Categorisation: a useful tool for applied perceptive studies

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CATEGORISATION : A USEFUL TOOL FOR APPLIED PERCEPTIVE STUDIES

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ABSTRACT

Categorisation is a very common way we perceive our sound environment and, as so, was widely studied. Nevertheless, categorisation experiments are not so often used in applied studies. The goal of this paper is to show that it can be a very useful tool for reducing the number of stimuli without any loss of the generality of the context.

That was checked in two cases : the first one dealt with door closing sounds. A large number of stimuli (35) was reduced to twelve thanks to a categorisation experiment; these twelve stimuli could then be used in a similarity rating experiment, enabling to know the perceptual space of such sounds. The second case involved sound computed from a simple model in which some structural variabilities were used. In that case, the perceptual spaces derived from the categorisation experiment and the similarity ratings one were very close to each other.

1 INTRODUCTION

As pointed out by Rosch [1], categorisation is a common way we perceive our environment, because it provides maximum information with the least cognitive effort. The relevance of this assertion has been proved for environmental sounds [2] or domestic ones [3]. The corresponding experimental procedure, named free categorization experiment, has also been used for industrial sounds, either from vacuum cleaners [4] or car horns [5]. In the first case, it was associated with verbalizations : listeners had to verbally characterize each of the categories they had defined. The analysis of verbalizations beeing complex and time-consuming, that reduces the interest of this methodology for industrial applications. In the second case (car horns), the categorization experiment was used to build groups of similar sounds; later, representatives of each group were used in paired comparisons (similarity ratings). But the validity of similarities issued from categorizations was not checked.

The goal of this paper is to go further in that direction and to show that free categorization experiment can be very useful for industrial applications. Two cases will be presented, in which reliable clusterings of sounds have been obtained from categorizations. Moreover, in one of these two examples, the perceptual space could also be built with this procedure.

2 EXPERIMENT 1

2.1 Categorisation experiment

Stimuli were computed so as to represent a baffled rectangular plate excited by a force source through three rubber mounts. That study was a part of a Ph.D. work related to the perception of industrial variability [6], so that several mechanical parameters (level and frequency content of the input force, stiffness of each mount, thickness and damping of the plate) could be slightly varied (for example, the thickness of the plate varied from 0.9675 to 1.0325 mm, which corresponds to the industrially accepted margin). That gave a total number of 38 sounds, each of them having a duration of 4 seconds.

All sounds were diotically presented through headphones (Sennheiser HD600) , in a quiet room; the experiment was controlled by a computer. Each sound was represented by a small button (by clicking on the button, the listener could hear the corresponding sound). The task of the listener was to group sounds in families having similar timbre; the number of families was up to him.

20 students from the laboratory participated to the experiment.

The result of the experiment was, for each listener, a 38x38 matrix with 0 (if the two corresponding sounds belonged to the same groupe) and 1 (otherwise). Averaging all individual matrices lead to a matrix which was considered as a distance one. That matrix was analysed through a hierarchical clustering; the computation of Rand indices [7] allowed to cut the obtained dendrogram in five groups (the partition thus defined was the closest to all individual partitions). Also, a MDS analysis of the distance matrix was realised; five dimensions had to be included in order to explain more than 80% of the whole variance.

2.2 Dissimilarity ratings experiment

Twelve sounds among the 38 of the previous experiment were selected and used for that second experiment. They were presented in pairs (according to Ross series technique); when listening to a given pair, the subject had to evaluate the similarity of the two sounds and gave his answer on a continuous scale going from "the sounds are the same" to "the sounds are extremely different". Twenty listeners (students of the laboratory and members of the staff) participated to that experiment.

An Indscal analysis [8] of individual dissimilarities was realised and allowed to build a three dimensional perceptual space (in that case, such a number of dimensions was enough according to Kruskal's stress).

The two perceptual spaces were compared thanks to a procrustean analysis (only the twelve sounds used in both experiments were used in that analysis). It appeared that the two perceptual spaces were very close, as can be seen in Table 1, in which the correlation coefficients between the first three dimensions of the two adjusted spaces are shown.

Table 1. Correlation coefficients between the coordinates of the twelve sounds used in the two experiments

		Categorisation		
		Dim. 1	Dim. 2	Dim. 3
Similarity ratings	Dim. 1	0.97	0.03	0.16
	Dim. 2	0.08	0.94	0.06
	Dim. 3	0.00	0.01	0.91

Therefore, it can be said that the categorisation experiment was very reliable, in the sense that it allowed to build a perceptual space close to that obtained from the Indscal analysis of similarity ratings.

3 EXPERIMENT 2

3.1 Categorisation experiment

That second experiment was related to the perception of car door closing sound. The sound emitted by the driver's door of 16 cars was recorded by a dummy head (Bruel et Kjaer type 4133) in a semi-anechoic room. For two cars, more recordings were realised with different door seals configurations; for eight cars, two successive recordings were used in order to evaluate the stability of the mechanical device used to close the door in a controled way. Therfore, the overall number of stimuli was 35.

As in the previous experiment, 31 listeners (students and members of the staff) participated to a free categorisation session, with the same procedure and the same analysis scheme.

The dendrogram thus obtained from the average distance matrix is presented in figure 1. The best partition of this dendrogram was in 6 groups (these groups can be seen in figure 1).

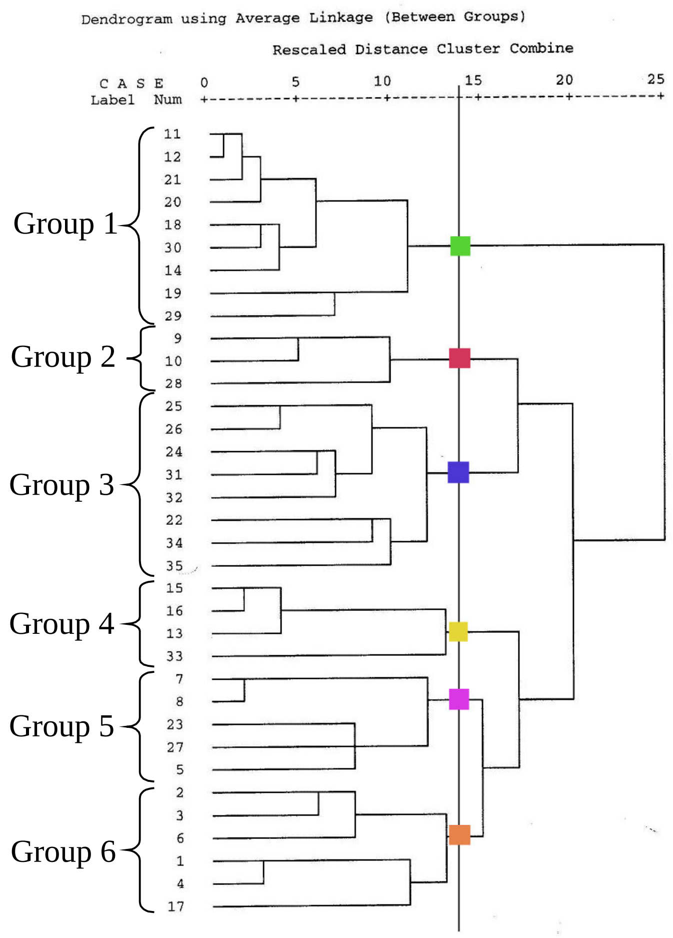

Fig. 1. Dendrogram computed from the results of the categorisation experiment, for car door noise.

3.2 Dissimilarity ratings experiment

In each group, two representative sounds were selected; they were the closest to the other sounds of their groups. The twelve sounds thus selected were used in a similarity rating experiment (40 listeners who were not members of the lab). The dendrogram obtained from the averaged dissimilarities is shown in figure 2.

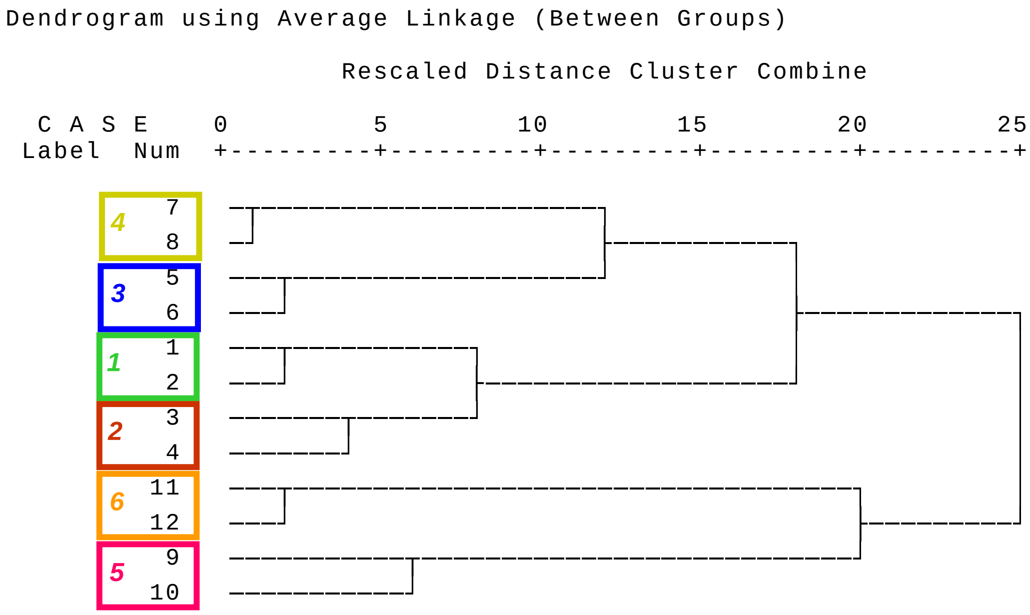

Figure 2 : Dendrogram computed from the results of the similarity rating experiment

The comparison between figures 1 and 2 shows that the two sounds from each group defined in the first experiment still belong to the same group in the second experiment; the set of sounds is still organised in six families. But the distance between groups varied a lot between the two listening tests : for example, in the categorisation experiment, group 4 was closer to group 5 than to group 1, which is no longer true in the results of similarity ratings.

That discrepancy between dendrograms lead to differences in the perceptual spaces obtained from the two sets of distances.

4 DISCUSSION AND CONCLUSION

In the two experiments, the clustering obtained from categorization experiment was confirmed by similarity ratings and proved to be a reliable one. Therefore, categorization can be very useful to reduce the number of stimuli while keeping all the important sound characteristics of the initial context.

But the second experiment showed that it can be hazardous to go further and to try to identify a perceptual space from the categorization results. Indeed, listeners do not have to relate any distance between the groups they have formed. The values in the cells of the averaged matrix may be only 0 and 1, provided the agreement between listeners is complete; intermediate values, which can be interpreted as distances between groups, are only secondary products of inter-individual variabilities. This can be the reason of the discrepancy between the two experiments : sounds used in the second experiment (real door slam noises from several cars) were more different than those used in the first experiment (for which mechanical parameters have been slightly modified). The computation of Rand indices between listeners showed that inter-individual variability was less important for doors than for radiating plates.

Nevertheless, we think that the first point is enough to give to categorisation experiments a major interest in sound quality applications, the more so as they can be easily and quickly realised (the average duration of experiments related in that paper was around 20 minutes for each listener).

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