Spatial context as musical expression

Berit Janssen
STEIM
Van Reesstraat 66
2593 PS Den Haag
0031-70-7854339
berit.janssen@gmail.com

ABSTRACT

This paper investigates the significance of associative cues in the acoustical perception of spaces. Reverberation has been intensively investigated in the past, even though the perception of reverberation, spatiality, is not easy to predict from room acoustic criteria. With some insight into the cognitive categorization of reverberation, spatiality can be used as an independent musical parameter. However, spatiality might also be evoked through sounds associatively connected to specific spaces, a phenomenon which has been dubbed source-bonding. This effect has not been subjected to systematic research so far. Consequently, first steps to gain a better understanding on the perception and organization of spatial context will be proposed.

Keywords
Reverberation, psychoacoustics, source-bonding

1. INTRODUCTION

Space plays an integral role in the production and reception of music. It does not only carry and amplify the sound waves, but also shapes sound to such an extent that a good concert can be thoroughly spoiled by bad acoustics. Over the past decades, most research on the influence of spatiality on music has been restrained to architectural parameters which influence the quality of concert hall acoustics, or virtual parameters relating to the quality of artificial reverberators. That space itself can be a musical parameter, because it can change the context of sounds and therefore also their meaning, has been somewhat neglected.

Composers of acousmatic music are naturally more aware of the impact of space as part of their musical vocabulary. The recording or synthesis, processing and juxtaposition of sounds often places specific sounds together as part of an imaginary space. This space is not only defined by reverberation, but also by the sounds themselves.

This paper will focus on this associative connection of sounds and spaces, and look into the question whether the associated spatial context has as big an impact on perceived spatiality as reverberation.

2. MUSIC AND SPACE

The performance of music has always relied on spaces: not only did they provide a framework which defined the social implications of music, as village squares, churches or concert halls were the stages of quite different performances, but spaces have also shaped music by their acoustic properties. Thus, a very reverberant space, such as the Gothic cathedral, would stimulate slow melodic music, since distinct notes melt into chords as they linger, whereas an outside performance space would lead to a preference for instruments carrying over long distances and radiating sound into all directions, such as percussion instruments [2].

A new situation has arisen in the 20th century with the advent of recording technology. The performance space and the listening space are not necessarily one and the same anymore: the music reaches the listener through loud speakers. This listening situation was called *acousmatic* by Pierre Schaeffer, based on the name for the *akusmatikoi*, the not initiated students of Pythargoras, who sat behind a veil, hearing, but not seeing the master [6].

The acousmatic portrayal of spaces is not limited to the reproduction of spaces found in reality, but can also be entirely imaginary. Especially with digital technology, the freedom of spatial manipulations seems unlimited, which provides a new means of artistic expression for electroacoustic music, but also for music and sound design for cinema or computer games [1].

Spaces can be evoked through their reverberation, which shapes the signal by spreading it in time, but also in space. Especially the latter effect needs sophisticated reproduction systems of multiple speakers, however, to envelop the listener convincingly in a soundfield. Moreover, there is also a spectral manipulation, since a room or space can be seen as a filter.

Sounds can also define spaces: there is an associative link between some sounds and their typical environments [8]. This will be investigated below, especially in respect to the question how reverberation and associative links influence each other.

3. REVERBERATION

The phenomenon of sound reflecting off surfaces and obstacles has been investigated systematically since the late 19th century, and forms the discipline of room acoustics. Hard, smooth surfaces reflect sound as an acoustic mirror, while rough surfaces scatter sound, and soft surfaces absorb it. This explains the different characteristics of different wall materials. Moreover, the volume and geometry of a space has a big influence on the reverberation. These parameters together account for the amount of temporal spreading through reverberation, but also predict to which degree the sound energy is scattered in a room, and spreads spatially. Moreover, interferences between direct sound and reflections lead to a filtering of sound, which means that the sound energy will be increased for some, and decreased for other frequencies.

But apart from the physically measureable aspects of reverberation, psychoacoustic effects have a great impact. Hence, the spatiality that is perceived in a specific space cannot be predicted by algorithms, since there are also higher level processes involved in perceiving spaces, which cannot be deducted from the physical properties of a space. Objective criteria for different perceptual phenomena have been established, which predict whether reflections will be perceived as part of the direct sound, as echoes, or as reverberation, or whether reflections will lead to a perceived spatial spreading, or whether interferences of sound waves will be perceived as colouration of the sound. Yet these criteria cannot predict the perception of spatiality for every space, let alone every signal, as speech, sounds, and different kinds of music seem to afford different cognitive strategies [5].

Moreover, these criteria do not illuminate how we perceptually map our environments based on acoustic cues. Some spaces sound hollow, others harsh, even others subdued. Is there a way we cognitively order the acoustic spaces we encounter?

A psychoacoustic experiment was performed by the author in order to find an answer to this question. Comparable to Grey's work on timbre [3], a multidimensional scaling approach was chosen, based on differences between reverberances as perceived by participants in a listening experiment. This resulted in a perceptual map of two dimensions, which accounted for 96.6% of the variation in the difference judgements. Kruskal's stress value was determined as s=0.06. [1] One of the two dimensions was interpreted as colouration, and the other proved to be highly correlated with the decay of energy. The initial leaking of energy seems to be characteristic for outside spaces such as forests, even though the reverberation time in forests may be of comparable order to inside spaces [4].

The results of this study call for more research with comparable methods, especially to gain a more thorough insight into timbral effects of reverberation, which are easily perceivable, but not satisfactorily measureable in the form of criteria. However, the influence of other aspects than reverberation on our perceived spatiality also demands attention: do sounds create associations of space? And if so, can these cues interfere with our perception of reverberation?

4. SPACES DEFINED BY SOUNDS

The associative conncetion between sounds and the spaces in which they originate seems a fascinating phenomenon to investigate. However, no systematic research seems to have been conducted. The most interesting texts on sounds defining space stem from composers of electroacoustic music, who see new capabilities of musical expression in the semantic implications of spatial context.

4.1 Juxtaposition

The British composer Trevor Wishart writes in detail on the different possibilities of combining spatiality and sounds. He claims that space can be consciously unreal, as the reverberation becomes unnaturally long or has an unlikely timbre, or the sounds populating the space can be unreal, if they do not resemble any natural sounds. Different combinations of real and unreal sounds and spaces are conceivable, such as real sounds populating unreal spaces, synthetic sounds populating realistic spaces, but also a completely unrealistic or completely realistic juxtapositions. However, not always does a combination of real sounds and real spaces lead to something which is "natural": sounds and spaces that never occur together in real life may be combined. This enables composers to create imaginary, and even surrealistic soundscapes [9].

4.2 Source-bonding

This wide realm of musical possibilities opened by the context of space has also been dealt with by Dennis Smalley, another acousmatic composer. He calls this part of compositional practice spatio-morphology [7]. Another interesting point he raises is that some sounds seem to create a space even if no other acoustical cues, such as reverberation, are present. Thus the call of a sea-gull, for instance, may evoke an association of the sea. According to Smalley, "sounds ... carry their space with them", a phenomenon for which he coined the term source-bonding [8].

5. COGNITIVE REPRESENTATION OF SPACE

Are spaces really defined as much by associative cues as by their reveberberation? Does this have an influence of how acoustical spaces are memorized and organized cognitively? Only by taking into account all involved cognitive processes, the perception of acoustical spaces can be truly understood. Therefore, the influence of recognized sound origins on the perceived aural space needs to be investigated.

5.1 Hypothesis

If there is an associative evoceation of spatiality through specific sounds linked to specific spaces, it can be expected that the judgement of reverberation is influenced by the presence of recognizable, source-bonded sounds. This leads to the hypothesis that source-bonded signals reverberated with impulse responses [2] corresponding to the associated spatiality will be judged more consistently than a neutral reverberated signal, whereas source-bonded signals reverberated with impulse responses not corresponding to the associated spatiality will be judged less consistently than a neutral reverberated signal.

5.2 Experimental design

A number of spaces is selected. The chosen spaces should bear everyday significance, some indoors and some outdoors, such as bathrooms, office rooms or streets. For these spaces, impulse responses need to be collected, which are then convolved with pink noise. These neutral samples will be played to a group of individuals, who are given the task to write down adjectives which come to mind as descriptions of the spaces, for which responses such as "open" or "intimate" are imaginable. Consequently, the most frequently chosen adjectives are used for a rating of the same sounds by a larger group of participants, who have to give an indication as to how much a specific space fulfills a specific description. In a third step, another group of comparable size and comparable demographic profile is asked to rate a number of specific sounds convolved with the same impule responses. These sounds should have very recognizable origins, such as bird song, or rushing water. A comparison of the two groups then gives an indication as to how much the presence of a source-bonded sound intervenes with the perception of spatiality.

[1] The stress value is a measure for the difference between an ideal map representing all items and their distances correctly, and the actual computed map. For s=0, the fit would be perfect.

[2] Impulse responses are the reactions of reverberant spaces to a test signal. This test signal should contain all frequencies, and with the same energy, which can only be approximated in practice. The reflections of the test signal is recorded with a microphone. Any signal can then be convolved with the recorded impulse response, leading to a reverberated signal.

6. CONCLUSION

The described experiment has still to be conducted, but it promises some exciting new insights into the perception of spaces, and their musical implications. This will not only be beneficial for the questions of compositional practice in acousmatic music, but can also provide valuable insights for the creation of virtual spaces, for instance in films, computer games and tele-communication. Moreover, this research can then also be integrated into other fields, such as acoustic ecology and room acoustics.

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