Soundscape design in train stations : Perceptual study of soundscapes

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1. Introduction

For many years the SNCF has been working on auditory comfort in train stations. The purpose of the present project is to design the soundscapes in all the different spaces that make up a train station. In order to achieve this goal, we propose to consider the problem along 3 axes : sound quality (perceptual dimensions), sound function (space function conveyed by the sound) and sound identity (one identity over all the spaces).

As a preliminary step, we propose a perceptual study on existing train stations to evaluate whether the soundscapes convey the function of the different spaces.

The present paper will describe the methodology developed in [1] and which consist in a comparison between the results of two auditory experiments : a free- and an oriented-categorisation task. Then the results will be analysed and discussed to finally conclude with future perspectives.

2. The goals of the study

1- What are the acoustical cues used by the listeners to describe the soundscapes ?

A recent study [2] showed that urban soundscapes were perceived by the listeners in two parts : *sound sources* and *background noise*. We can separate *sound sources* into two parts : human sound sources (steps, voices or crowd noise) and mechanical sources (trains, departure boards or ticket punching machines). Moreover, background noise is interpreted in terms of the room effects perceived by the listener (volume, reverb and absorption). Thus we propose 3 hypotheses concerning the acoustical cues : human activity, sound sources and perceived space.

2- Do people recognise the spaces ?

Given the correspondence between the space typology, the functions and the sound sources (see Table 1), we want to know whether listeners are able to recognise a space simply by listening to its soundscape and what are the main perceptive cues used.

SPACES	FUNCTIONS					SOUND SOURCES																	
	transit	short waiting	long waiting	ticket purchase	shopping	punching machine	departure boards	train noises	announcements	whistle	departure ring	shops noises	wheeled suitcases	bar noises	office noises	ticket dispenser	music	intercom	stairs	air conditionning	voices	urban noises	steps
Platforms	□	□				△		△	△	△							△				△	△	△
Corridors, Stairs	□								△				△				△		△		△		△
Halls	□	□		□	□	△	△	△	△		△	△	△	△	△	△	△	△			△	△	△
Ticket Offices		□	□	□											△			△			△		
Waiting rooms			□						△								△			△	△		
Shops		□			□				△			△		△			△			△	△		

Table 1: Table of spaces-functions-sound sources.

Thus, two experiments were carried out. First, a Free-categorisation experiment that will give a perceptual representation of the soundscapes [3]. Then, an Oriented-categorisation experiment that will give an recognition score for each space and a functional representation of the soundscapes.

3. Experimental protocol

3.1 Sound samples recording and selection

The sound samples were recorded with an ambisonic microphone (Soundfield ST250) on a DAT Sony PC204Ax, all of which is stand-alone with batteries. We chose ambisonic because it can be replayed on any type of sound reproduction system [4] and it was shown [2] that it had very good results for improving the sense of immersion.

The choice of the train stations was based on 4 criteria : type (through-transit or terminus), age (old, renovated, new), volume (number of travellers per year) and acoustical particularities. Six French train stations were recorded.

Then, 66 sound samples of 15 seconds each were selected within the 6 train stations in order to have representative situations of all the 6 spaces of the typology (see Table 1).

3.2 Procedure

The two experiments used the same 66 sound samples that were amplified by a Yamaha P2075 stereo amplifier and presented binaurally on a Sennheiser HD 250 linear II headphone. The listeners were seated in a double-walled IAC sound booth. The experimental sessions were run using a Matlab interface running on an Apple computer.

Experiment 1: Perceptual representation

Subjects : 55 listeners were recruited for this experiment. They were only informed that they would listen to train stations soundscapes, and no information about the spaces was given. None of them reported having hearing loss.

Procedure in 3 steps:

– Using the computer interface, the subjects were asked to create as many groups of sound samples as they wanted based on their similarity criteria.
– They were asked to write verbalisations for each category in order to explain their classification.
– Finally, they were asked to choose a prototype in each category.

Experiment 2 : Space recognition

Subjects : 40 new listeners were recruited for this experiment. Before coming to the lab, they were mailed an introductory text about the purpose and giving an architectural description of the 6 spaces. None of them reported having hearing loss.

Procedure in 3 steps:

– Using the computer interface modified with the names of the 6 spaces, the subjects were asked to recognise each sound sample.
– Then they were asked to choose a prototype in each category.
– Finally they were asked to choose a preferred sound sample according to their personal judgement.

3.3 Results

Experiment 1

A hierarchical cluster analysis was performed on the data to give the perceptual representation of the 66 sound samples. This analysis provided a hierarchical tree that can be optimised by a bootstrap method [5]. Thus, 8 categories are obtained, each category can be explained by a listening analysis performed by an expert. Then, a verbal analysis was performed on the descriptions of the groups that corresponded to a minimum of 50% of the 8 perceptual categories. The results (Table 2) show that listeners described the categories using terms concerning sound sources (suitcases, machines, departure boards, etc.), human activity (conversations, steps, etc.) and the perceived space (small closed space, reverb, etc.). Moreover, they used personal judgements (quiet/noisy, pleasant/unpleasant) and space recognition (platforms, hall, waiting rooms, bar, toilets, etc.).

Category	Verbal analysis
1	Small closed space, shopping conversations, steps
2	Small closed space, very quiet, no reverb
3	Background noise, music, waiting
4	Steps, suitcases, voices, activity, high reverb
5	Announcements, departure board and machines
6	Platforms, machines, trains, departure
7	Announcements, trains
8	Hall, large space, high reverb, announcements

Table 2 : Verbal analysis of the 8 perceptual categories.

Experiment 2

The recognition scores for each space are presented in Table 3. The first column correspond to the spaces where the samples were recorded, the first raw to the response category. These results show that all the spaces were well recognised (score > 50%) except for the waiting rooms, 47% of which were recognised as waiting rooms and 22% as shops.

	Platforms	Halls	Corridors	W.Rooms	T.Offices	Shops
Platforms	**67**	12	7	9	1	4
Halls	19	**52**	11	6	4	8
Corridors	16	14	**55**	2	5	8
W.Rooms	5	5	12	**47**	9	**22**
T.Offices	2	4	2	11	**53**	28
Shops	3	20	5	5	9	**57**

Table 3 : Recognition scores of the six spaces (%).

A hierarchical cluster analysis gave 6 categories (same method as in Experiment 1). Table 4 presents these 6 categories, the sound samples that comprise them and the mean recognition scores of the samples.

Category	Sample provenance	Recognition scores
1	Ticket Offices	58 % as T.Offices, 23 % as Shops
2	Shops, Halls, Ticket offices	55% as Shops, 15% as Halls, 11% as T.Offices
3	Corridors, Stairs	73 % as Corridors, Stairs
4	Waiting rooms	61 % as Waiting rooms
5	Platforms	76 % as Platforms
6	Halls	54 % as Halls, 20 % as Platforms

Table 4 : Recognition scores of the six categories.

Experiment 1 vs. Experiment 2

If we compare the samples that comprise the categories of Experiment 2 with those in Experiment 1, we find that :
- 9/10 of the functional category 3 come from the perceptual category 4.
- 8/9 of the functional category 4 come from the perceptual category 2.
- 7/9 of the functional category 5 come from the perceptual category 6.

Thus, for 3 spaces (corridors, waiting rooms and platforms), there is a good correlation between the perceptual representation of these samples and the representation of the spaces.

4. Conclusion – perspectives

The results of Experiment 1 show that the cues used by the listeners to decribe the soundscapes are sound sources, human activity, and perceived space (room effect). Moreover, they use personal judgements like pleasant or unpleasant and also space recognition.

The results of Experiment 2 show that there is a good recognition of the spaces, simply by listening to their soundscapes, especially for the corridors, the waiting rooms and the platforms. This result proves that the soundscape of a space conveys its function.

Finally, these results show that each element of the soundscape is sensitive for the listeners and thus will be useful for performing soundscape design in train stations. Moreover, it will be possible to improve the function of a space by modifing its soundscape.

References

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