Volume 19, 2013 http://acousticalsociety.org/

ICA 2013 Montreal
Montreal, Canada
2 - 7 June 2013

Noise
Session 4aNSa: Effects of Noise on Human Performance and Comfort I

4aNSa4. Comparison of discomfort caused by two types of backup alarm

Laurent Brocolini*, Lucie Leger, Etienne Parizet, Jean-Marie Verlhac and Xavier Carniel

***Corresponding author's address: Laboratoire Vibrations Acoustique - INSA Lyon, Villeurbanne, F-69621, Rhone, France, laurent.brocolini@gmail.com**

Nowadays used on most of construction vehicles, tone backup alarm causes a strong discomfort among resident citizens. To solve this problem, "CETIM" (Mechanical Industries Technical Centre) decided to characterize and test another kind of alarm. This one is called "Cri du Lynx" in french (Lynx scream) because of its particular sound looks like a white noise. A previous study showed that the average sound level of the noise-alarm detectability is 67 dB (A) while it is 64 dB (A) for the tone-alarm (in a 80 dB(A) background noise). However, the noise-alarm could be used if it is less disturbing than the tone-alarm. The present work aims to compare the discomfort caused by exposure to tone and noise back-up alarms. About 50 people rated 2 times the discomfort caused by 11 sound environments. Each sound environment consisted of a site construction sound environment set at about 65 dB (A) mixed with a sequence of tone or noise alarm set at 56, 59, 62, 65 or 68 dB(A). One of the 11 stimuli had no alarm. Through an ANOVA it can be said if the kind of alarm and / or the sound level has an influence on the discomfort.

Published by the Acoustical Society of America through the American Institute of Physics

Received 22 Jan 2013; published 2 Jun 2013

INTRODUCTION

Noise around construction sites is of major concern for residents living close to these sites [NG 2000]. Many sources can be heard: engines, pneumatic hammers, impulsive shocks, but also warning sounds. Warning alarms are mandatory for all vehicles; they are switched on when the vehicle is moving backward. Their level and their characteristics must satisfy a regulation [DIRECTIVE 2003/10/EC 2003] [ISO 2003]. Today, two types of alarm exist: the conventional one is a tonal sound (usually around 1 kHz) and a new one is a band-pass noise (usually between 1500 Hz and 5 kHz). According to their promoters, these new alarms can facilitate their detection while reducing annoyance for the neighborhood. The goal of this study was to evaluate this second claim. The annoyance of the two types of alarms was evaluated using a large sample of listeners.

METHODOLOGY

Stimuli

Background noise

The background noise used in this study is a construction site noise; by mixing various recordings, a 10 minutes long sample was built. In this file, many sources can be heard, but without any alarm sound. The level of this noise was 65 dB(A).

Alarms

Two alarm types were considered: the first one is a tone (f = 1235 Hz) and the second one is a band-pass noise (1500 – 5000 Hz). They have the same temporal evolution (500 ms on / 500 ms off). Various samples were built, using 5 signal-to-noise ratios (-9 dB(A) to +3 dB(A) with a 3 dB(A) step). For a given signal-to-noise ratio and a given alarm type, a 30 second length sound was created, using the following rules:

- the number of alarm sounds was randomly selected between 2 and 4,
- the duration of each sound was randomly selected between 5 and 11 seconds,
- the time between two alarm sounds was randomly selected between 3 and 5 seconds,
- the overall time during which an alarm could be heard was fixed to 21 seconds.

Figure 1 shows an example of the sounds thus created.

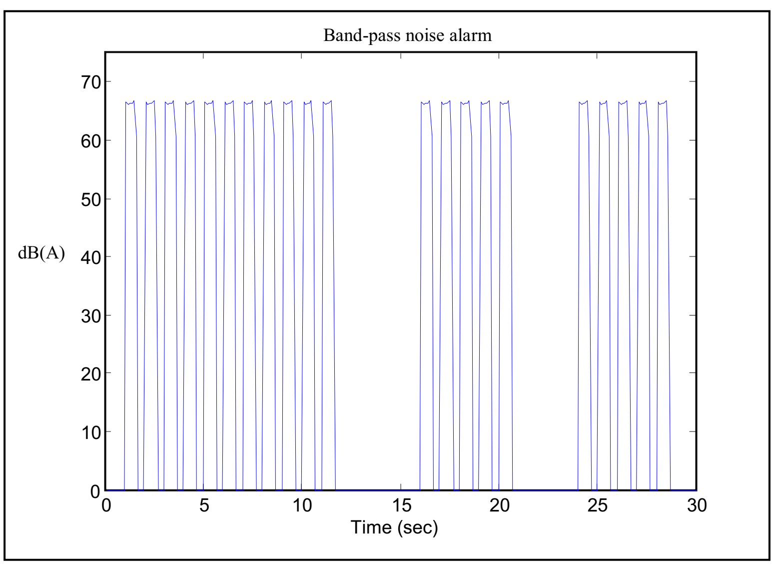

FIGURE 1. Temporal evolution of a 30 seconds sequence of white noise backup alarm randomly generated.

Stimuli

Each alarm sample was mixed with a randomly selected excerpt of the background noise. This excerpt had a duration of 30 seconds and its equivalent sound level was adjusted to 65 dB(A) before mixing. For each participant, 22 sounds were created, organized in two blocks of 11 sounds. Ten of these sounds included alarm signals (2 types *x* 5 signal-to-noise ratios) and one was made of construction site noise only, without any alarm sound.

All these sounds were presented by a loudspeaker (Tapco S8) in a sound proof booth. An equalization was applied so that the frequency response of the loudspeaker was flat, when measured at the position of the listener.

Procedure

The two blocks of sounds were presented to the subject. Presentation order was randomly arranged in each block. After listening to each sound, the participant had to evaluate the annoyance of the sound.

Although conducted in laboratory and in a closed room, the present study aims to assess the discomfort caused by backup warning alarms from the resident's point of view. Therefore, subjects were asked to imagine themselves to be on the balcony on their flat or in their garden, while talking to a friend or reading a book. They had to wonder how much they would be annoyed by the sound in such a situation. But, taking into account that they were in a laboratory, it was decided to ask them to evaluate the unpleasantness of the sound, as this task is easier in such a contect. They had to give their answer using a scale labelled from "not at all unpleasant" to "extremely unpleasant". (Figure 2). This scale was continuous but 5 levels were indicated, as recommended by Fields et al. [Fields 2001].

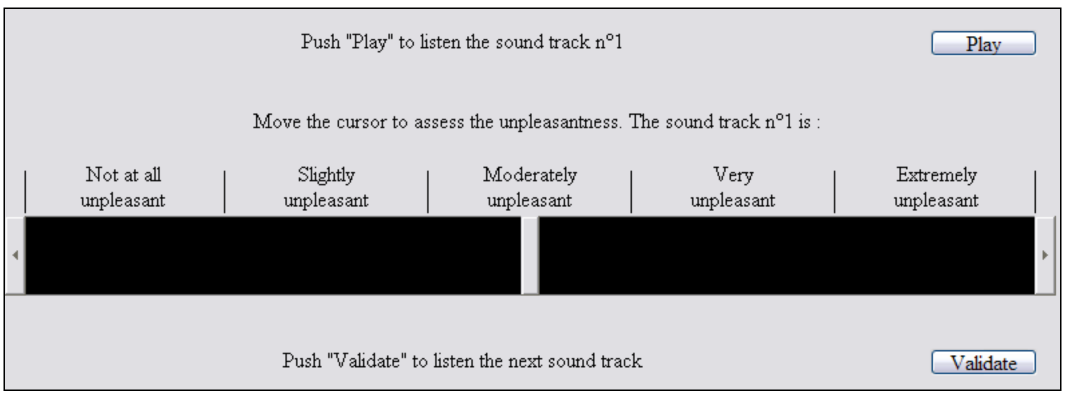

FIGURE 2. Graphical interface from which the subjects were able to assess the discomfort felt.

The cursor's position was transformed into a value between 0 ("not at all unpleasant") and 100 ("extremely unpleasant").

Subjects

88 people participated to the experiment. 47 were students from INSA (aged between 18 and 23, 22 women and 25 men) and 41 were recruited outside the lab (aged between 30 and 67, 21 women and 20 men).

RESULTS

Data considered in the following are the differences between unpleasantness evaluated by a listener for each alarm type and signal-to-noise ratio and the reference unpleasantness, which was obtained from the evaluation of the construction site alone sound in the corresponding block. This way, 20 values were considered in the analysis (2 alarm types, 5 signal-to-noise ratios and 2 blocks). As a first analysis of variance showed that there was no effect of the block, data were averaged over the two blocks, giving a number of 10 values for each participant.

The results of the 2 factors analysis of variance is presented in the table 1

TABLE 1. 2-ways analysis of variance (alarm type and signal-to-noise ration)					
Source	**Sum Sq.**	**d.f.**	**Mean Sq.**	**F**	**p**
Type	2903.3	1	2903.3	13.67	0.0002
S/N	8166	4	2041.5	9.61	0
Type*S/N	338.7	4	84.67	0.40	0.8096
Error	184746.7	870	212.35		
Total	196154.7	879			

The p-values show that there is a significant effect of both factors, but these two factors are independent since there is no significant effect of the two factors interaction.

Figure 3 shows the increase of unpleasantness of the two alarm types, as a function of signal-to-noise ratio. It can be seen that, for a given signal-to-noise ratio, the band-pass noise alarm is less annoying than the tonal one.

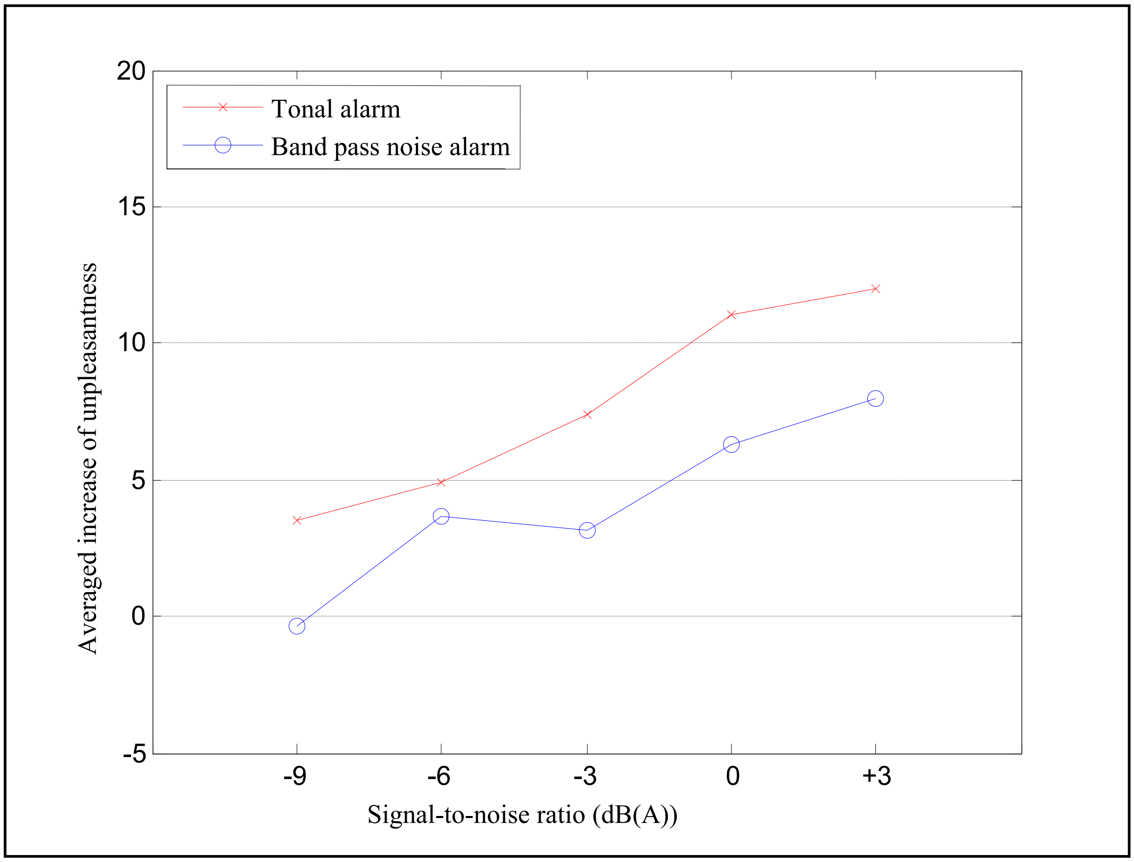

FIGURE 3. Averaged increase of unpleasantness depending on the signal-to-noise ratio

Post-hoc analysis showed that this difference is not significant at -6 dB(A), but it is at all other levels. Also, it was checked that the band-pass alarm sound at +3 dB(A) is less unpleasant that the tonal one at 0 dB(A). Therefore, using this kind of alarm can be beneficial to residents, when alarm levels are high as compared to all other noise sources.

CONCLUSION

This study showed that the new type of alarm can be useful to reduce noise annoyance of construction site. In the meantime, one should wonder whether it satisfies the basic requirement of a backup alarm (to warn workers on the site). A second study will be devoted to the evaluation of the detectability of these two types of warning sounds.

ACKNOWLEDGMENTS

Authors are grateful to heavy equipement vehicles companies for the funding of this study.

REFERENCES

Ng, C. F. **(2000)**. "Effects of building construction noise on residents: A quasi-experiment," Journal of Environmental Psychology, Volume 20, Issue 4, December 2000, 375-385.

European Parliament and the Council of the European Union. **(2003)**. "Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)," Official Journal of the European Union, 42, 38-44.

Fields, J. M., De Jong, R. G., Gjestland, T., Flindell, I. H., Job, R. F. S., Kurra, S., Lercher, P., Vallet, M., Yano, T., Guski, R., Felscher-Suhr, U., Schumer, R. **(2001)**. "Standardized General-Purpose Noise Reaction Questions for Community Noise Surveys: Research and a Recommendation," Journal of Sound and Vibration (2001), 242(4), 641-679.

International Organization for Standardization (ISO). **(2003)**. "Ergonomics - Danger signals for public and work areas - Auditory danger signals," ISO 7731.