“Ambiances” in Railway Stations – The role played by acoustic

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Summary
Comfort has become a requirement, and is more or less well standardized. These standardized criteria have been able to reduce discomfort but do not always contribute to the well-being. The next step is to build an environment, which is appealing to our senses, emotions and memories. It is the ambiances/atmospheres of a station that we want to conceive. A review of the literature defined the main contributors, their interactions and their functions within a room. Acoustic has an important role to play in the design of the ambiance. The design of the sound environment should considered the architecture, the light and the equipment (lift, mechanical stairs, trains…). These are the components that will help writing the music sheet of the station. Defining the ambiance precisely still requires more understanding toward the relationship between perception and objective criteria.

1. Introduction

Historically, stations were built around the trains and were not necessarily focused on the passengers. The station was a gate within the city, an opening to new possibilities, made possible by a revolutionary means of transportation. Stations are massive building where the trains occupied the center place. More recent or redesigned stations tend to allow more space and attention for the passengers. Trains are not anymore the only focus of the station. Stations offer other functions than waiting and getting in and out of a train. Some are integrated within a shopping mall (Gare Saint Lazare, Paris, France, Stations in Tokyo, Japan). Services (post office, medical laboratory, hairdresser, shoemaker, restaurant, coffee shop, music store…) are deployed, so the time spent within the station is profitable for the passengers and the owners of the buildings. Occupants of a station, might not be there to travel by train. The uses within the station are changing and the environment needs to adapt.

Architecture, design, and also light, sound, noise, air displacement, smell… are components that participate to the perception of the users and the way they will experience the station.

This paper presents the concept of ambiance, its main components and their interactions. To design a successful ambiance, a process has to be designed to include its conception within the conception phases of the stations. A detailed example of this approach is given with the acoustic modality. It shows the acoustic criteria that are considered to build ambiances in coherency with the architectures, lightings and the uses of the station.

2. Defining “Ambiance”

2.1 From comfort to ambiance

The origins of the notion of “Ambiance” in architecture goes back to the 19th century and the industrial revolution. Breakthroughs in science and engineering allow builders to actually control the environment: lighting, acoustics, thermal conditions etc… can now be planned and designed. Architects and engineers innovate to ensure evermore comfort in our spaces. In 1842, the French academy of letters wrote down the official definition of comfort: “material well-being, ease of life”. In a very hygienic fashion, environmental comfort slowly becomes the norm.
This pursuit of the universal comfort has led modern architects to wonder if environmental normalization is not leading to increasingly standardized, sanitized and in a way impersonal environments. In fact architect Barbara Erwine says: “normalization has led to environments that are acceptable but not inspiring, comfortable but not comforting, predictable but not memorable” [1]. Thereby, ensuring material and physiological

comfort may not necessarily lead to environmental well-being.

Therefore, another layer of environmental evaluation needs to be taken into consideration. The approach presented in this study offers to explore the notion of "ambiance" as an evolution to the notion of comfort. The underlying methodology consists in adopting a sensory and affective approach of the built environment.

The ambiance, the atmosphere of an environment, is defined by the architect Juhani Pallasmaa as follows: "an ambiance [or atmosphere] is a global and sensory feeling based on perceptive mechanisms and emotional responses" [2]. It must be highlighted that a user assessment of an ambiance is highly subjective. Emotional responses closely depends on the user past experiences, memories and imagination. This variability needs to be considered, but a part of the subjectivity can be objectified.

2.2 Factors influencing an ambiance

Peter Zumthor, architect and author of "Atmosphere" says: "We perceive atmosphere through our emotional sensibility—a form of perception that works incredibly quickly…. Something inside us tells us an enormous amount straight away. We are capable of immediate appreciation, of a spontaneous emotional response" [3]. Our appreciation of an ambiance comes from a holistic perception process. Through his senses, the user perceives simultaneously countless of environmental factors. Although it would be impossible to compile an exhaustive list of these factors, some are more dominant than others. We can enunciate lighting conditions, acoustics, odor, thermal and ventilation conditions, architectural assets, materials and textures etc.

These factors have a direct effect on our environmental comfort and well-being. They can influence how we perceive and assess the space we are in and how we interact with it. They can lead to specific uses. To illustrate this statement we will focus specifically on railway and subway station oriented studies.

Commuters in railway stations or underground subway stations are in transit from point A to B. His constant motion is being seconded by perceptive activity, he is vigilant to information or signs that could help orientate him in his transit. Jean-Paul Thibaud, in his study [4] explores how ambiances and in particular light, acoustics or materials can help guiding a commuter and influence his mortician behavior. For example the inverted pyramid of Le Louvres underground access in Paris acts as a large skylight that splashes the underground space with natural light. Aside from the physiological and psychological benefits of natural light, Thibaud shows how this window acts as a perceptive beacon, a lighthouse that helps the underground pedestrian to always locate himself in the underground corridors. In a similar way, natural light coming down from exits help commuters locate them.

Another example are the mechanical departure/arrival displays we could find in railway stations. When updated, the pallets rotation emits a characteristic "Clac-Clac-Clac" sound. This sound has a strong use value as it directly informs of the update occurring on the display. On a more affective note, this sound symbolizes the arrival of someone close or the departure and potential travel. It's a sound that every commuter knows, it is part of the ambiance you may expect in railway station hall (Figure 1).

A last example deals with the effects of odors on commuter behavior. Lange et al [5] led an experiment in train compartments. The researchers compared the quantity of garbage left outside bins in two different compartments: the first was left as it is, the second one was odorized beforehand with cleaning product smell. The experiment revealed that commuters in the odorized compartments were cleaner and less likely to leave garbage in comparison with those in the first compartment.

These different examples show how lightings, sounds or odors can influence not only our environmental comfort but our behavior as well.

Figure 1. Mechanical information display (Montparnasse station, Paris).

The different components that generate the perception of the ambiance of a space may interact. Candas and Dufour [6] showed that the intensity or color of the light could affect the vasodilatation and may decrease lightly the body temperature and so modify our comfort. Santos and Gunnmarsen (1999) [7] have studied what are the optimal levels for comfort when combined environmental factors are involved. They have especially investigated the relationship between temperature, air quality and noise. They found that the use of air conditioning may be affected by the noise generated by the air conditioner. It means that people may support warmer temperatures if there is no noise disturbance than the opposite. Light and sound also have an interaction with the type of the materials used in a space. Rough or asperities within the surface help diffuse the sound and light in the space. This is interesting to have a homogeneous distribution of light and sound within the room. Architects can use these properties to generate different ambiances. For examples, long monotonous corridors can be rhythmed by alternating absorbent and reflecting material. Lighting can amplify this effect by alternating low intensity light where the absorbent material is localized and brighter light with the reflective material. Some studies showed that the effect of alternating the intensity of light may affect the displacement of the users [8].

One environment can be perceived differently depending on our culture, age, social group… Ambiance components may remain the same but their relative importance and their interaction might change according to targeted public/populations. Therefore, it is important to know these cultural differences to manage the various components efficiently and avoid "perceptive bugs".

The challenge is to design spaces that go beyond comfort and offer ambiance qualities and environmental assets that can improve the commuter's journey experience.

3. The role played by acoustic

3.1 Factors and criteria affecting and defining the sound quality

In stations, the main acoustic criteria used for defining the acoustic treatment are the intelligibility, the sound pressure level (SPL) and the reverberation time.

Intelligibility of the announcements is a legal requirement defined such as emergency messages can be heard and understood by all the public in case of an evacuation. The standard NF EN 60849 states that every sound system installed for security purposes must ensure a minimum level of performance. The criteria used is the STI (Sound Transmission Index). If the minimum level of STI is respected (50%), the sound system will communicate complex instructions precisely with a sufficient intelligibility. The STI depends on the acoustics' response of the room and the background noise.

Kim and Soeta [9] have studied the effects of volumes, sections, shapes of a station and the absorption and diffusion properties of the material used on acoustic criteria. The results showed that all these factors affect significantly the STI, SPL and the reverberation time (RT). Depending on the room to be treated, several solutions may be envisaged. Speech rate of the message and background noise were also confirmed to affect the intelligibility.

Beside the STI, the D50 is also a good criteria used to evaluate the intelligibility. It represents the ratio of energy perceived by a receiver from sound sources during the first 50ms over the whole sound duration [10]. This parameter depends directly on the acoustics' response of the room and the directivity of the different sound sources. The D50 helps the acoustician to locate the acoustic treatments required and choose the optimal speakers and their locations.

For railway stations, intelligibility was the main factor and studies were conducted to determine an efficient objective criteria [11]. However, the literature is lacking of studies investigating the acoustic comfort within a station.

Most of the research was led to characterize the sound quality of amphitheaters, symphony hall…, where the main activity of these rooms is to listen to music or theater pieces. The standard ISO 3382-1 describes a number of objective room acoustic parameters, which are used for these purposes. They include measures of energy ratios, decay times, sound strength and several quantities related to the spatial aspects of sound fields. Bradley [12] review these criteria (see Table 1). The study investigated if the measurement methods are sufficiently described to get a repeatable measure. His review also study the correlation between the objective criteria and the subjective perception. His

Table 1. Acoustic criteria defined in ISO 3382-1 from Bradley [13]

Type of measure	Measures	Notes
Decay times	T_{60}, reverberation time	Physically important
	EDT, Early Decay Time	Subjectively important
Sound strength	G, Strength	Hall effect on sound levels
Clarity measures	D_{50}, Definition	Clarity of speech
	C_{50} Clarity	
	C_{80} Clarity	Clarity of music
	T_S Centre time	
Spatial impression	LF_{early}, Early lateral energy fraction	Apparent source width
	$IACC_{early}$, Early inter-aural cross correlation	
	GLL, Late lateral sound level	Listener envelopment

conclusion reveals that not all methods provides repeatable measures. Criteria have not been yet confirmed to represent subjective values. Also there is a lack of understanding of what are the just noticeable differences, which may be useful to specify and evaluate the acoustic of a room. Giménez *et* al. [14] also investigated the correlation between acoustic objective criteria and the corresponding subjective perception. Their conclusion were similar as Bradley, only a small number of criteria are correlated to the acoustic criteria. Four groups of parameters showed some correlations: Spatiality (JLF3, JLF4, JLFC4, IACCL3), Clarity-Balance (C80av, C50av, Br, BR), Envelopment (Glate, LJ4, LEV), and Reverberation (Tmid, EDTmid, TS1k). They also demonstrated that what composed the perception of the sound quality is not entirely covered by the existing criteria. With acoustic criteria, which are not well correlated to the perception and perception components that are not entirely covered by the existing criteria, specifying a sound environment is a complex task. Kahle [13] proposed that all acoustic criteria (loudness, frequency balance and spatial aspects) should be calculated separately for the early and late parts of the impulse response. New criteria, based on a combination of existing criteria have also been proposed using multi-dimensional analysis [14].

All these study have been performed for high-quality acoustic spaces such as symphony halls. In a station, the receivers (the passengers) are moving, the sound sources (equipment, trains, passengers, loudspeakers…) are spread within the rooms, and are usually not constant. Passengers also change the impulse response of the room by adding absorption and diffusion. The environment is therefore significantly different from a concert hall and useful criteria used in concert hall may not be adapted for stations. Intelligibility (STI, D50), loudness (SPL) and reverberation (EDT, RT) give already some idea of the sound environment. The use of other criteria such as $IACC_{early}$, $IACC_{late}$, C80, 'warmth' (T_{rbf}/Tr_{hf}) might help designing more precisely the sound environments of a station. More studies are still required to first analyze what are the component of the sound that make sense for the passengers and then what objective criteria are correlated to the perception.

3.2 Integration of the sound within the ambiance

To conceive a coherent ambiance, the components and their interactions have to be understood. Meng *et* al. [15] studied, in underground shopping streets, the interactions between acoustic, light, air temperature, humidity in different areas where people had different activities (shopping, dining, walking…). Correlations were found among all these factors. For example a brighter area will sound louder and that also depends on what type of activities people have.

The first step in defining the right ambiance of a space is to determine what will do the people in this area: buy tickets, walk to the platform, wait for the train, do shopping, have a coffee…Once activity has been established the right combination of light and acoustic treatments can be applied. Ambiance should be defined for each space. For example, the ticket area might be quiet with indirect and neutral lightings. Where people walk, the light and sound may alternate between neutral and bright, such as to generate a rhythm and tend to accelerate passengers' flow. The platform will have absorbent materials, required for intelligibility, but it can be positioned such as to provide quiet areas within the platform. In these quiet zones, the lightings can be warmer. Also, reverberation should not always be significantly reduced. There should be a certain coherency between the architecture and what sound atmosphere people are expecting. If intelligibility is

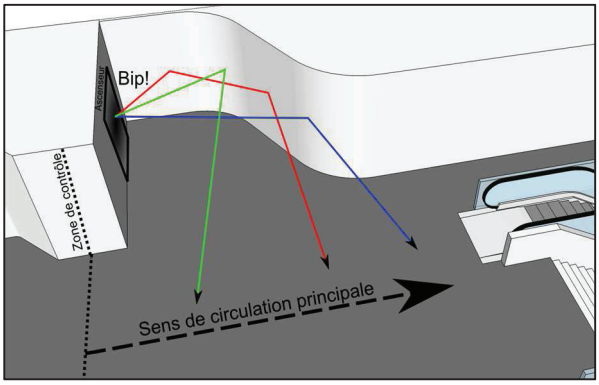

Figure 2. Use the shapes of the room to localize the sound of the lift and help orientating the passengers.

assure, reverberation may contribute to the right ambiance.

These scenarios propositions can also respond dynamically to the internal and external environment of the station. Lightings and sounds can adapt to the weather outside or the activity inside. With the LED technologies, it is now possible to control the color of light with the luminance and temperature outside. This allows a certain porosity of the underground station with the outside. It will also affect the perception of sound and temperature of the passengers. Sound systems can also be controlled by activating the right loudspeaker network to provide a better intelligibility.

Sound can also be used to help the passengers' orientation in the station. Equipment's sounds such as lifts, mechanical stairs, ticket control, trains… can be recognized easily. They should be treated so they do not generate discomfort, but help localizing the equipment. If we can localize the sound of the lift, we have a helpful information for our orientation. Underground stations in Japan add sounds to facilitate the orientation of the passengers. Birds' singings indicate the exits, river or water noises indicate the location of the toilets. Tardieu *et* al. [16] proposed a sound solution to help passengers finding their way to a distant platform. Adding sound may not be required. Using the right acoustic treatments and the shapes given by the architecture, may be sufficient. Figure 2 shows how the "bip" of an elevator can be propagated toward the passengers' flow. The position of the loudspeakers may also help the passengers' orientation. If loudspeakers are located toward the passengers along their route, they feel directed. It generates a similar effect that can be combined with adding light to the entrance corridors. It is calling to our eyes and ears and our feet follow.

Conviviality is an important part of the ambiance and the passengers' experience. Sound and music highly contribute to that. Setting-up pianos in railway stations gathered people. During an event in a railway station in Paris, the stairs were used as a piano. People played songs together and the atmosphere of the station changed (Figure 3). Exhibits (concerts, arts in general…), might contribute significantly to an improved ambiance. But it should be anticipated. If the piano cannot be heard due to the background noise, or if the concert excites a room, which is too reverberant, it will generate the opposite effect.

Conceiving the right ambiance is a task that requires discussion between various disciplines at each stage on the station's conception. The first issue arises when the architects propose the volumes of the stations. Open and important spaces are usually preferred because natural light can be diffused, because passengers can see and understand the organization of the station. The acoustician prefer smaller and closed volumes, so reverberation and late reflections can be reduced. With great and open volumes, noise sources will need to be reduced as

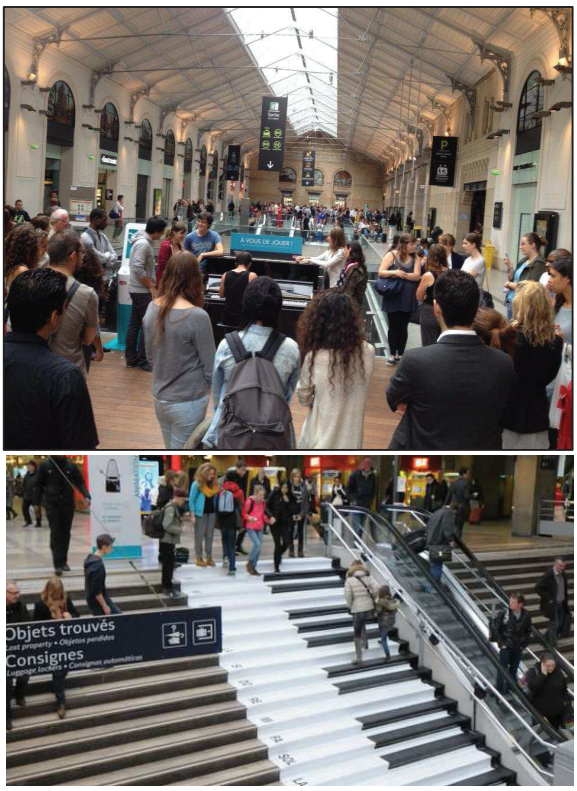

Figure 3. Conviviality is a main component of ambiance: real piano (up) and stairs 'piano (down) installed in railway stations in Paris.

close as possible from the source. Specific directive loudspeakers may be required to not excite the entire volume… These are solutions, but need to be considered as early as possible in the design process. The second and third stages are the definitions of shapes and types of materials to be used. Recommendations can be made to the architects such as avoiding surfaces that can focalize the sound (cupola), or having two important parallel surfaces that may generate uncomfortable flutter echoes. Choosing the materials is probably the most critical phase. Usually discussions are needed between many different actors involved in the design and maintenance of the station. To find the materials that respond to all the requests, often require some cleverness.

Conceiving a sound ambiance can be seen a writing a musical piece where the verses and chorus are represented by the different areas of the station and the structure is given by the architecture, the lights and the equipment s' sounds. However, at the design phase, the melody cannot be much elaborated because the acoustic criteria are not rich enough to represent all the components of the perception.

6. Conclusion

Ambiance/atmosphere of a space is evaluated globally, depending on many components that interact. Through the example of the acoustic component, we saw the need to integrate the ambiance conception within the various steps required to build a station.

Studies can show what the main contributors of ambiances are and what could their interactions be. It helps defining a guidelines for the conception, but might not be sufficient to get the proper ambiance at first. Objective criteria are lacking to specify what we want the passengers to perceive.

More understanding is needed. With the rising of new tools allowing visual and acoustic immersions, partial parametric studies can be performed and then validated on the field.

With the competition between other means of transportation, the railway passengers' satisfaction has become a competitive argument. Also, Technologies are now mature and affordable to get to the next steps. Although the tuning cannot be perfect at first, it seems that stations will have, and has already, improved ambiances.

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