Applied Acoustics 73 (2012) 61–65

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

Application of free sorting tasks to sound quality experiments

Etienne Parizet [a,*], Vincent Koehl [b]

[a] Laboratoire Vibrations Acoustique, Insa-Lyon, 25 bis avenue Jean Capelle, 69621 Villeurbanne Cédex, France
[b] Université de Brest, LISyC EA 3883, Centre Européen de Réalité Virtuelle, 25 rue Claude Chappe, 29280 Plouzané, France

ARTICLE INFO

Article history:
Received 30 December 2010
Received in revised form 29 April 2011
Accepted 12 July 2011
Available online 11 August 2011

Keywords:
Sound quality
Free sorting experiments

ABSTRACT

In many studies devoted to the sound quality of industrial products, a perceptual space is determined through dissimilarity judgements on pairs of stimuli. A drawback of this procedure is that it can be very time consuming if the number of stimuli is large. An alternative procedure consists in a free sorting of sounds: averaging individual results provides a set of data which are considered as indicators of dissimilarities and analyzed using a multi-dimensional scaling method. The validity of this alternative can be discussed, as the psychological processes involved in the two procedures are different.

This study compared these two approaches in a particular case (door closure sounds). In this specific case, it was observed that dissimilarities obtained from the two procedures can be different, the more so as sounds are dissimilar and these differences can lead to slightly different perceptual spaces. Nevertheless, a free sorting experiment is a reliable way of reducing the number of stimuli in a large set of sounds. It allows selecting some representative sounds and narrowing the set of sounds while keeping in the subset most of the timbre features. This provides a useful preliminary step to a paired-comparison experiment.

1. Introduction

In sound quality applications, the identification of important timbre features is a key factor. This knowledge allows the selection of sound metrics which can be used as input of a preference model. It also gives useful indications about the way the object should be modified in order to improve its sound quality. Numerous methods can be used to identify these attributes; a very common one consists in asking subjects to evaluate the dissimilarity between two sounds presented by pairs. After collecting the individual data, multi-dimensional techniques lead to a perceptual space, in which stimuli can be placed so that their relative distances are close to their perceived dissimilarities. The axes of this space can then be related to timbre features, as implicitly used by listeners when achieving the task. These timbre features are inferred by the experimenter (e.g. by listening to sounds with very different coordinates along this axis, or by computing correlations between these coordinates and candidate sound metrics, as loudness, sharpness and so on). Such a procedure has been widely used in many applications: sounds from musical instruments [13], synthesized ones [16], car sounds [15,18], aircraft noise [1] as examples. A major drawback of this procedure lies in the number of pairs to be presented to the listener, which is a square function of the number of sounds. This can make the experiment very long and tedious for the listener.

Another procedure consists in free sorting experiments. Subjects are asked to group stimuli together, on a similarity basis; they can make as many groups as they want to. This task is related to categorization process. But the relation between categorization and similarity evaluation is strong [22], though some exceptions have been pointed out (see [20], for an example). Individual results are co-occurrence matrices, made of 0 and 1 and indicating which sounds were grouped together by the subject. Averaging individual co-occurrence matrices provides a matrix which is considered as a dissimilarity one, and, as such, can be analyzed thanks to a multi-dimensional technique. Various examples can be given, in the field of visual perception (see [3] or [8], haptic perception [19] or [23], food evaluation [7], or perception of everyday life situations [6]. In the field of sound perception, this kind of analysis was realized in the case of environmental sounds [5,9], everyday sounds [10,11], cars dashboard tapping sounds [17] or loudspeakers quality [14]. In spite of the advantage of such a procedure, a question should be kept in mind: as the task of listeners does not consist in evaluating dissimilarities between sounds, can averaged data be considered as dissimilarities? Will the perceptual space obtained from these data be close to the one obtained from real dissimilarities? For sound stimuli, only one published study compared results obtained from these two methods [2]. This study used musical excerpts as stimuli and showed a good agreement between results. The goal of this paper is to present another example, using

* Corresponding author.
E-mail address: etienne.parizet@insa-lyon.fr (E. Parizet).

0003-682X/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apacoust.2011.07.007

another kind of sounds (car door closure sounds), and to discuss how free sorting experiments can be used in typical sound quality applications. Three experiments have been conducted:

- in the first one, a set of 35 sounds was sorted by listeners; this allowed to split this set in 6 groups of similar sounds;
- in the second experiment, 12 sounds extracted from this set (two sounds for each group) were sorted, using the same procedure. It appeared that stimuli could still be clustered in six groups, indicating that the organization of sounds, as determined from the first experiment, was robust enough;
- finally, in a third experiment, subjects were asked to evaluate dissimilarities between the same 12 sounds presented by pairs. The perceptual spaces obtained from the results of this experiment and the previous one proved to be slightly different.

The comparison of the results of these three experiments will provide some guidelines about the way a free sorting experiment can be used in such applications.

2. Experiment 1: free sorting of 35 sound samples

2.1. Stimuli

Car door closure sounds were used in that experiment; they were part of a study presented in another paper [18]. At the beginning of this study, 16 cars were used. Each car was entered in a semi-anechoic room and the driver's door closure sound was recorded with a dummy head (Bruel et Kjaer type 4133) placed outside the car, in the typical position of the driver leaving the car. Sounds were sampled at a 16-bits resolution with a 44.1 kHz sampling frequency. Some modifications of the door seals were realized on two cars, increasing the number of stimuli to 27. Finally, for eight situations, a second recording of the closing was introduced in the set of sounds in order to check the repeatability of measurements. Thus the overall number of stimuli was 35. Their duration was of approximately one second.

2.2. Free sorting experiment

Sounds were presented to listeners through headphones in a quiet room. Subjects were informed they were listening to door closure sounds. They were asked to group together similar sounds, forming as many groups they wanted to. They could listen to sounds as many time as they felt necessary.

Thirty-one subjects participated to the experiment (students or staff member of the laboratory).

2.3. Results

For each listener, a 35×35 co-occurrence matrix was determined. Each cell of this matrix was 0 if the two corresponding sounds had been placed in the same group by the listener, 1 otherwise. First of all, the importance of inter-individual variability was evaluated. Using Rand Index as an indicator of agreement between two individual clusterings [12], it was not possible to separate the panel into sub-groups of listeners. Therefore, all individual co-occurrence matrices were averaged, which lead to a dissimilarity matrix. The values of this matrix ranged between 0 and 1. It should be noted that data thus obtained are real distances, as they fulfil the triangle inequality $d(x,z) \leq d(x,y) + d(y,z)$.

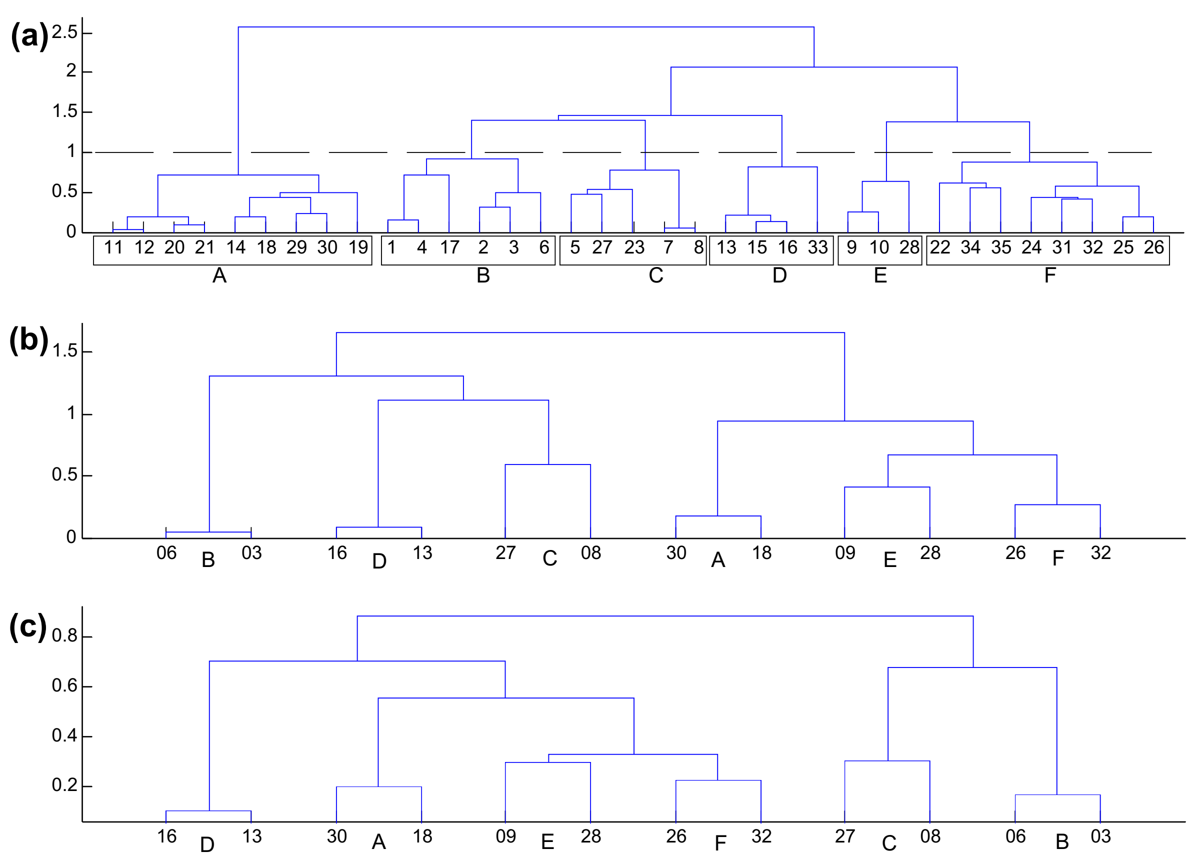

Fig. 1. Dendrograms obtained from the three experiments: (a) free sorting, 35 sounds, (b) free sorting, 12 sounds and (c) dissimilarity evaluation, 12 sounds. Groups of sounds are labelled with letters.