UNPLEASANTNESS AND ANNOYANCE OF TYRE NOISES

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ABSTRACT

The European Leon-T project aims to reduce particles and noise emissions from industrial road vehicle tyres. For noise, an experiment consisted of evaluating the short-term annoyance of different tyre noises for people living near a traffic lane. Signals were simulated by adjusting two parameters identified as the most prominent ones in a previous study (intensity, tonality). A full factorial design was used, with two levels for each factor. Four sequences of about 10 minutes were prepared and played in a sound-proof booth in which a participant had a relaxing activity (e.g. reading a magazine). After each sequence, the participant rated the annoyance of the sequence. 48 people took part in the experiment (24 young students and 24 people aged between 40 and 60). The results of this experiment will be presented at the conference. In particular, they will be compared with those of a previous study in which listeners rated the unpleasantness of isolated passing noises, in an active listening situation.

Keywords: *tyre noise, noise annoyance, sound perception*.

1. INTRODUCTION

As car engines becomes quieter and quieter (and this is particularly true for electric vehicles), tyres are the most dominant noise sources at moderate speeds, especially in terms of exterior noise, to which local residents are exposed. This is also true for trucks (light and heavy) making deliveries in urban areas. These deliveries can also occur at night – and noise is known to disrupt sleep [1], which can ultimately lead to significant health issues [2]. Subjective experiments on tyre noise in passenger cars have been published (e.g. in [3]). However, to the best of our knowledge, there are no equivalent articles on truck tyre noise. The Leon-T project, funded by the European Commission, aims to improve knowledge in this area. In this project, experiments are being carried out at the University of Gothenburg to measure the effect of different tyre noises on sleep. Preliminary experiments on the perception of these noises have been conducted at the Vibration Acoustics Laboratory of INSA-Lyon. The aim of these experiments was to evaluate the effect of some sound characteristics (level and tonality) on unpleasantness and annoyance.

2. EXPERIMENT 1: UNPLEASANTNESS

2.1 Procedure

As a previous experiment (using recorded stimuli and a free sorting task) has shown that, for tyre noises heard inside a dwelling, subjective intensity and tonality are the most prominent features, 36 stimuli were synthesized. They simulated a passing-by vehicle (70 km/h) and varied according to their levels (from 40 to 52 dBA), tonality, pitch of the emerging frequency (300 or 500 Hz) and its bandwidth. These stimuli were filtered so as to simulate the attenuation of a façade. Their duration was about 2 s.

These stimuli were presented to 31 listeners (students at Insa), through headphones (Sennheiser HD 650) in a soundproof booth. The task of the participant was to evaluate the unpleasantness of each sound – the answer was provided by moving a cursor on a continuous scale labelled from “not at all unpleasant” to “extremely unpleasant”.

2.2 Results

Results showed that level and tonality were the most influential parameters. As it could be expected, level was the dominant parameter. But the importance of tonality was

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also noticeable (half as the one of level). A regression tree using these two parameters could represent the subjective results in an accurate way.

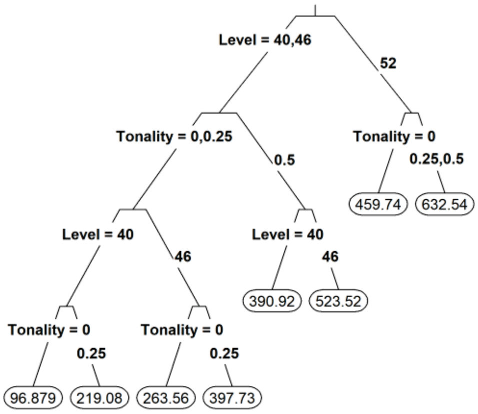

Figure 1. Regression tree for the unpleasantness evaluation.

3. EXPERIMENT 2: ANNOYANCE

3.1 Procedure

While the first experiment required participants to actively listen to sounds, this one placed them in a passive listening situation. More precisely, 10-minutes sound tracks were prepared, representing a traffic flow. In each sound track, passing-by sounds were synthesized by controlling two tyre sound parameters (level and tonality), as the previous experiment has shown their important contribution. Two levels were used for each factor: level was fixed to 40 or 52 dB(A) while tonality was 0 or 0.5 (this value represents the ratio between the energy of the tonal part of the sound and the one of the non-tonal part). The four noise conditions (plus a silent one) were presented in a random order, following a preliminary silent condition. After each condition, the participant had to:

- Evaluate the annoyance due to the sound, by moving a slider on a continuous scale, labelled from “not at all annoying” to “extremely annoying) and stored as numbers from 0 to 1000;
- Answer the French Canadian MFI20 questionnaire [4], aiming at evaluating his own assessment of fatigue.

Some physiological measurements were also conducted throughout each noise condition. At the very beginning of the experiment, the participant was also asked to fill a NoiseQ-R questionnaire to evaluate their noise sensitivity [5].

48 participants took part in the experiment. Half of them were students from Insa-Lyon (aged between 20 and 31), half of them were older people recruited outside Insa (aged between 41 and 60). Each participant was seated in a comfortable chair in the sound-proof booth of the lab. Sounds were presented through a pair of loudspeakers (Focal Alpha 50), placed 2 meters from the participant. The participant was asked to relax, reading a book or a magazine, playing cross-words…

3.2 Results

Both factors modified the self-assessed annoyance, as shown by a RM-Anova: $F(1,46) = 22.8$, $p < 0.001$ for tonality and $F(1,46) = 27.0$, $p < 0.001$ for level. Figure 2 shows that tonality increases annoyance in the same way as a large increase in noise level (12 dBA). No aged-effect could be observed: $F(1,43) = 2.22$, $p = 0.14$.

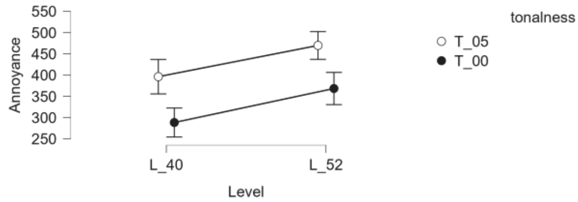

Figure 2 Influence of noise level and tonality on annoyance.

The analysis of other data will be presented during the conference.

4. CONCLUSION

Current regulations on pass-by noise only consider noise level. This study shows that tonality is also an important source of annoyance.

5. ACKNOWLEDGMENTS

This work has received funding from the European Union’s Horizon 2020 programme under grant agreement N° 955387.

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