Sound Amplification Technology and the Acousmatic Experience

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ABSTRACT

This paper aims to link the use of sound amplification technology to the Acousmatic theory as conceived by Pierre Schaeffer. The argument pursued here is part of my multi-disciplinary PhD thesis that researches the influence of the use amplification technology on music from Semiotic, Sociology of Music and Aesthetic perspectives.

KEYWORDS

Music Technology, Amplification, Acousmatics, Aesthetics.

1. INTRODUCTION

There are many publications that deal with the mediatisation of music. The research discourse is mainly about mediatisation through reproduction, broadcasting, and the possibility of creating and recreating sounds (for instance as described by Pierre Schaeffer). After reviewing this literature I have identified a gap in this discourse: technology applied to make musical instruments and voices louder, for instance to make them available to a larger audience at a concert, seems to be taken for granted in many publications. The issue of a potential influence of amplification technology on musical practices is not addressed. However, nowadays it is very common to amplify music at concerts, making the question of its impact on that music a very interesting one. In my PhD research project I take a multi-disciplinary approach to study the influence of amplification technology on music. Apart from describing the well-researched relation of sound amplification to Acoustics I am relating this thesis to theories from Semiotics, Sociology of Music and Aesthetics. The aim is to develop a theoretical framework and meta-language that will benefit both the praxis of music and the sciences that study music and its culture.

2. ACOUSMATIC THEORY

Pierre Schaeffer's theorem of *Acousmatics*, or *Reduced Listening*, very accurately describes the influence that the developing technologies of capturing and reproducing sounds had and have had on music (and other aural arts). Influenced by Husserl's phenomenology Schaeffer proposes that listening reduces a signal from its source. This reduction allows us to perceive sound as a phenomenon in itself. The possibility of detaching a sound from its source by technological means has made this phenomenological experience apparent. In his magnum opus *Traité des objects musicaux* [10] Schaeffer tried to develop a language for describing sounds *in themselves* [3] based upon this reduced listening.

2.1.1 See no evil hear no evil

Schaeffer borrows the term Acousmatic from Pythagoras' students or *akousmatikoi* who were listening to their teacher from behind a screen, to prevent visual distraction from his words[1]. According to Schaeffer, a sound becomes detached from its source when we record it. For instance when walking down a street we come across a barking dog, the source of that sound is evident. But when we record that sound with a microphone and some sound recording device, we are able to separate that sound from its source. We can now play back that dog's bark whenever and wherever we want. Possibly the person who first recorded those barks has a recollection of which dog where was the source of that sound, but most people confronted with that played back bark have no idea. The bark is now, in Schaeffer's terms a *concrete* sound. We can use it as a ring-tone, a sample in a hip-hop track or as an element in a composition with other concrete sounds, which we he have come to know as "Musique Concrète". The recording media in Schaeffer's days (first on discs, later magnetic tape) allowed for a materialization of the recorded sound into a solid concrete object. Materialized in a much more immediate way than recorded sound nowadays, using digital technology, available for direct manipulation. The term concrete also suggest the idea of working directly or concretely with sound, rather than in traditional composing where a system of abstract notation represents the sounds to be made concrete [7]. This may not sound like a big deal, but lets not forget, Schaeffer drew up this theory in the 1940's, when the possibilities of generating sounds and using them for musical purposes where limited[2]. His discovery of the Acousmatic nature of sound came after working with "closed grooves" on a vinyl record. After a modification of the groove on a disk it repeats the same section

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[1] According to Chion [3] the writer Jérôme Peignot called the word Acousmatic to his attention. Historical sources (again from Chion) include a poem *Acousmate* by Guillaume Appollinaire and the book *Stromateis* by Clement of Alexandria ca. 250 BC.

[2] Limited to early electronic instruments like the Hammond Organ (1935), the Trautonium (1928) and the Theremin (1920) see for instance Chabade [2] and Bongers [1].

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over and over again. Later when magnetic tape became available this was easier to realize by using tape loops.

2.1.2 Wagner and cats

Before the technical detachment of sound became possible Wagner tried to get rid of the visual aspects of the source of the sound: nothing should distract the spectator of the action on stage. In the Bayreuther *Festspielhaus*, built after Wagner's specifications (and still home to many performances of Wagner opera's), the orchestra pit is largely hidden or "sunk" under the stage and fenced of by a screen[3]. A century later a theatre orchestra was banned from pit or theatre all together: in the musical Cats the orchestra (or band) plays in a different room (sometimes even in a different building) and the sound is relayed electronically, a video connection allowing the conductor to see the stage and vice versa for the performers on stage. For performances of Stockhausen electronic music such as *Gesang der Jünglinge,* the composer suggests to dim all the lights with the exception of a little bright moon projected on the proscenium. If you are uncomfortable listening with your eyes closed you can look at the "moon", ensuring very little visual distraction.

2.1.3 Listening without seeing: music

Using Schaeffer's Acousmatic theory in a context of amplified music seems a strange idea, as in most cases at a concert the visual connection from the audience with the performers is not hindered by anything. On the contrary, in concert halls the lay-out and lighting are approached in such a way that we may always see what is happening on stage. In the sense of Schaeffer's descriptive account using his theory for amplified sound is not an option. However there is a more prescriptive approach to the Acousmatic experience: in his *The Aesthetics of Music* Roger Scruton [11] makes the Acousmatic experience crucial for perceiving music as music. For Scruton, both thought and awareness of the cause or the source are excluded when we listen to music. In other words: music becomes detached from its source when we listen musically. This also suggests that for listening to music as music it makes no difference whether we listen to a symphony in a concert hall, or to that same symphony on the radio or played back from a record. In Scruton's account we hear music as Acousmatic, and everything we hear non-Acousmatic as "just" sound. Scruton embarks on his argumentation by referring to Schaeffer:

> "In listening […] we spontaneously detach the sound from the circumstances of its production and attend to it as it is in itself: this, the 'acousmatic' experience of sound, is fortified by recording and broadcasting, which completes the severance of sound from is cause that has already begun in the concert hall."

For the scope of this paper I am interested in that beginning of "the severance", where one or more microphones pick up the sound (of instruments). In the case of amplification this sound is relayed instantaneously through loudspeakers in the same room.

2.1.4 Listening without seeing: film

Michel Chion, in the context of film extends the idea of Acousmatics also to voice and sound effects [3]. In this paper I will restrict myself to music and explore the potential of the term "Acousmatic" for understanding the way in which amplification detaches a musical sound from its source.

[3] As a consequence the sound of the orchestra is dampened, avoiding overpowering of the singers by the orchestra.

3. Acousmatics and amplification

As we have seen above, Schaeffer's theory does not cover what happens if we capture sound (with a microphone) and instead of storing or broadcasting it on the radio, directly relay it through a loudspeaker in the same room. In other words reproducing the sound instantaneously in the same room and so amplifying that sound. This seems to be a special case of broadcasting, where both the sound source and its immediate reproduction are audible in the same space at roughly the same time. To make this more apparent, consider the following ways of listening to a violinist A playing composer B's first Suite in recital hall C, with an imaginary curtain to fulfil the non-visual requirement:

1. We could sit in the hall and listen to the violinist's performance.
2. We could sit at home and listen through a loudspeaker to a direct radio broadcast of that performance captured with a microphone close to the instrument[4].
3. We could sit at home and listen, through the same loudspeaker, to a recording made with the same close microphone of the same performer, of a same performance of that work in the same hall.
4. We could sit in the hall and listen to that same recording, through the same loudspeaker, set up in the hall for that purpose.
5. We could sit in that hall and listen to the same violinist playing the same work picked up by the same microphone, and relayed to that loudspeaker in the hall so that this amplified sound is perceived equally loud as the acoustic source, the violin.

There are many more possibilities to add to these examples, such as listening to a recording or a radio broadcast of it on our mobile phone whilst sitting in the hall, but for the scope of this paper these examples suffice. Using the combination concert hall and "classical" music is by way of example; I don't intend to single out any sort of music. The effects described here apply to any sound with a mechanical source, that is picked up by a microphone. An instrument, a human voice or even a loudspeaker as the sound of an electric guitar is often "picked-up" by a microphone pointed at the guitar's amplifier's speaker.

3.1.1 Acousmatic implications

There are a number of factors in the five different listening situations that are relevant to a discussion of the Acousmatic theory: our listening location (hall C or at home), the use of a (close) microphone for recording, broadcast and amplification; and the loudspeaker used for listening to these mediations. Apart from the musical parameters that differ every time violinist A plays this particular piece by B in hall C there is another obvious difference between a recording played back in the hall, and the performance in person: the absence of the player and her or his instrument and, as a consequence, of the acoustic source.

[4] The microphone and loudspeaker and paraphernalia are of a theoretic ideal type that doesn't introduce any colouring or phase distortion. For argument sake I will assume that said machinery is analogue, as the use of digital devices introduce a latency that will unnecessarily confuse this discussion.

3.1.2 *Recording introduces an infinite temporal displacement*

The examples where a recording of the performance is being used differ from the other examples in that the sound from the instrument is picked up and stored before played back. This introduces a time factor indefinitely larger than the amount of time we usually associate with the physics of sound in a hall, or a direct broadcast via the radio or a direct relay through a loudspeaker.

3.1.3 *Amplification introduces a finite temporal displacement*

Only in the first example is A's violin the source of the sound, transmitted through hall C where we sit and listen to it (for Scruton's aesthetic theory this would be an Acousmatic Experience too). In situations 2, 3 & 4 we are listening Acousmatic in the sense that Schaeffer described: the sound of the violin is detached from the body that produces it and of the room it was initially transmitted in. When a sound is amplified, as in the last example, not only do we hear the acoustic source (the violin), at almost the same time we hear the sound that is picked up by the microphone and relayed through the speaker. There is a time factor of another magnitude here: the electronic signal travels much faster (electrons travel at nearly the speed of light) through the cables to the loudspeaker as the sound waves emitted from the instruments travel trough the air (at the speed of sound)[5]. Depending on the relative distances of the listener to the instrument and the loudspeaker, the reproduced sound from the latter can be perceived even before the sound of the original source. The law of the first wave front describes the physical and psycho-acoustic workings of this phenomenon. This law, also known as the precedence effect or Haas effect, will be treated in section 4.

3.1.4 *Electronic source causes spatial displacement*

Amplifying an acoustic source, such as a violin, creates a new electronic source, the loudspeaker. We can hear the electronic source at the same time, after or before we perceive the sound from the acoustic instrument. This has as a consequence that it alters the spatial parameters of how we hear the acoustic source in the concert hall. The electronic source creates its own reflections, in a different relation to the room's acoustic than those caused by the acoustic source. Although coming from distinctly different sources, we may or may not be able to discern between the reverb related to the acoustic or the electronic source, depending on the relative distance between us, and the two sources. This enhances the spatial displacement of the violin caused by the finite displacement in time.

3.1.5 *Level of Amplification*

Apart from the relative distance between the listener and the two sources there is another important parameter in this discussion: the level of amplification. In the last example I proposed a level of amplification that makes the electronic source perceived just as loud as the acoustic. The situation changes dramatically if we amplify the violin at a barely audible level, or, if we amplify the violin to such extremes that the acoustic source becomes inaudible. The level of amplification and its perceived impact, in relation to the acoustic source form a continuum, which I would like to describe as an "Acousmatic Continuum". The way a theory of amplification subscribes to Schaeffer's Acousmatic theory changes accordingly. As long as we hear the violin as an acoustic source we do not perceive the violins sound as "detached" (in Schaeffer's vocabulary). But when the acoustic source is overshadowed by the sound from the loudspeaker, making it harder to hear whether we are listening to violinist A or a recording of his performance, we could consider it as an Acousmatic experience.

[5] The speed of light is roughly one million times higher as the speed of sound in air.

4. AMPLIFIED SOUND AND TIME COMPENSATION

The psychoacoustic effect that comprises of several different auditory phenomena is known as the Haas effect (after Helmut Haas [6]). Differences in phase, and level between perceived sounds are, within certain limits, decisive as where we locate a sounds source. Practically this means that, again within certain limits, if we perceive the direct "acoustic" sound of violin A before we perceive the amplified sound of violin A coming from a loudspeaker in the concert hall, we hear violin A as the location of the sound, not the loudspeaker. The critical limits are circa 30 milliseconds in time (as a reference, we start perceiving sounds as an echo when the difference is larger than about 50 milliseconds) and circa 10 dB (SPL) in level. The problems related to the temporal displacement of sound caused by the difference in speed (of sound in air and electrons in a conductor) where acknowledged as early as 1925, in a patent filed by inventor B.S. McCutchen (US patent nr. 1642040) who proposed a delay mechanism (that didn't work however). The first practical electronic delay systems became available with the tape-echo in the late 1960s, which has occasionally been used to compensate timing differences in amplification systems. With the advent of digital (sound) technology since the 1980s it has become much easier and nowadays it is common to use digital delay devices to "time align" acoustic source(s) and loudspeakers. However advanced this may sound, the time alignment is optimized for only one place in an auditorium, as in every seat the relative distance to loudspeaker and acoustic source is slightly different. It is important to consider that this time alignment allows for compensation of the difference in the speed of sound in air (from the acoustic source) and the speed of sound in the electronic domain. It does not account for time differences between aural and visual perception.

4.1.1 *Time compensation and video*

At performances where the action on stage is both amplified and enhanced by video screens or projections another temporal displacement becomes apparent. The light of the images travels to us at the speed at light, whereas the sound (from the instruments or the loudspeakers) travels to us at the speed of sound. There is experimental evidence that we are unable to detect difference in arrival time between sound and light inferior to 40–50 ms [8]. This means that audiovisual synchronicity is not problematic when the distance is no larger then roughly 20 meters [9]. However larger auditoriums, or in a sports stadium the visuals may not be synchronous with the sound. To compensate for this the video needs to be delayed, relative to the audio. Again this can only be optimized for one area in the auditorium. In this we also find the reason why the difference in aural and visual perception of the same event on stage (the violinist exciting the strings of his instrument with a bow) has no direct relevance to a discussion of the Acousmatic experience.

5. AN ACOUSMATIC CONTINUUM?

In Scruton's words, the *severance* of sounds begins in the concert hall. This suggests a process rather than a singular event. As I have written above, within the realm of amplification, the temporal displacement is depending on the distance from the listener to the acoustic source and the loudspeaker. And the spatial displacement is depending of the temporal displacement and the level of amplification. If we fix the position of the listener in the middle of the hall, with ideal situation of an equal distance to acoustic source and loudspeaker and regard the difference in time between the sources as a constant, the level of amplification is the remaining controllable factor in the acousmatic process. This will allow us to plot out the spatial displacement as a function of the level of amplification. With low-level amplification the acoustic source can still be perceived, the amplification "helping" a little bit in making the acoustic source appear louder. With a high level of amplification the sound of the acoustic source will no longer be perceivable as such as the it is "overpowered" by the loudspeakers.

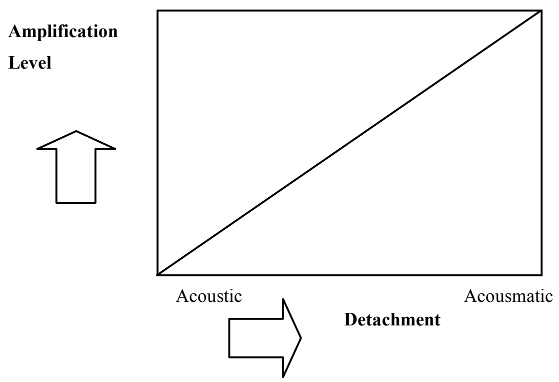

Figure 1 Amplification level vs. detachment

There is a risk of oversimplifying the theory by contrasting the Acousmatic with the Acoustic, as this diagram suggests. Michel Chion, who studied and worked with Schaeffer, wrote a guide to accompany Schaeffer's *Treaté des objects musicaux*, which was translated very recently [4]. In the first section that deals with the Acousmatic he points out:

> "We must take care not to misinterpret the acousmatic situation, for example by making a distinction between the "objective" – what is behind the curtain – and the "subjective" – "*the listener's reaction to these stimuli*" in an over–scientific simplification of the phenomenon. On the contrary "*the acousmatic involves a reversal of the normal course of events* (…) *it is no longer a question of knowing how a subjective listening interprets or distorts 'reality' or of studying reactions to stimuli; the listening itself becomes the origin of the phenomenon to be studied*. (…) *The question: 'What am I hearing?… What precisely are you hearing?" is turned back on to the subject, in the sense that he is being asked to describe, not the external references of the sound he perceives, but his perception itself.*" (Italics from translation)

Once more this directs us to the problem of applying the Acousmatic theory to amplified sound, as the visual connection remains intact. Being able to see the (acoustic) source of the sound will make it problematic to listen to the sound as a phenomenon on its own and hence not strictly acousmatic. The above diagram suggests that there is a continuous relationship between the level of amplification and whether we perceive the detached sound as Acousmatic. Such a relation, an Acousmatic Continuum would be a useful paradigm for a theoretical discussion of amplified sound. However, with the visual connection intact, the auditory experience can only be Acousmatic in a Schaefferian sense when the amplification is so loud that we can't hear the acoustic source anymore. But for now I will use the term Acousmatic Continuum to indicate the relation between the detachment of sound and the level of amplification.

5.1.1 Acousmatic Continuum and music

In the complexity of the multi-modal experience that for instance a concert of music with amplification is, the notion of a Continuum may provide us with a framework that helps us understand the relation between amplified sound and its acoustic source. In a practical way I find the following diagram helpful, depicting different sort of music as a function of the amount of amplification that is used.

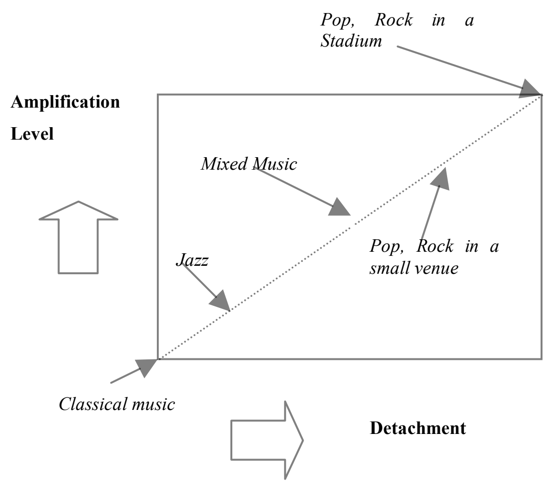

Figure 2 Amplification level and amplified music

Under the lemma Classical music we can find what is usually un-amplified music, for instance a performance of a string quartet in a concert hall. Jazz usually has some amplification, for instance the double bass and guitar are usually amplified and most jazz-vocalists use a microphone.

5.1.2 Mixed music

Somewhere in the middle of the diagram we could place what is often called "Mixed Music". This is usually defined as a work for orchestra and pre-recorded "Tape" (and hence Acousmatic) material. Often with those kinds of performances the orchestra or acoustic instruments are amplified a little bit to allow for better blending of the acoustic and Acousmatic or sounds. Examples are Stockhausens *Kontakte*, or *Hymnen* (Region III, mit Orchester), Reich's *Different Trains* or Nono's *La Fabbrica Illuminata*. Simon Emmerson [5] suggests that this kind of combined acoustic/acousmatic music could possibly disappear as:

> "There is a feeling amongst many performers that the medium itself is inappropriate for the flexibility demanded by different acoustics, venues, audiences and other musical variables (p108)"[6].

[6] Apart from these inflexibilities, Emmerson points out, there is the problem of synchronisation, (unless synchronised timing between the tape and performer a not essential, or even undesired). For instance, in Stockhausens Hymnen with Orchestra (3rd region) the conductor has to know the

Inappropriate or not, the practise of “Mixed Music” shows us the complexity of the relation between room acoustics, acoustic (generated on an instrument or with a human voice) and electronic (re-generated by a loudspeaker) sounds.

5.1.3 Amplified music

The next step up the acousmatic scale is Pop or Rock music in a small venue, or a bar. Most instruments are perceived coming through the loudspeakers but often louder instruments like horns or drums are still acoustically louder than the amplification. At a stadium concert, where everything we hear of the performance on stage, comes from loudspeakers we can consider what we heard as an Acousmatic experience–under “live” conditions. In a way we are listening to a recording (mixed in real time) that is played back instantaneously. And sometimes it is hard to judge whether what we see and hear is really performed live or is it all “playback” with musicians miming to pre-recorded material.

5.1.4 Different functions of amplification

Emmerson is one of the first authors to systematically look into the amplification of sound in a musical context. In his book [5] *Living Electronic Music* he identifies six functions of amplification that he considers vital to discussing “live music requiring electronic technology for its presentation”, in other words amplified music. These are (in my words paraphrasing the author):

Table 1 Six Functions of Amplification

1	Balance	Correcting Acoustic imbalances
2	Blend	Integrating timbres
3	Projection/ Spatialisation	Zooming in perceptually/intentional (ac ousmatic) dislocation.
4	Perspective	Suggesting different acoustics (dislocation of space and time)
5	Coloration	Intentional distortion
6	Resonance	Use of feedback

For a discussion of the acousmatic we are mainly concerned with the first two functions or reasons of amplification, and the spatial dislocation (whether intentional or not) that goes with it.

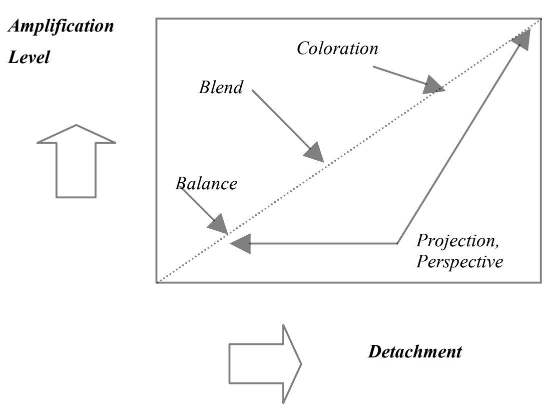

Figure 3 Amplification functions

In the above merger of the Continuum and Emmerson’s functions we can see that some of these functions are fully dependant of the level of amplification and some to a lesser extent. Projection (and Spatialisation) can (theoretically) be realized at any level and Perspective as soon as the added synthesized acoustic can be heard. Full spatialisation, to give a sound a wholly different location in a room (this goes beyond panning between a “left and right” loudspeaker, can be realized when we no longer hear the acoustic source and the electronic sound has become detached. Blend and Balance are more particularly defined in each situation (provided that agreement on an acceptable balance is possible). Coloration (here different from applying filters to the amplified sound) by intentionally distorting a sound electronically will naturally need a certain amount of amplification to come to the desired effect.

6. FUTURE RESEARCH

In the near future I hope to realize some experiments that will allow for empirical verification of the above. The experiments would be conducted with both speech and music while parameters could be the amplification level and the distance between the acoustic (instrument) and the electronic (loudspeaker) source. Participants will be registering when the localization shifts from the acoustic to the electronic source. Other parameters could include time compensation (to engage the Haas effect) and a “Pythagorian” screen, hiding the source from the audience to single out visual clues. Expected outcomes should include a critical distance between an amplified instrument and the loudspeaker that provides the amplification. In relation to the Continuum described above this experiment can stipulate two different phases of that Continuum, first dislocating the source and after that making the source inaudible due to a very high level of amplification. Along this line the experiments could be extended to position the six different functions of amplification as mentioned by Emmerson.

7. CONCLUSION

Amplification of acoustic sources such as musical instruments including the human voice can be realised by immediate and local electronic reproduction of that source. The (finite) temporal and spatial displacement caused by the instantaneous reproduction of the sound in the same room suggests a detachment of the sound and its source. This detachment works much in the way of the Acousmatic experience as described by Pierre Schaeffer. However being able to see the acoustic source makes this a problematic exercise for the Schaefferian requirement of “hearing without seeing”. The sound becomes detached from its acoustic source, depending on the level of amplification that is applied. Louder amplification means a sound becomes more detached from its acoustic source and its initial mode of transmission. Because of this interrelationship I suggest we should think of relation between the detachment of sound and the level of amplification as a continuum. Calling this continuum Acousmatic would be going too far as the visual connection with the source is not lost. Another term, equally evocative as Acousmatic, will have to be found to describe this unique and important relation. The Continuum can be used as a tool to identify and position different sorts of (amplified) music and sound amplification functions.

“Elektronische Musik” by heart to be able to distil cue’s, timing and tempo information, while conducting an orchestra.

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