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PERCEPTION OF WARNING SIGNALS IN URBAN CONTEXT

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1. INTRODUCTION

Efficiency of warning signals is directly correlated with the security of people. Frequently, signals are not efficient enough to be perceived and localized on time, or they are played so loud that they become annoying for people who are not concerned with them. The aim of this research is to find how to improve the quality of warning signals with regard to the listening context and without raising the volume unnecessarily. Psychological and acoustical approaches were adopted in order to understand the behaviour of human faced to warning signals and to relate their reactions to acoustical properties of the signals. A listening experience was realized in order to find perception thresholds of warning signals in different background noises and to grasp the semantic signification of the signals.

2. METHOD

Sound Corpus

15 warning signals were selected, taking into account acoustical properties and representativity of sound in urban ambiences : 7 priority vehicles sirens (police, ambulance, fire brigade,...), 2 car horns, 3 bicycle bells and 3 whistles. Two sound ambiences, both representative of Paris [1], were selected: road-traffic noise and public park ambience. They were recorded with a specific stereophonic technique in order to ensure ecological validity to the listening conditions [1].

Test sequences were made up of 20 seconds of one of the two sound ambiences, upon which was mixed a warning signal, repeated five times with a 3 dB step increasing sound level between each iteration. One exception : the fire engine siren, which lasts 5 seconds, required looping the ambiences up to 38 seconds and was mixed four times only. The sequences were reproduced on loudspeakers in a fairly anechoïc surrounding [1]. Traffic ambience was reproduced at 81 dBA max. (10 dB below effective outdoor level, a level proved more ecologically valid in our listening conditions), public park ambience at 65 dBA max. (effective outdoor level).

Experimental Procedure

Subjects were first asked to quote ten warning signals and to give their characteristics. Then, they listened to 16 road-traffic sequences followed by 16 public park sequences. For each ambience, the first sequence presents no warning signal (reference sequence). Subjects had to react as soon as they heard a warning signal and the sequence was stopped. Then, they were asked to identify the perceived signal. Finally, warning signals were presented alone at a comfortable sound level and subjects had to identify them.
26 persons took part in the experiment, half of them began with the road-traffic and half of them with public park. In the second case, sequences were presented in reverse order after the initial reference sequence. This, in order to estimate the influence of order on the subjects' answers.

3. RESULTS

Threshold vs. Audiogram

Before beginning the experience, subjects were submitted to an audiogram test. A few of them had auditory deficiencies, but their responses were not significantly different from those of other subjets. This is in agreement with the hypothesis that people perceive the emergence of signals relative to background noise and thus, that perceptive thresholds in noise should be roughly identical for everyone. No other masking effect, due to auditory deficiencies, disturbed the test results.

Threshold vs. Context

Global results show that 10 signals have stable threshold (within standard deviation) in the public park context, whereas only 2 are stable in the traffic context. Even though the public park is very rich in acoustical events (voices, birds, footsteps,...), it has less masking effect than traffic noise. For the traffic context, a truck passing just before the third iteration of the signal alters the threshold stability. Therefore, thresholds responses are sometimes distributed very low on the third iteration: scores are transfered on the fourth iteration. Another reason is the order effect which increases the threshold of the first sequence only for each context and each group. However, it was possible to define a threshold for every signals by taking the first maximum in the distribution of responses.
Thresholds levels were then compared accross traffic and park contexts for each warning signal. The influence of the contexts can be measured by:

$$\Delta = (L_{ambT} - L_{ambP}) - (L_{sigT} - L_{sigP}),$$

where $L_{amb.}$ is the sound level in dBA of the ambience when threshold is reached, and $L_{sig.}$ is the sound level in dBA at the signals threshold. Indices T and P refere to traffic and park respectively.

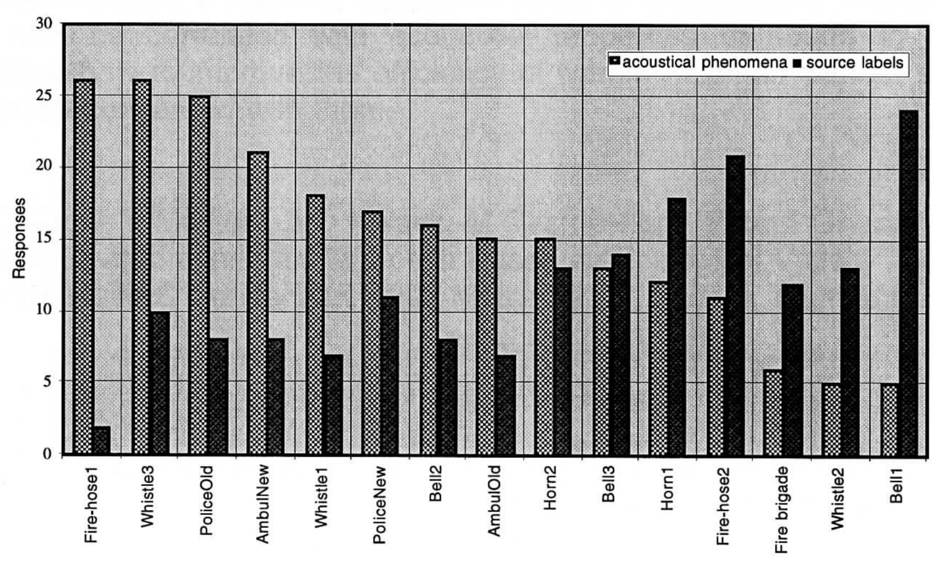
If $\Delta > 0$, the signal is perceived earlier in the park context than in the traffic context; if $\Delta < 0$, the signal is perceived earlier in the traffic context.
This classification of warning signals, more related to human perception and not based on acoustical properties, must now be analyzed in terms of acoustical properties. In order to explain it, the semantic signification of the warning signals must first be obtained.

Signification of the Warning Signals

Verbal data are not distributed at random over all the signals, some phrases being specifically associated with specific signals. Therefore, it becomes possible to identify relevant properties of the signals, that is, those perceived and integrated as significant for the subject. They depend on the subject's knowledge and his memory. Three types of items can be identified from the semantic analysis :

- acoustical phenomena (siren, hooter, alarm, onomatopeia,...)
- source labels (ambulance, whistle, bell,...)
- substantive phrases (bicycle bell, car horn, car alarm,...)

Source labels are directly correlated with the signal signification. Thus, it is possible to classify signals according to the sense given to them. Acoustical phenomena bring forward the connexion between the sense affected to a signal and its global acoustical properties. The latter constitute relevant variables for experiments on mental representation of sound (see above Threshold vs Context).
Outside any context (signals alone), source labels outnumber by more than four times acoustical phenomena. Only hooters are mainly described as acoustical phenomena. In context (park and traffic), the number of occurences of acoustical phenomena increases, and eventually outnumbers source labels. Four classes of signals, the same in both contexts, can be extracted from the test results (Figures 1 and 2):



<-----1----> <----------2----------> <-------3-------> <-----4----->

Figure 1. Semantic analysis : road-traffic context

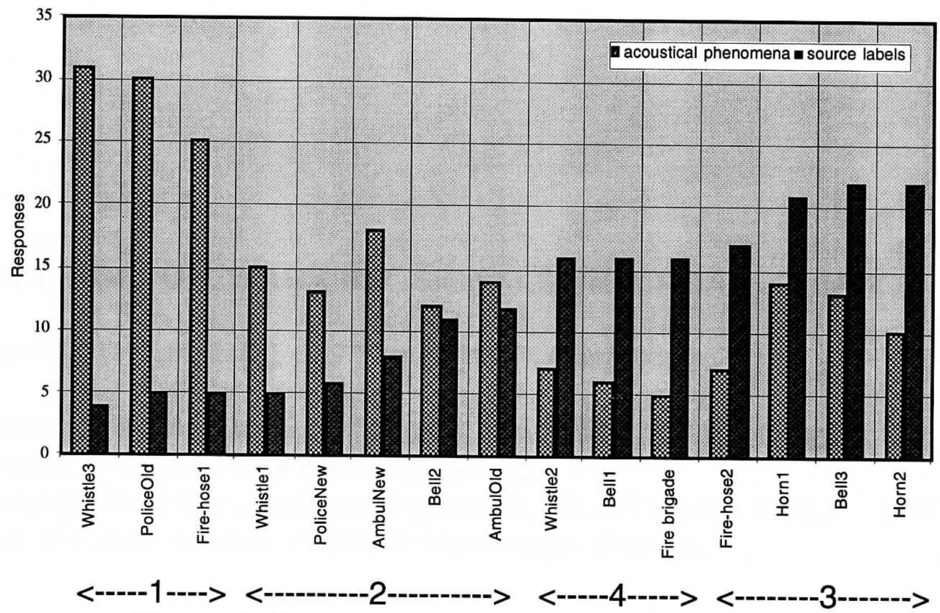


Figure 2. Semantic analysis : public park context

- Classes 1 and 2 are mainly described by source labels. Those signals can be considered as prototypical mental representations.
- Classes 3 and 4 are mainly described by acoustical phenomena. Those signals give indications about global acoustical properties of the signals.

4. CONCLUSION

The perception and the signification of warning signals has been tested in two different urban contexts and outside any context. Results show that perception thresholds of warning signals depend on context. Semantic analysis gives a new classification of warning signals in terms of signification. Those classes must now be correlated with acoustical properties of sound in order to determine how to improve the efficiency of warning signals without annoying people not concerned with them.

[1] C Vogel, V Maffiolo, J-D Polack, M Castellengo, 'Sound Characterization of Urban Environments: an Approach Based on Ecological Validity', presented at the 102nd AES Convention, 1997 March 22-25, Munich, Germany.