Comparison of procedures for the quantification of the impulsivity of environmental sounds

Giovanni Brambilla

CNR Istituto di Acustica, Area della ricerca di Roma Tor Vergata, via del Fosso del Cavaliere, I-00133 Roma, Italy

Abstract: Any procedure for the quantification of the impulsivity of environmental sounds should be: i) sufficiently adequate in describing the human perception of impulsivity; ii) easy to be applied in field by portable equipment or in laboratory without requiring expensive apparatus and too much time. A few of the several procedures already developed have been compared one another. The subjective responses on the clear perception of impulsivity, collected in earlier studies, have been correlated to the selected descriptors in order to determine their threshold values for the onset of impulsivity and to evaluate how each descriptor is adequate and sensitive in describing the perception of impulsivity.

INTRODUCTION

Several procedures have been developed in the recent years for the detection of the impulsivity in the environmental noise and for the assessment of the enhanced annoyance evoked by such a feature (1,2). At present, there is no agreement yet on a unique procedure accepted on international base despite the effort made in recent years towards such aim. One of the reasons lies in the complexity of the phenomenon that shows different patterns both in time and in the acoustic energy involved. For instance, three categories of impulse noise are defined in the draft revision of the ISO 1996-2. In order to contribute to the discussion on the above issue, a comparison of the most frequently used or promising procedures has been carried out and is described in this paper. For this purpose experimental data collected in earlier studies (3) have been re-analysed. The subjective responses on the clear perception of impulsivity have been correlated to the selected descriptors of impulsivity to determine the corresponding threshold values for the onset of impulsivity and to evaluate how they are appropriate and sensitive in describing the perception of impulsivity.

DESCRIPTORS OF IMPULSIVITY

The following objective parameters have been considered for the comparison:

a) difference $L_{AeqI} - L_{AeqS}$ between the $L_{Aeq}$ levels measured at the same time with the impulse (I) and slow (S) time weighting respectively;

b) increment $I$, computed from the short-term $L_{Aeq10ms}$ time series values considering only the positive differences between successive $L_{Aeq10ms}$ values and taking the maximum (see fig. 1);

c) raising $R$, as above but the positive differences between successive $L_{Aeq10ms}$ values are added up together until a decrease of $L_{Aeq10ms}$ occurs, therefore $R \geq I$ (see fig. 1).

EXPERIMENTAL

Experimental data collected in earlier studies (3) have been re-analysed. The data refer to 26 environmental sounds heard in laboratory at $L_{Aeq}=55$ dB(A) for 20 s by a group of people varying between 48 up to 112 subjects.

![Figure 1. Definitions of increment I and raising R](image-url)
Details on the experimental protocol have been described elsewhere (3,4). The 50% of subjects rating the sound stimulus as clearly impulsive has been considered as threshold value for the onset of impulsivity. To evaluate how each descriptor is adequate and sensitive in describing the perception of impulsivity, the specificity $P$ and sensitivity $S$ have been determined as follows:

$$P = \frac{\text{true negative}}{\text{true negative} + \text{false positive}} \cdot 100 \%$$  \hspace{1cm} (1)

$$S = \frac{\text{true positive}}{\text{true positive} + \text{false negative}} \cdot 100 \%$$  \hspace{1cm} (2)

where true negative is a sound not clearly impulsive for both the majority of the subjects and the descriptor, false positive is a sound judged not clearly impulsive but detected as impulsive by the descriptor, true positive is a sound clearly impulsive for both the majority of the subjects and the descriptor, false negative is a sound judged clearly impulsive but detected as not clearly impulsive by the descriptor.

RESULTS AND DISCUSSION

For each descriptor the threshold value for the onset of impulsivity has to be determined in order to optimize the number of true negative and true positive cases ($P=100\%$, $S=100\%$). For this purpose the values of each descriptor have been plotted against the percentage of subjects reporting the sound stimuli as clearly impulsive, as shown in fig. 2 for the raising parameter $R$. The results obtained for the three descriptors are summarised in Table 1. The raising $R$ shows the best performance, while the increment $I$ results to be the most specific descriptor for impulsivity and its threshold value of 10 dB for the onset of impulsivity previously determined (5) is confirmed to be appropriate.

CONCLUSIONS

The procedures developed for the objective quantification of impulsivity show promising performance in relation to the perception of impulsivity and they are already implemented on portable equipment. It is desirable that they would be validate on a larger scale in the view of their possible inclusion in future standards.

REFERENCES


\begin{table}
\centering
\begin{tabular}{|c|c|c|c|}
\hline
Parameter & $L_{Aeq} - L_{A(qS)}$ & Increment $I$ & Raising $R$ \\
\hline
Threshold of impulsivity dB & 2 & 10 & 14 \\
Specificity $P\%$ & 63.6 & 90.9 & 81.8 \\
Sensitivity $S\%$ & 86.7 & 60.0 & 80.0 \\
Correlation coeff. Pearson $r$ & 0.54 & 0.57 & 0.61 \\
Correlation coeff. Spearman $r_s$ & 0.57 & 0.59 & 0.65 \\
\hline
\end{tabular}
\caption{Performance of the descriptors}
\end{table}