



Fighting "noise" = adding "noise"? - Active improvement of high-speed train Sonic Ambiances

Ricardo Atienza, Niklas Billström

► To cite this version:

Ricardo Atienza, Niklas Billström. Fighting "noise" = adding "noise"? - Active improvement of high-speed train Sonic Ambiances. Ambiances in action / Ambiances en acte(s) - International Congress on Ambiances, Montreal 2012, Sep 2012, Montreal, Canada. pp.235-240. halshs-00745544

HAL Id: halshs-00745544

<https://shs.hal.science/halshs-00745544>

Submitted on 25 Oct 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Fighting “noise” = adding “noise”?

Active improvement of high-speed train Sonic Ambiances

Ricardo ATIENZA, Niklas BILLSTRÖM

Konstfack, University College of Arts, Crafts and Design, Stockholm, Sweden
Ricardo.Atienza@konstfack.se - Niklas.Billstrom@konstfack.se

Abstract. *The aim of this research project is how to actively improve the sound ambience in high-speed trains. Essential aspects are intimacy, a comfortable and enjoyable environment, a coherent sound identity, and the like. There is a need to move beyond conventional noise reduction techniques and modify the way we perceive these environments by employing efforts such as altering sonic composition. This can be achieved by the subtle addition of new sonic components able to divert the attention from the background environment. Two separate routes have been examined here: 1. introducing new sound textures that cannot be distinguished as separate elements in the train environment, “coloring” it in different ways; 2. introducing specific sound textures that will be perceived as subtle but composed added layers.*

Keywords: *sound design, attentional masking, altered soundscapes*

Introduction

The research Project ISHT (Interior Sound Design of High-Speed Trains) is a collaborative effort between several Universities in Stockholm, (Konstfack, KTH and Stockholm University), ÅF (a Swedish technical consulting company), and the train manufacturer Bombardier, which involves sound designers, acousticians, psycho-acousticians and composers. The key question in this project is how to actively improve the ambience in high-speed trains, an environment characterized by tough sonic conditions.

Essential aspects of this improvement include offering a comfortable and enjoyable environment, providing intimacy, improving the travelling experience, designing a coherent sound identity, dealing with the “tempo” of the trip, etc. In order to accommodate these requirements, we need to go further than just “reducing the noise level”. Beyond customary – and limited – insulation, absorption or even active noise cancelling, it is possible to modify the way we comprehend these environments by altering their sonic composition. This can be achieved by subtle addition of new sonic components able to divert attention from the background environment.

However, the concept of “added sound” includes a large range of practices, from subtle insertions to dominant saturation, and from site-specific conception to “ambient” large-scale production. Today’s public environments are exposed to an endless collection of added sounds, which structure and function can hardly be considered as sustainable, and which diffusion is often not controlled. We want to stress the fact that our intent, rather than contributing to this general cacophony, was to promote a critical reflection on the appropriate conditions, characteristics and use of such additive methods – for further insight on this subject, see the considerations proposed by Hellström (2005).

Overview of the research project

As explained in the previous paragraph, this research project combines different disciplines to approach several questions with regard to the sound quality of a high-speed train environment. One main aspect of this project concerns the large range of its thematic content, from more traditional acoustic questions approached via psycho-acoustical or sound design methods, to more recent demands for the proactive design of sound environments. We regard the consideration of these different questions as a condition for a coherent approach on the field of Sound Design.

This paper will focus on the phases of this research project specifically with regard to the field of sound design (phases 3 and 4, table 1) while offering an overview of the questions treated (table 1). These phases can be described as follows:

	Action	Method	Aim
1. Getting started: data and auralisation / Bombardier – Konstfack – ÅF			
1. a	Collecting data on train prototype	Multichannel recording and measurement	Rough material for an auralisation of the train environment (phase 1b)
1. b	Constructing a simulated sonic environment	Auralisation	To offer a virtual space in which to develop several <i>in vitro</i> research methods
2. Evaluating potential improvements of the train / Bombardier – Konstfack – SU – ÅF			
2. a	Group listening test <i>in vitro</i>	Pairwise comparison	Evaluating the perceptual relevance of potential technical improvements of the train in terms of noise reduction (passive)
2. b	Individual listening tests <i>in vitro</i>	Best-worst method	As for 2.a, but realized individually in an immersive and open setting (listening time and order of the sequences)
2. c	<i>Innotrans</i> train fair, Berlin 2010	Auralisation on train prototype	Scientific diffusion / public presentation of phase 2 in a static train
2. d	3D sound-modeling	Auralisation methods	Development of simple auralisation tools and techniques to be used by manufacturers
3. Non-attentional added-sound environments / Konstfack – SU – KTH			
3. a	Developing the sound textures to insert	Exploring sound characters / Pre-enquiries	Exploring and developing different sound textures – different characters – that could have a positive effect on the train environment. <i>In vitro</i> + <i>in situ</i> (explorative European high-speed train-trip)
3. b	<i>In vitro</i> listening tests	Focus groups	Evaluating, in group discussions, the resulting environment (train + “non-audible” added sounds)
4. Attentional added-sound environments / Konstfack – SU – KTH			
4. a	Creating the sound textures to insert	Composition – Improvisation	Exploring different sound textures –different characters – with a potential positive effect on the train environment. Commission to external composers under specific guidelines.

4. b	<i>In situ</i> listening tests	Pleasant-Eventful qualification	Individual evaluation of the “attentional” soundscapes using personal devices and trip circumstances (the closest to “real” conditions)
4. c	<i>In situ</i> listening tests	Integration in “info-tainment” platform	Individual evaluation of the “attentional” soundscapes in organized trips and as a part of an interactive environment (phase 5)
5. Interactivity, Info-tainment / KTH – Konstfack			
5	Phone application / <i>in situ</i> tests	Sonification / Qualitative enquiry	Development and evaluation of interactive tool (phone application), integrating trip-information (sonification) and added sound textures

The development on phase 1 of an auralisation (acoustic simulation) of the train environment at Konstfack’s Sound Lab allowed us to realize, during the following phases, different kinds of evaluations and sound productions. Such a virtual space was built up from a multi-channel recording – including vibration – and measurement campaign realized on a Bombardier train prototype, and has been adjusted progressively to the particular requirements of each phase.

The first application of this tool came with phase 2, where this auralized space provided the necessary environment for one of the methods employed in a double listening test which opposed two different psycho-acoustic protocols. These were the “Pairwise comparison” method – group tests in auralized space, short fragments compared by pairs in every possible combination – and the “Best-worst” method – immersive setting (headphones-based, specific space simulating some of the attributes of a train-wagon including a screen/window), individual tests, open listening time and order of the sequences to listen. The aim of this phase was to characterize the relevance of implementing different acoustic improvements. The results of these two different methods offered a high degree of coherence, thus proving their pertinence in this particular research field.

Added-sound environments

For “sustainable” reasons (see introduction), phases 3 and 4 are based on processes able to modify the way we perceive a sound environment with just subtle alterations of its sonic matter. One main concept operates in these phases: attentional masking (or *informational* masking as described by Nilsson, 2010) opposed to conventional “energetic” masking. In simple words, the objective was to divert the passengers’ attention, as opposed to hiding background sounds. This attentional masking has been applied in two different ways, exploring both unconscious and conscious diverting processes:

- introducing new sound textures that would not actively be perceived as added elements, but generally as merely a part of the train environment, “coloring” it in different ways – phase 3;
- introducing sonic “composed” textures that could be clearly perceived as new, added layers but always in an intimate relationship with the train environment – phase 4.

Both phases, 3 and 4, may be regarded as complementary sides of the same question, thus allowing a more complete comprehension of the complex question of added sound environments.

Non-attentional altered environments

The matter of how easy is it to perceive an added texture depends on several factors, as the complexity of the context – the metabolic effect as defined by Augoyard & Torgue (2006) –

and the attentional/listening mode of each passenger. Several criteria have been considered here for the production of such “inaudible” sequences:

- The increase of the overall sound pressure should be extremely limited (irrelevant, (<1dB).
- The new sound textures should carefully consider the spectral and dynamic characteristics of the sound environment. This condition limited our intervention to a narrow spectral range where it was possible to add sound efficiently at a low-pressure level. The sequences proposed are thus specific to each situation (to each train sound profile).
- The sound textures employed should not be easily recognizable and named, rather they should be as free as possible from any meaning. The first explorations indicated that natural sounds, for example, were perceived as unexpected and associated to undesirable phenomena in the train.

Our objective could be described with the words of Neuhaus (1992) when describing one of his *place* pieces: “a deliberate point of making the sound almost plausible within the space. It also leaves it hidden [...]”. For this reason, all the examples produced in this phase were obtained by different filtering protocols, directly applied on the train sonic environment (on the recordings).

After a first selection process, based on expert and non-expert focus group listening sessions, three examples were retained:

- a Shepard scale (1) extracted from the train spectral profile, giving the illusion of a perpetual falling sound and looking for an interaction with the sensation of speed,
- a sequence (2) based on an extreme noise cancellation protocol, generating a texture of sparse sound “points”, looking for more open temporal conditions,
- a harmonic structure (3) based on the train dominant frequency, searching for its perceptual masking by providing a slow color variation.

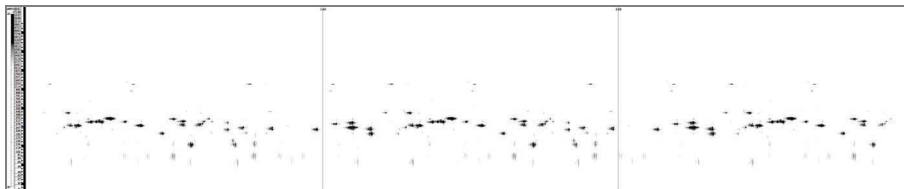


Figure 1. Example 2, extreme noise cancellation of the train sonic background

These 3 examples, mixed with the background sound of the train, were finally evaluated via 3 focus groups at the Konstfack Sound Laboratory, where long immersive sessions were proposed (10' per example). The participants were invited not to pay attention to the sound, but simply attend to any other activities they would normally do on a train trip.

The result of this method confirmed the efficiency of examples 2 and 3 while questioning the viability of example 1 (Shepard scale) as interfering with the sensation of speed. Example 2 (extreme noise cancellation) provided the sensation of a more permeable and light environment, where the train variations and the outdoor surrounding events could be more present, which was considered a positive quality. Concerning example 3 (harmonic structure), it proved to be efficient in diverting the attention from the dominating tones of the train, while providing a relaxing environment where the background sound was less present.

Attentional altered environments

If the previous phase considered the possibility of inserting “non-audible” sounds, phase 4 approached the aspect of altering sound environments from the opposite perspective, assuming that the new added layer should be perceived, even though it was subtle and completely integrated with the train background. This approach was specially conceived for an intentional and individual listening mode, and also intended to provide a comparative case for phase 3; this comparison is particularly pertinent when considering an evaluation of sounds not meant to be perceived separately (phase 3).

Two composers, not part of the research team, were contracted to produce these additional sounds. They received a guideline document that detailed various recommendations extracted from the results of the previous phase. They were asked to produce their sound textures while being immersed in the train environment (a recording was provided), being free to use any kind of sound; acoustic, electroacoustic or purely electronic. Some of the characteristics requested were to propose long and subtle sound sequences, taking care of how were they blended with the environment – not hiding aspects, but conducting a dialogue with the background sounds. Other recommendations included low-density textures and reduced spectral ranges adapted to the context.

Four examples were finally selected, two produced at the Sound Laboratory and two by the composers. They corresponded to four different basic concepts, all attempting to characterize primary sound structures:

- A. Variation: noise-based, reminiscent of the rail (rhythms, textures), irruptions of alien sounds.
- B. Repetition: instrumental. Breathing concept; organic rhythms, a resting body.
- C. Improvisation: instrumental. Indeterminacy, organic/natural improvisation. Aerial character.
- D. Cycle: noise-based. Idea of a slow sea wave. Occasional irruptions of alien sounds.

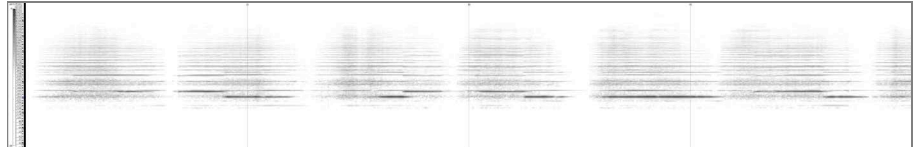


Figure 2. Sequence b, 1 minute. Repetition

The evaluation of these examples aimed to be as close as possible to the actual *in situ* conditions, even if the train was not yet in operation. It was thus conceived to be inserted in “real” trip circumstances, offered as a collection of sound sequences to carry and hear in personal sound devices. A train-noise profile was offered as a basic level calibration and open headphones were used in order to assure a full mix with the environment.

As a consequence of this open set up, several parameters could not be fully controlled, such as the background sound profile and level of the different trains and situations involved, but we considered these possible deviations as an assumed risk in order to be as close as possible to the final conditions. This point was particularly pertinent considering the design of a sound texture to be used on a voluntary basis – which was not the case on phase 3.

About 30 subjects participated in a study where they were asked to evaluate each fragment, using an open scale that opposed pairs of qualities. These attributes could be finally reduced to two main qualities: pleasantness and eventfulness. The results of the questionnaire showed a clear preference in terms of pleasantness for the sequences based on the concepts of cycle (d) and repetition (b), both offering simple and periodic structures and including silence as a major element in their structures, while the sequence based on the idea of

improvisation (c) was given a negative evaluation. The impression of indeterminacy seems to be in general a negative attribute, strictly ordering the reception of the 4 sequences. On the other hand, no major differences could be determined with regard to the second quality, eventfulness, probably due to the initial conditions imposed to the production of these sound examples. It is also interesting to notice that no major changes seem to be observed depending on the “nature” of the sounds (synthetic, natural), being examples d and b based on different families of sounds; this point would require more extensive investigation that would extend beyond the number of cases available in terms of tempo of the cycle and nature of sounds.

References

- Augoyard J.-F. & Torgue H. (eds.) (2006), *Sonic Experience. A Guide to Everyday Sounds*, McGill-Queen's University Press, Montreal, 216 p.
- Hellström B. (2005), *Theories and Methods Adaptable to Acoustic and Architectural Design of Railway Stations*, Conference paper: Twelfth International Congress on Sound and Vibration, Lisbon, 11-14 July, www.acousticdesign.se/upload/files/Paper_hellstrom.pdf
- Neuhaus M. (1992), *Notes on Place and Moment*, in Max Neuhaus: Sound Works, vol. 1, inscription www.maxneuhaus.info/soundworks/vectors/moment/notes
- Nilsson M. E. *et al.* (2010), *Auditory masking of wanted and unwanted sounds in a city park*, Noise Control Engineering Journal, 58(5), pp. 524-531

Authors

Ricardo Atienza is a researcher and lecturer at Konstfack and a researcher at the Museum of Architecture, Stockholm. PhD Architect, he is also associate researcher at CRESSON, France. In addition, he also conducts professional practice in the fields of Sound Art and Design. Ricardo.Atienza@Konstfack.se

Niklas Billström is a researcher and guest teacher in Sound at Konstfack, the University College of Arts, Crafts and Design in Stockholm. He has extensive experience as a sound designer and sound artist in fields such as music, radio, game development, theater, and art projects. Previously an active double bass player. Founder of Alice Musik Records. niklasbillstrom@telia.com