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Between air and electricity : microphones and loudspeakers as musical instruments

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4 Interacting with microphones and loudspeakers: movement, material and space

Three forms of interaction: movement, material and space

This chapter turns toward investigating the possibilities of the *interacting* approach towards microphones and loudspeakers. By employing microphones and loudspeakers according to the paradigm of the *tuning fork principle*, as discussed in the previous chapter, sound is not only generated, as is the case with the *tympanic principle*, but is also shaped by the particular qualities of the microphone(s) and loudspeaker(s) used as well. I examine different methods used by composers and musicians for *interacting* with microphones and loudspeakers. These methods may be brought together by the idea that the microphone and loudspeaker themselves are audible instead of functioning only as neutral transducers of sound. At the beginning of chapter 3, I mentioned acoustic feedback as a possible result when microphone, amplifier and loudspeaker are the constitutional elements shaping the sound. However, a stable sound shaped by this set-up is not enough, since performing music implies, most of the time, that a musical instrument produces many different sounds instead of only one. How a variety of sounds can be produced with microphones and loudspeakers and what assortment of interactions might be possible between them, the performers, and other elements of the set-up, is the topic of this chapter.

When considering conventional musical instruments,⁶⁷ I define three different actions central to the interaction between performer and instrument. The first is supplying energy. This is accomplished by actions like bow movements, string plucking, hitting objects and blowing on reeds and into pipes. This energy generates certain physical vibrations, which act in the audible domain: objects such as strings, reeds and membranes begin to vibrate, exciting other elements, such as soundboards, to vibrate as well. I call this energy supply *movement*, as it brings the object into vibration, and the force, range or quality of movement might change these vibrations.

The alteration of the physical characteristics of the vibrating body of the musical instrument, the second action of musical instrument playing, can be achieved by, for example, shortening or lengthening strings or pipes. The exact shape of these vibrations depends on the amount of the energy as well as the material of the object brought into vibration. These different shapes of

⁶⁷ The term musical instrument is used here by me as the first category of objects one can make music with, as defined in chapter 2. I use the term conventional (musical) instrument to refer to musical instruments that belong to the first category, which do not use electricity for sound production. Although the electric guitar, for example, is a first category musical instrument, it is not a conventional instrument, due to its reliance upon electricity.

vibrations will, of course, generate different sounds, since they produce other patterns of air pressure waves. I term this second kind of action *material*, since it is the materiality of the objects that is changed and which causes a modification in the sounding result.

A third aspect of playing a musical instrument, often neglected, but which became more relevant with the introduction of microphones and loudspeakers into music, is *interaction* with *space*. Musicians tend to adapt their performance to the space where the performance takes place in, playing differently in a highly resonant space than in one with dry acoustics (Alpers 2008, 44). As I will demonstrate later in this chapter, this form of *interaction* has become especially prominent in compositions for microphones and loudspeakers.

Comparable to the situation with a musical instrument, every component of an acoustic feedback chain acts as a filter, since it has its own characteristic spectrum (Emmerson 2007, 133). A filter does not necessarily only function to diminish certain frequencies but is also able to amplify frequencies. This implies that microphones and loudspeakers add their own sound colour, just as the different parts of an instrument do. The system of microphone, amplifier, loudspeaker and space as well as the distance between microphone and loudspeaker all serve to amplify some frequencies while dampening others. By changing one of the elements of the entire system, the feedback sound will change as well. The three different aspects of musical instrument playing are therefore applicable to the acoustic feedback system: a different type of microphone or loudspeaker (which is nothing else than a change in *material*) will change the sound, another performance *space* influences the sound, and a change in the distance between microphone and loudspeaker through *movement* changes the resulting sound as well.

I view these three possibilities—*movement*, *material* and *space*—as relevant in the interaction between musicians and their musical instruments. What follows is an investigation of the implementation of these interactions in the works of various composers and musicians. I decided to look primarily at what could be called "concert" works rather than at sound installations. This might seem odd, since it is especially within the multifarious sound installations developed during the last fifty years that microphones and loudspeakers often play an important role. The reason to exclude them from my research is that in sound installations there is no interaction between performers and musical instruments or other objects. In general, no performers are even present, and the objects used in sound installations are often not associated with musical instruments. It is for this reason too that sound installations are often regarded as being part of a fine art tradition rather than a musical one. The human-sound object interaction is most often found in the relation between the audience and the installation, which results in other types of interaction, requiring a different type of research.

MOVEMENT

The first interaction I will examine is how movement can change the energy supply within the set-up of microphone, amplifier and loudspeaker. What should be kept in mind is the difference between the energy supply of conventional instruments and that of microphones and loudspeakers. The energy needed to bring microphones and loudspeakers into action is delivered in general by electricity. Changing the amount of electricity supplied to microphones and loudspeakers might indeed change their sound, but cannot be seen as a part of the *interaction* approach with microphones and loudspeakers, as defined in chapter 2. The interaction does not take place between the performer, and microphones and loudspeakers, but between the volume slider (or any other control device) which controls the electrical signal and the performer. This way of changing the energy supply is therefore related to the *generating* approach. What I wish to examine in this chapter is *interaction* with microphones and loudspeakers, implying that I need to search for a way of changing their energy supply by interacting with them, instead of by manipulating the electrical signal.

In an acoustic feedback set-up, the microphone picks up air pressure waves which are, for the most part, generated by the vibrations of the loudspeaker diaphragms. As I mentioned earlier, the amplitude of these diaphragm vibrations could be manipulated by diminishing or increasing the current supply by means of, for example, a volume slider. To achieve an alteration in these vibrations related solely to an interaction between performer, and microphones and loudspeakers, the distance between microphone and loudspeaker can, for example, be changed. When the distance between microphone and loudspeaker is increased, the vibrations emitted by the loudspeaker reach the microphone with less energy. The changes in sound due to changes in distance can in no way be compared with the effect produced when the volume knob is turned down. All manners of alteration in pitch and sound-colour, as well as volume, will occur in such a set-up. The closer the microphone is brought towards the loudspeaker, for example, the higher the pitch of the feedback will be, in general. As revealed by this experiment, the acoustic feedback set-up is an interactive system in which no single parameter can be changed without also bringing about changes in other parameters. This is similar to how all musical instruments function: playing a violin string while applying less force will result not only in a smaller amplitude of string vibrations but fewer audible partials as well.

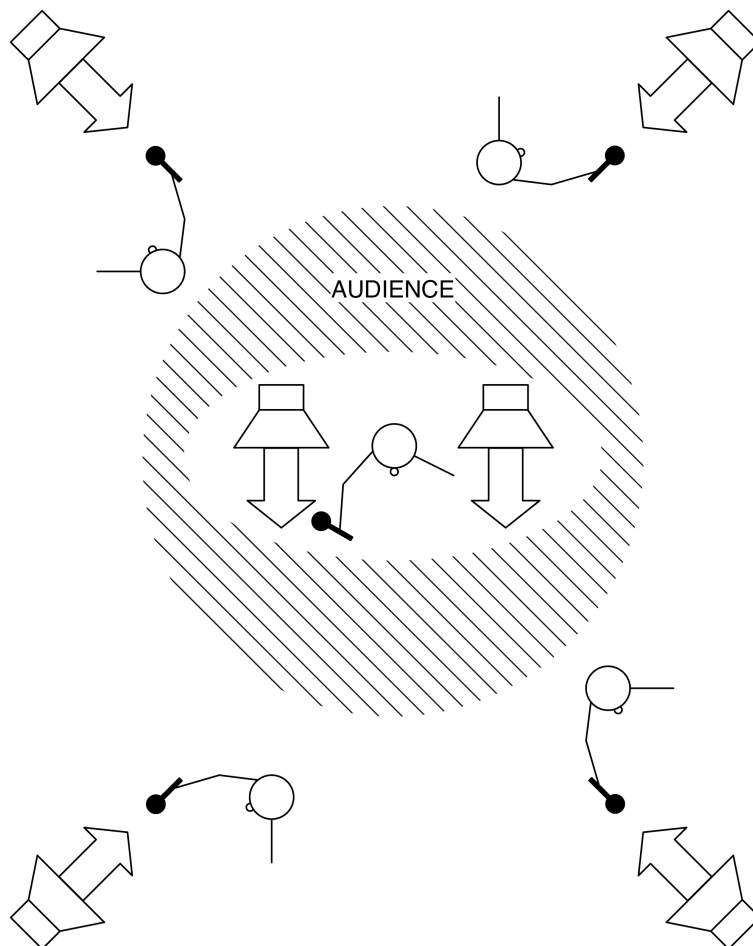
Movement 1: changing the distance between microphone and loudspeaker: *Quintet* by Hugh Davies

In the piece *Quintet* (1968) by Hugh Davies*, the performers move microphones, thus changing the distance between microphone and loudspeaker. The piece is scored for five performers, five microphones and six loudspeakers (see scheme *Quintet*). The basic musical feature for this piece is the use of acoustic feedback, and each performer has his own acoustic feedback set-up (Davies 1971, 86). Loudspeakers are placed in all four corners of the performance space, and in front of each loudspeaker stands a performer with a microphone in his hand. The fifth performer is placed in the middle, controlling the volumes of all loudspeakers and equipped also with a microphone and two loudspeakers.

The score consists of a text with a time line, providing descriptions of what kind of sounds should be heard during a certain time span. The main activity of the four players in front of the loudspeakers is to change the acoustic feedback sounds by moving their microphone forwards and backwards, always with the front of the microphone pointing toward the loudspeaker. In the score, Davies describes the desired sound results as well as how to move the microphone. At 1'45", for example, the performers should "move the microphone slowly in different directions, producing increasingly wider pitch intervals" (Davies 1971, 87). At other moments in the piece the performers are instructed to hold steady the last produced sound, make tremolos between close pitches or play arpeggio patterns. Davies indicates three areas of pitch with the letters H, M and L for high, medium and low.

What gives the set-up vitality as an instrument is the very strong interaction between the movements of the performer and feedback sound: every slight movement with the microphone changes the sound. The set-up is a "circle" in which every element influences the next element: from loudspeaker output, to performance space, to microphone input, to (processed) electrical signal sent back to the loudspeaker again. As outlined in chapter 3, the sound has no recognisable starting point in this set-up, nor does the shaping of the sound have a clear end point. The relationship between performer movements and resulting sounds is much less predictable, though, than is the case with conventional instruments. Whereas the *interaction* relationship is very strong, the resulting sound is often surprising for the audience as well as the performers. Using microphones and loudspeakers to produce feedback is to use them in a way not intended by the manufacturer. These devices, therefore, have an inherent, designed, resistance against this *interacting* approach, which would force them to act to the fullest extent possible as a conventional musical instrument.

Owing to what could be called "misuse" of microphones and loudspeakers in this piece, the artistic essence is embodied not only in the sounding result but also in the efforts of the



Hugh Davies *Quintet*: the performers modify the acoustic feedback between microphones and loudspeakers by moving the microphone and in this way changing the distance between microphone and loudspeaker.

performers to obtain it. This means that something that might be regarded as a mistake under other musical circumstances, for example a similar gesture resulting in a differing or unintended sound, is a vital element of this composition, directed toward another revelation of the possibilities of microphones and loudspeakers to behave like musical instruments. Davies himself calls this misuse a "glitch": "Here I define the 'glitch' as an accidental or deliberately-caused malfunctioning of a musical instrument or item of audio-related equipment, which often has an unpredictable and potentially fruitful result; by 'malfunctioning' I encompass all methods of creating sounds that were not intended by the inventors, designers or manufacturers" (Davies 2004, 2). The acoustic feedback has a life of its own which may be influenced by the performer's

movements, but the sound will never be under the total control of the performer.

Davies not only composes for this unpredictability, but also makes use of the fact that the existence of this instrument is provisional. Contrary to a violin, which remains the same instrument also when not being used in a performance, the microphone and loudspeaker in a feedback set-up are in an exceptional situation and can be reconnected into another set-up. After the performers have been interacting with the feedback for nearly ten minutes, at 9'15" something disconcerting happens in *Quintet*. The fifth player, who is controlling the volumes, switches the connections between microphones and loudspeakers.⁶⁸ The acoustic feedback sound suddenly ends, and the movements of the performers do not directly impact the sound anymore, since their microphone is now connected to the loudspeaker of one of the other performers. The instruments have been dissolved by this action, and need to be traced back again. At this point, each performer searches for acoustic feedback with his microphone by pointing it towards the loudspeakers of one of the other performers. Whereas in the first nine minutes the unpredictability lies in the instrument itself, at 9'15" the performers have lost their instrument altogether. The hesitation of the performers during this moment is audible, even in the CD recording (Hinant 2003), although in a live performance it obviously becomes even easier to perceive, since the audience also sees the performers searching (listen to the audio example *Quintet*). With this radical dissolution of the instruments and the need to search for a new instrument, Davies underlines the fragility of this set-up. The instrument is not tangible, nor does it inhabit a certain location in the performance space.

Some remarks on acoustic feedback in music: from mistake to music

Feedback became a common feature of much music during the 1960s.⁶⁹ In some pieces, such as *I feel fine* (1964) by the Beatles, it was used more as an effect or ornamentation. The feedback at the beginning of this song was probably recorded by accident. The Beatles recognised its musical quality and decided to use it in the song. Acoustic feedback did exist from the beginning of the invention of sound reproduction technology using electricity and was, of course, regarded as a problem, since it disturbed the *reproducing* and *supporting* approaches, especially the latter, because all amplification systems have a potential to cause feedback. Early telephone systems had also to fight against a "howling" sound, as I discussed in chapter 3. The reason that feedback became so popular as a means of musical expression during the 1960s might be related to the

⁶⁸ The fifth player is as well adding some signal processing to the acoustic feedback signal, like ringmodulation.

⁶⁹ The *Resonance magazine* devoted a whole edition to feedback in music and in the arts in general (Aufermann 2002).

fact that the acoustic feedback problem was, at that point, largely solved,⁷⁰ since the development of amplification technology and the use of filters and other equipment had rendered sound emission much more controllable (Wicke 2001, 247–248). Feedback between loudspeaker and microphone could now be avoided, and there was a clear difference between which sound belonged to the performance and which did not. The sound of acoustic feedback "entered the spotlight in the 1960s probably due to that decade's character of rebellion and dissent" (Myers 2002, 12) and was regarded as useful material to express this attitude, since it is created by purposely misusing the equipment.

Apart from these "effect" appearances, as in the Beatles song, acoustic feedback became fundamental musical material for many artists, such as Jimi Hendrix, David Bowie or Sonic Youth. For these artists, feedback functions not merely as a sound symbol but as one of the central sounding elements of the piece. Owing to this musical interaction, misuse becomes a new kind of manipulation. During the performance of such a piece, attention is drawn to the *interaction* between the players and the acoustic feedback system. Whereas this is normal for all conventional instruments, for the microphone and loudspeaker it is through this "misuse" that microphone, amplifier and loudspeaker receive and make their own voice audible.

Whereas the uncontrollable aspects of musical instruments were tempered as much as possible in the context of conventional musical instrument development, it was often exactly the unpredictability of sound production with acoustic feedback that made this an interesting music-making tool for many composers and musicians. Moreover, during the 1960s it was an easy and cheap way to invent live electronic music, used to advantage by composers such as Robert Ashley* (composing his famous feedback piece *Wolfman* in 1964) and David Tudor* (who composed the feedback piece *Microphone* in 1970 for the 1970 World's Fair in Osaka). Morton Subotnick* mentions using feedback during live performances with piano as early as 1962 (Bernstein and Payne 2008, 126) and Eliane Radigue*, who later produced her principal works utilising the ARP 2500 synthesiser, relates that she did not have access to a real synthesiser during the 1960s and therefore used acoustic feedback as her principal electronic sound instead. All of these composers regarded the instability and fragility of the feedback system as an interesting element within their compositions. Radigue, for example, describes the sound control process as follows:

So I worked with electronic sounds, these wild electronic sounds made out of feedback effects from a mic with a loudspeaker. It is very subtle to do that, because you have to find the right distance, just slowly moving it so the sound is slightly changing. You must be very dedicated and precise (Rodgers 2010, 55)!

⁷⁰ In chapter 3 I discussed the invention of acoustic feedback control methods developed by Paul C. Boner.

Movement 2: introducing silence: *Pendulum Music* by Steve Reich

In Davies' *Quintet* the result is silence, when the distance between microphone and loudspeaker is so large that the microphone no longer picks up enough acoustic input from the loudspeaker to produce acoustic feedback—the set-up does not supply sufficient energy to maintain the acoustic feedback loop. Moving the microphone closer to the loudspeaker initiates feedback again. The closed circle previously formed by the set-up is opened slightly by this silence, since the connection between loudspeaker output and microphone input becomes much weaker. The loudspeaker still emits what the microphone is picking up, but the signal coming from the loudspeaker is, through distance, so reduced that it is insufficient to realise an acoustic feedback process. These microphone movements, approaching and withdrawing from the loudspeaker, therefore open and close the circle of this set-up. The instrument is, thus, constructed as soon as the feedback sound is heard and dismantled as soon as there is silence again. The next piece that I will discuss, *Pendulum Music* (1968) by Steve Reich*, uses the appearance and disappearance of acoustic feedback as its main musical material. Several microphones hang above an equal number of loudspeakers, lying with diaphragms facing up on the floor (Reich suggests 2, 3, 4 or more in the original score (Nyman 1999, 12), see scheme *Pendulum Music* and a picture of the original score). At the beginning of the performance, each performer takes a microphone in her hand, pulls it to the side and releases it to swing directly over the loudspeaker. Next, the volume of the amplifier is turned up, until a soft feedback sound can be heard. The microphones swing forwards and backwards (see video *Pendulum Music*).

Whereas the phasing effect caused by the microphones swinging back and forward at different speeds was probably the main compositional interest for Reich himself, I will investigate what happens with the feedback sound during this performance. The feedback only occurs when the microphone is close enough to the loudspeaker. At the beginning of the performance, a large part of the arc created by the swinging movement of the microphone takes place in total silence. Only when the microphone is quite close to the loudspeaker a short feedback sound is audible. This feedback sound primarily consists of only one pitch. When the movement of the microphone becomes smaller and slower, the feedback sounds become longer, but often more varied as well, since the microphone remains closer to the loudspeaker, and there is more time for sounds to develop. Although the arc of the microphone pendulum becomes smaller and smaller as the piece progresses and the microphone loses its momentum, the feedback sound increases in length as well as in variation of pitches and sound colours, depending on the distance between microphone and loudspeaker, and the velocity of the microphone movements. At the end of the piece, all microphones hang motionless above the amplifier, and the feedback sound stabilises to become a continuous sound.

PENDULUM MUSIC

FOR MICROPHONES, AMPLIFIERS, SPEAKERS AND PERFORMERS

2, 3, 4 or more microphones are suspended from the ceiling by their cables so that they all hang the same distance from the floor and are all free to swing with a pendular motion. Each microphone's cable is plugged into an amplifier which is connected to a speaker. Each microphone hangs a few inches directly above or next to its speaker.

The performance begins with performers taking each mike, pulling it back like a swing, and then in unison releasing all of them together. Performers then carefully turn up each amplifier just to the point where feedback occurs when a mike swings directly over or next to its speaker. Thus, a series of feedback pulses are heard which will either be all in unison or not depending on the gradually changing phase relations of the different mike pendulums.

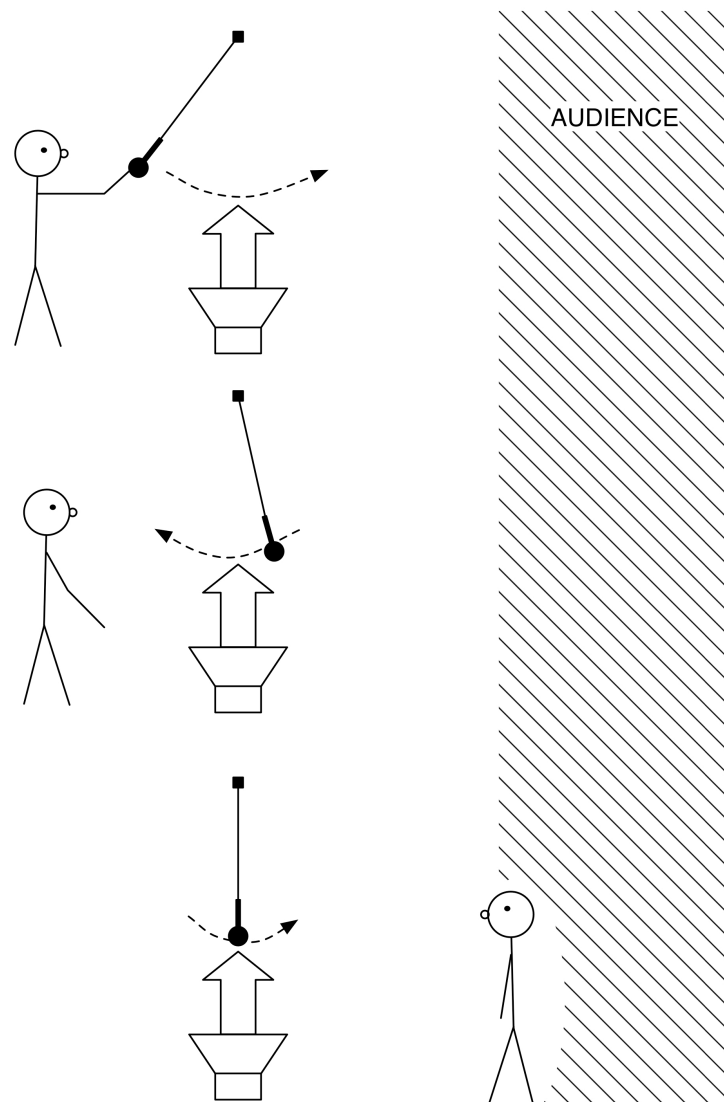
Performers then sit down to watch and listen to the process along with the audience.

The piece is ended sometime after all mikes have come to rest and are feeding back a continuous tone by performers pulling out the power cords of the amplifiers.

Steve Reich 8/68

Steve Reich Pendulum Music score.

What kind of instrumental playing is this? Is there any going on at all? And if not, what else is going on? It is obvious that the sound sources of what is audible, are microphone, amplifier and loudspeaker. The interaction with the performer takes place only at the very beginning in complete silence, since the volume is not yet raised to a level that creates feedback. The biggest movement, the first swing of the microphone after the performer releases the microphone, takes place before any sound occurs. Starting with an open space of silence, this piece closes towards a circle of feedback sound. The instrument comes into being during the performance, seemingly appearing out of nowhere.



Steve Reich *Pendulum Music*: the scheme depicts three stages of the piece. At the top the performer is holding the microphone, in the middle the performer has released the microphone and at the bottom the performer has joined the audience to listen to the swinging microphones.

Reich requests the performers explicitly in the score to watch and listen to the process along with the audience, once they have released the microphones (Nyman 1999, 12). As musicologist Richard Taruskin observes concerning *Pendulum Music*: "What makes the music, then, is not the composer, not the performer, but it (call it the force of gravity)" (Taruskin 2009, 373).

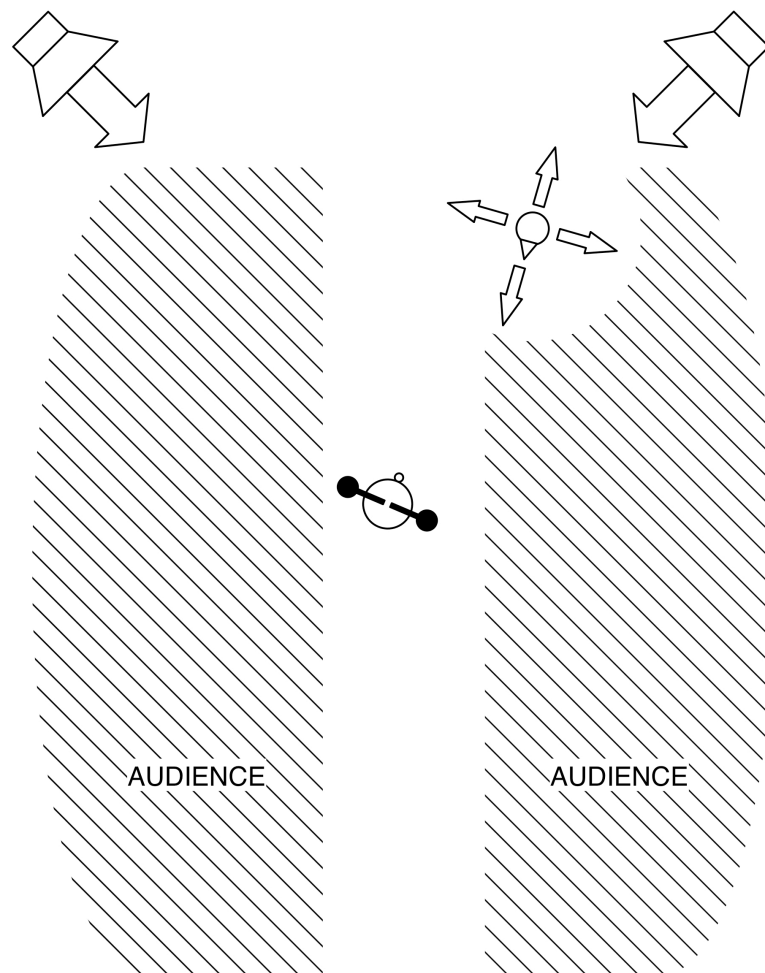
Indeed, the force of gravity causes the decay of the swinging of the microphones until they finally become stationary. But the force of gravity is not the musician, neither is it the source of the

sound. Nobody is playing after the first release of the microphones. What happens is that, with every swing of the microphone, more of the sound appears, more of the sonic potential lying dormant within the system of microphone, amplifier and loudspeaker. Contrarily to the interaction with conventional musical instruments, which need to be compelled through with movements by performers to reveal their musical world, this piece seems to reveal more of its musical world as less movement occurs. The performers sit down to listen to how the musical instrument develops, when it is not being forced to produce sounds but allowed to discover its own sound world. As demonstrated with *Pendulum Music*, using acoustic feedback in a composition can stimulate forms of *interacting* between performer and sounding object which are substantially different than those arising in performances with conventional musical instruments.

Movement 3: listening as a performative act: *Bird and Person Dyning* by Alvin Lucier

Apart from turning the feedback on and off by changing the distance between microphone and loudspeaker, as in *Pendulum Music*, one might imagine as well that the microphone picks up not only the sound of the loudspeakers, but that of another sound source as well, as is done in *Bird and Person Dyning* (1975) by Alvin Lucier*, for example. The silence caused by opening the feedback circle is now intruded upon by another sound producer, which enters from outside the feedback set-up.

Listening itself becomes a performative act within this piece. A small electric bird chirps in the space, and the performer, often Lucier himself, moves his head as if trying to locate the bird by listening to its song. He wears binaural microphones in his ears, and the sound picked up by these microphones is emitted through two loudspeakers. As mentioned in the score, the amplifier's level should be high enough to provoke feedback (Lucier 1995, 372). Since the feedback sound is related to the distance between the microphone and loudspeaker and the reflections of the sound in the performance space, there is a clear *interaction* between performer movements and resulting sound, as in *Quintet* and *Pendulum Music*. Every movement of the performer's head results in a change in the feedback sound. At the same time, the bird is also amplified through the microphones, located in the ears of the performer, and the amplified sound of the bird also interacts with the feedback sound. The binaural microphones pick up the direct electronic bird sound as well as all its reflections in the performance space. These are again projected into the performance space through the loudspeakers and influenced by reflections in that space, resulting in complicated patterns of interferences of sound waves. This generating of new frequencies in space is called *heterodyning*, hence the title also refers to this



Alvin Lucier *Bird and Person Dyning*: the sound of the electronic bird is picked up by the microphones in the ear of the performers. The microphone signal is emitted by the loudspeakers and depending on the distance between microphones and loudspeakers acoustic feedback is produced as well.

effect through the word "dying" (see scheme *Bird and Person Dyning* and view the video *Bird and Person Dyning*).

The sound in this piece is shaped not only by the distance between performer and loudspeaker, but also by that between performer and bird. Lucier makes movements that signify listening or, as he himself says, "do you know how robins turn their heads to listen?" (Lucier 1995, 172). Lucier describes the task of the performer as follows:

The performance simply consists of the performer moving slowly around the space searching for phantoms. When I perform the work I usually move through the audience,

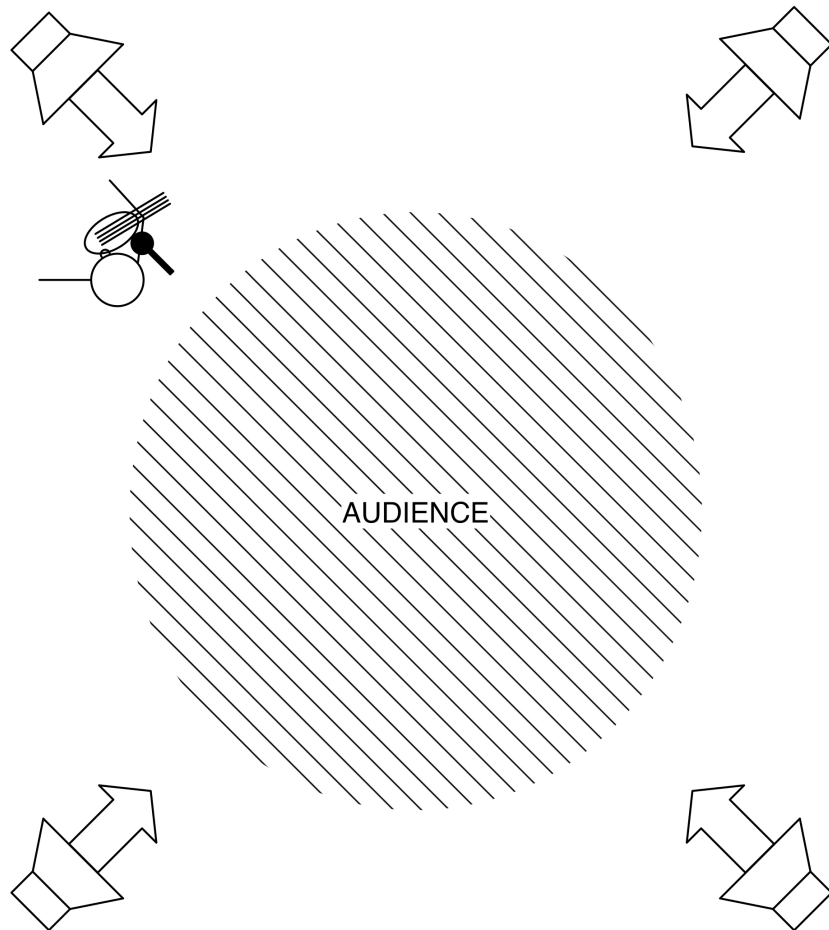
toward the birdcall and speakers, stopping briefly when I hear heterodyning. I tip my head from left to right, to fine tune the results and move them to various points in space. The spatial relationships between the binaural microphones and the loudspeakers determine the geographical locations of the phantom birdcalls. I relish the theatricality of the situation. Sometimes the results are vivid—transpositions and their mirror inversions occur. At other times, however, the room just produces a few unwanted resonances. The performer accepts the task of finding the appropriate strands of feedback that create phantom images of the birdcall. The performance is not an improvisation (Lucier 2002, 24).

The performer's listening is now an audible feature of the performance. In contrast to Reich's *Pendulum Music*, there is a constant interaction in *Bird and Person Dyning*, between movements by the performer and the resulting sound. This interaction does not rely on the gestures of conventional instrument playing, as does most of the piece *Quintet* by Davies. The movements incorporated in this piece are derived from, and thus denote, the practice of listening, which is often regarded as being silent and passive. The bird plays the role of the more conventional musician during this performance, but its way of making music is quite predictable: the bird repeats exactly the same phrase, again and again. The variable part of the performance is more present in the actions of listening performed by Lucier, generating constant changes in the sound result, since the reception of the bird sound as well as the feedback sound itself changes according to the head movements.

I examined several pieces that use movement to interact with microphones and loudspeakers. In my analysis, the kind of *interaction* between performers and microphones and loudspeakers is often quite different from what commonly takes place in a musical performance with conventional musical instruments. The performers are "looking for their instrument", as in *Quintet*, "listening to their instrument", as in *Pendulum Music*, or "using their listening as a sound controlling act", as in *Bird and Person Dyning*. Microphones and loudspeakers can thus be part of a musical performance, and performers can interact with them. What happens when these devices are actively taking part in a musical performance is a change in performance praxis itself. Owing to their resistance to acting in ways we expect of conventional musical instruments, they twist the familiar elements of a performance into a new configuration.

Movement 4: interacting with another sound source: *Green Piece* by Anne Wellmer

In the first two examples analysed in this chapter, the sound is shaped entirely by microphone, amplifier and loudspeaker as well as the performance space itself. In the last performance (*Bird and Person Dyning*) this system is expanded through the introduction of the little electronic bird.



Anne Wellmer *Green Piece*: the sound of the viola is picked up by a microphone. The microphone signal is emitted by the loudspeakers and depending on the distance between microphone and loudspeakers acoustic feedback is produced as well.

Until now there was direct communication between loudspeaker and microphone; neither could be identified as the initiator of the chain of sound production. However, this works differently in the piece by Lucier. When the electronic bird calls, the microphones pick up a signal which changes owing to something other than the performer's movements. The electronic bird is not part of the microphones and loudspeaker set-up, as described at the beginning of this chapter. The microphone turns aside from the loudspeaker as its only partner for shaping the sound and picks up the vibrations of another object. The circle of feedback is opened, and a starting point for the sound, namely the electronic bird, is introduced. Whereas the feedback sound in this performance is still a circle without a clear starting point or end point, there is also what I would like to call a "line of amplification" present in this piece. The electronic bird initiates this line, which is subsequently extended by the microphones picking up its sound, and which finishes

with the loudspeakers emitting the sound in the performance space. Does this also signify that the *interaction* approach no longer suffices to describe this situation in its entirety and that the amplification of the electronic bird in this piece is part of the *supporting* approach?

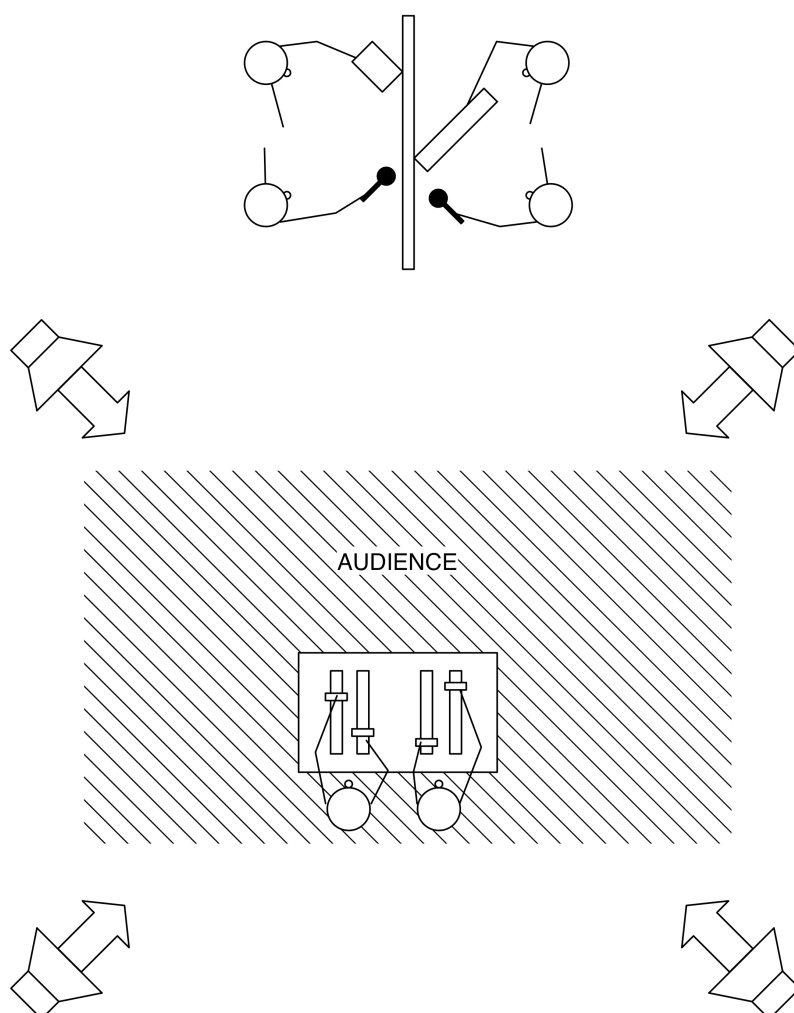
To answer this question, I examine *Green Piece* (2006) by Anne Wellmer*. In this piece a viola player wears a wireless microphone, and four loudspeakers are placed in the hall (see scheme *Green Piece*). As in Lucier's piece, the performer walks around during this piece, and in this way can approach a loudspeaker, causing feedback as well as retreat again, thus diminishing the feedback. Because the vibrations of the viola are continually received by the microphone (which is attached to the viola), the performer is able to colour the feedback. If the viola plays certain frequencies, feedback will be triggered in response to these frequencies or related frequencies. Fixed sounds are played through the loudspeakers, which will also influence the feedback. The instability of the acoustic feedback set-up is exploited by Wellmer as a means to create live electronic sound processing, shaped by a constant interaction between viola, microphone, loudspeaker and performance space. The feedback is no longer functioning in the performance as a central, but rather isolated, phenomenon, but in constant dialogue with the sounds of the viola. Whereas in Lucier's piece the electronic bird sound was not influenced by the acoustic feedback, in the piece by Wellmer the viola reacts to what is happening sonically as the result of acoustic feedback (listen to the audio example *Green Piece*).

It becomes clear from the last two examples—the pieces by Lucier and Wellmer—that in applications other than acoustic feedback, such as amplification, microphones and loudspeakers can become audible as sound shaping devices as well. Varying the distance between microphone and a sound source will not only make the latter louder or softer, but also different in sound colour. When the microphone is further away from the sound source, more resonances of the space will be picked up, whereas when it is closer to the sound source, more high partials of the sound of the object and less space resonance will be introduced into the sound produced. In this way, it is possible to compose a piece in which movements of the microphone are the only changing parameter, without the occurrence of any acoustic feedback. The next piece I explore is based on this idea of microphone movements as a compositional parameter.

Movement 5: amplification only: *Mikrophonie I* by Karlheinz Stockhausen

In *Mikrophonie I* (1964) by Karlheinz Stockhausen*, microphone movements which result in differences in amplification are used as an important part of the composition, as already revealed by the title. Stockhausen's inspiration for this piece came from listening closely to the sounds of the tam-tam and realising that he heard all kind of sounds that would remain inaudible for the audience if they were not amplified (Manion 2012, no page numbers). He

decided to use a microphone as a replacement for the ear. Although the microphone should fulfil a listening function in this piece, similar to the role of the microphones in *Bird and Person Dying*, there is a significant difference here. The microphones are treated "as a doctor who probes a body with a stethoscope", as Stockhausen mentions in the preface of the score (Stockhausen 1964, 9). Whereas Lucier's piece focus on the subjectivity of listening, making audible the listening of an individual, Stockhausen seems to be more interested in discovering



Karlheinz Stockhausen *Mikrofonie I*: microphone movements are used to pick up tam-tam sounds. The left is diffused by the loudspeakers at the left side of the hall, the other at the right side.

the intimate realms of the sound of the tam-tam, which would remain unheard without the help of a microphone.

Stockhausen conceived *Mikrophonie I* as a piece in which the microphone is put to use as a musical instrument. He searched for a way of eliminating the fixed microphones on stands which always maintain the same distance from the instruments they pick up. In *Mikrophonie I* Stockhausen aspired to bring the position of the microphone into play as a composable parameter. He describes his compositional intentions as follows:

The microphone has, up to now, been treated as a lifeless, passive recording instrument for the purpose of obtaining a sound playback that is as faithful as possible: now it also had to become a musical instrument, and to be used in turn to affect every aspect of sound. Thus it had to be able to contribute to shaping pitches, harmonically and melodically, also rhythm, dynamic level, timbre and spatial projection of sound, according to composed indications (Stockhausen 1964, 9).

The microphones should be used to modify the same parameters as every conventional musical instrument is able to do and guide all aspects of sound shaping. The result is indeed probably one of the most elaborate scores for movements with microphones ever written. *Mikrophonie I* is scored for tam-tam, 2 microphones, 2 filters and potentiometers, and should be performed by six players. These players are divided into two symmetrical groups, each comprised of one player who causes the tam-tam to sound by manipulating it with different objects; one player who picks up, with a highly directional microphone, the sounds produced by the first player as well as occasionally playing the tam-tam with objects; and a third person controlling the filter and faders for the final sound result. At each side of the tam-tam (front and back) there is an object player and a microphone player; the filter and fader players are positioned in the audience space (see scheme *Mikrophonie I*). By dividing the musical process into these three different areas, Stockhausen sees the possibility of connecting all aspects of instrumental praxis with the electronic sound world. For him, through using a microphone and processing the sound it picks up, the vibrations of any sounding object receive the possibility of merging into a coherent music composition (Misch and von Blumröder 1998, 119). His way of achieving this is, first of all, to deliver the microphones into the hands of the musicians. In the score of *Mikrophonie I*, Stockhausen notates diverse movements for the microphones. The two main parameters described are the distance to the tam-tam surface (three different distances are defined, from very close to far away as well as the distance of the microphone to the point of excitation by the object used to play the tam-tam (most of the time played by player one). This second parameter is also divided into three different distances: direct sound from the object, sound from further away, and indirect sound. The closer the microphone is to the object, the more prevalent high frequencies will be in the sound, since rapid air pressure waves decay the fastest. When the

microphone is placed further away from the object, there will be not only fewer high frequencies but also more sound input from the space present in the resulting sound. Whereas the loudest and sharpest sound will possibly be transmitted when the microphone is held very close to the object as well as the tam-tam, there will be a decreasing scale of high frequencies and direct sound until the microphone is held so far away from the object that it picks up as much as possible of the indirect sound of the tam-tam. The score requires rapid and virtuoso transitions between all these positions. Obviously, these kinds of changes in sound cannot be obtained by simply moving the volume slider of the microphone input at the mixing desk, since that would only change the amplitude of the signal without changing any of its spectral qualities.

The sound produced with these microphones is emitted over eight loudspeakers surrounding the audience. Stockhausen uses these uncommon loudspeaker positions to provide every audience member a stereo image of the sound, instead of just the few people sitting in the so called sweet spot. The two diagrams depicted here, reveal the difference between a common four loudspeaker set-up and a set-up using eight loudspeakers for four channels. There are three sweet spots now, instead of only one (Stockhausen 1996, 78). As Stockhausen mentions, the audience should hear primarily the sound of the loudspeakers, and only at very intense moments the direct sound of the tam-tam (Maconie and Stockhausen 2010, 79). Both loudspeakers at the audience's right side amplify the front microphone, and the left loudspeakers amplify the microphone at the back side of the tam-tam. In this situation, the sound perspective of the audience becomes far removed from an unamplified auditory perspective of the tam-tam. At both sides the audience hears a tam-tam, and with every microphone gesture they are—in terms of sound—moving closer or further away from the tam-tam and the object that is manipulating the tam-tam. Movements of the right and left side, as conveyed by the speakers, might be completely different. It might be clear that, in the end, what is heard is neither solely the amplified tam-tam and objects nor the microphone movements alone, but a complex sound world that is the result of all those elements together. Stockhausen himself described these sounds without any reference towards the tam-tam or the microphone: "We heard all sorts of animals that I had never heard before, and at the same time many sounds of a kind I couldn't have possibly imagined or discovered, not in the twelve years I had worked in the electronic music studio up to the time of that experiment" (Maconie and Stockhausen 2010, 78). The enormous discrepancy between sound input (the tam-tam) and the output through the loudspeakers is what Stockhausen calls the *microphonic process* (Maconie and Stockhausen 2010, 78). The resulting sound seems to no longer refer to the tam-tam, but to create a totally new sound world. Evidently, this is not only owing to the microphone movements and loudspeaker amplification. The filters used also alter the tam-tam sound considerably.

In the pieces by Lucier and Wellmer the line of amplification initiated by the sound-producing object is an amalgam with the circle of feedback. Each influences the other and there is no clear

division between the two processes. Naturally, in technical terms both are even the same, since feedback occurs because of a high amplification level. The level of amplification is controlled in Lucier's and Wellmer's pieces by the movements of the performer, changing in this way the distance between microphones and loudspeakers. Nonetheless, regarding what is recognised as the semantic sound source, it is possible to make a distinction between "sound coming from the bird or the viola, and amplified through the loudspeakers" and "feedback sound, coming from nowhere". There is no certain localisation of feedback sound (as demonstrated by *Quintet*) and the sound seems to be produced by musical instruments that appear out of nowhere (as in *Pendulum Music*). The source of the bird and viola sounds can be easily localised and attributed to the bird and viola. The amplified sound emitted by the loudspeakers points towards those objects. This amalgam of two different forms of sound production is dissolved in Stockhausen's *Mikrophonie I*, since the starting point of all sounds heard through the loudspeakers is the tam-tam. The difference between the circle of feedback and the line of amplification is therefore not only a mere difference in technical set-up, but above all a difference in interacting with musical instruments. The pieces in this chapter developed from interacting with a musical instrument that exist mainly due to movements by the musicians but without any clear material reference (*Quintet*), towards interacting with already sounding material in the form of a tam-tam.

In fact Stockhausen, in a way similar to Davies in *Quintet*, is attempting to transform the microphone into a musical instrument, since both he and Davies use microphone movements to influence the sounding result. The circle of feedback is broken in *Mikrophonie I*, however, and has become a linear process, with a clear starting point (the objects manipulating the tam-tam), further sound shaping (microphone reception and subsequent filtering by the third performer) and a clear end point (the radiation of the sound through the loudspeaker). As Stockhausen mentions explicitly in the score, feedback should be avoided by placing the front loudspeakers as far away as possible from the tam-tam (Stockhausen 1964, 9). The similarity between the approaches of Stockhausen and Davies are by no means accidental, since Davies actually performed one of the filter-playing parts during the first performances of *Mikrophonie I*. He might have acquired his first ideas for *Quintet* during a *Mikrophonie I* rehearsal, when acoustic feedback happened accidentally.

Microphone movements in amplification: supporting or interacting?

In *Mikrophonie I* the microphones serve in the process of amplifying the sounds, a very common use of microphones, as heard in many other applications. But should this line of amplification, leading towards a certain sound-producing object, not be regarded as a form of the *supporting* approach? Should it be said that the use of the microphones in *Mikrophonie I* is more instrumental or interactive than, for example, when used for the amplification of singers? Why

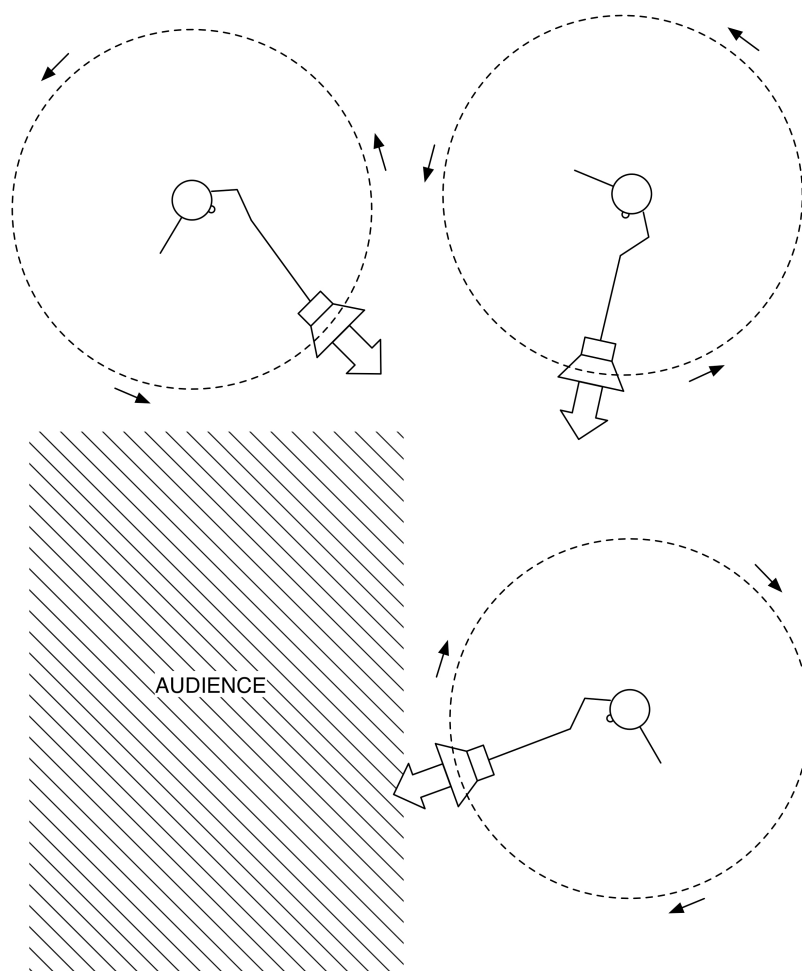
could a singer such as Ella Fitzgerald not being seen as "playing" the microphone, as she also changes the distance between her mouth and the microphone to change the quality of the vocal sound?

First of all, as I stated in chapter 2, when introducing the four approaches *reproducing*, *supporting*, *generating* and *interacting*, these are no rigid classifications but different theoretical models. For many singers, the microphone is a prolongation of their voice, and the microphone is in that case *supporting* the voice. A singer does not need to notate the microphone movements he or she is making, since they rehearse their microphone use as a core element of their singing practice. The amplification is most of the time used to serve the singing voice, a practice that I call the *supporting* approach. They develop a personal repertory of microphone techniques to complement and augment their vocal techniques, and often a favourite type of microphone. In *Mikrophonie I*, microphones are neither a prolongation of the musical instrument nor devices to support the tam-tam character; on the contrary, they seek to discover a sound world in the tam-tam that which would otherwise remain inaudible. The amplification in Stockhausen is often in counterpoint to the sound produced by the tam-tam. Whereas the sound of the tam-tam slowly fades out, for example, the microphone is moved rapidly back from and towards the tam-tam, resulting in a fast fade in-fade out-sound emitted by the loudspeakers. The microphone transmits a voice of its own, instead of "only" *supporting* another voice. Whereas in the *supporting* approach the line of amplification points straight towards the object or person producing the sound, in *Mikrophonie I* this line is full of twists, turns and curves. Furthermore, the shape of the line also changes during the piece. These bumpy lines of amplification manage to create semantic acts of sound creation which seem to come from something else than the original amplified tam-tam (these acts are described by Stockhausen as "all sorts of animals that I had never heard before"). There is an audible difference between a *supporting* amplification and an *interacting* amplification. Of course, there is no reason that singers would not use this *interacting* form of amplification as well, and I would argue that many singers do use several forms of *interacting* amplification next to *supporting* amplification. That these kind of combinations of several approaches can be even used as compositional strategies is what I will explain in chapter 5, for example by singer Ute Wassermann in her piece *Windy Gong*.

Movement 6: moving loudspeakers: *Speaker Swinging* by Gordon Monahan and *Three Short Stories and an Apotheosis* by Annea Lockwood

In *Mikrophonie I* the tam-tam is the starting point of the line of amplification. The "curves" in this line, which serve to make the amplification *interacting* instead of *supporting*, are principally shaped by the movements of the microphones. The loudspeakers radiate this sound in the performance space but do not move themselves. Two examples which serve to illustrate a form

of *interaction with movement* initiated by loudspeakers instead of microphones are *Speaker Swinging* (1982) by Gordon Monahan* and *Three Short Stories and an Apotheosis* by Annea Lockwood*. In *Speaker Swinging*, each of three or more performers swings one loudspeaker connected to a rope. The loudspeakers are connected to eight audio oscillators (sine and square wave generators) (see scheme *Speaker Swinging* and view the video example *Speaker Swinging*). Different acoustic effects occur as a result of the rotary motion of the speakers, the Doppler effect, for example.⁷¹ The loudspeaker itself should become audible through the fast movement, becoming a musical instrument, as Monahan says himself: "*Speaker Swinging* grew out of a

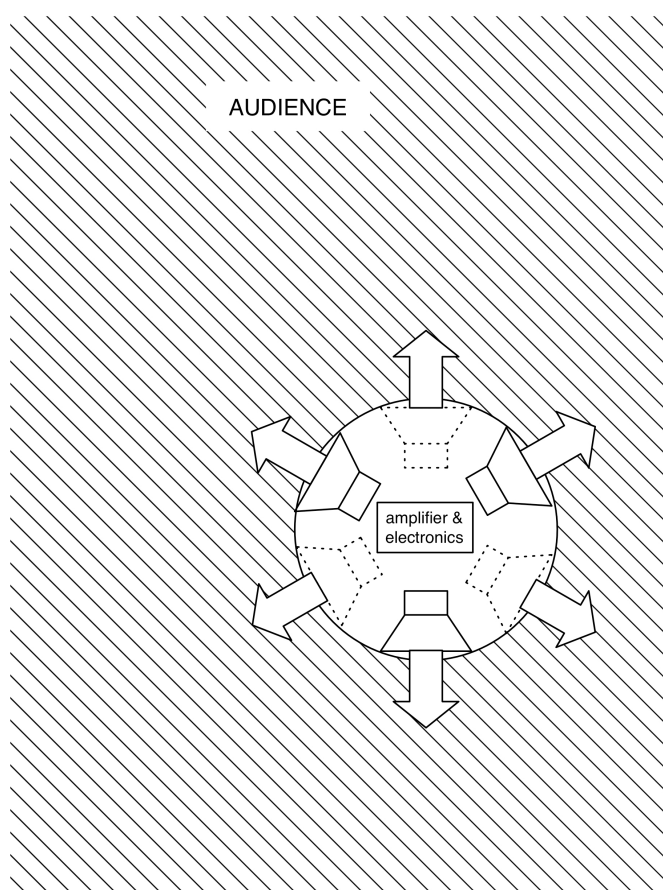


Gordon Monahan *Speaker Swinging*: three performers swing a loudspeaker.

⁷¹ The Doppler effect is the name for the change in frequency that is perceived when, for example, an ambulance passes by the listener at high speed. The ambulance siren tone seems to be higher when the vehicle approaches then when it is moving further away.

desire to animate the typical electronic music concert and in effect, to realise the loudspeaker as a valid electronic music instrument in itself" (Monahan 1982).

Annea Lockwood moves sound in a particular way through space by means of a Sound Ball, consisting of six loudspeakers, six amplifiers, six filters and a radio receiver, which receives a mono audio signal (see scheme *Sound Ball*), so that all six loudspeakers in the ball receive the same audio signal. The ball was built by Bob Bielecki. As Lockwood explains, she decided to use a mono signal to make the movements by the ball more audible than would be the case when two different signals were used (Amirkhanian 1986, no page numbers). She has used this ball in

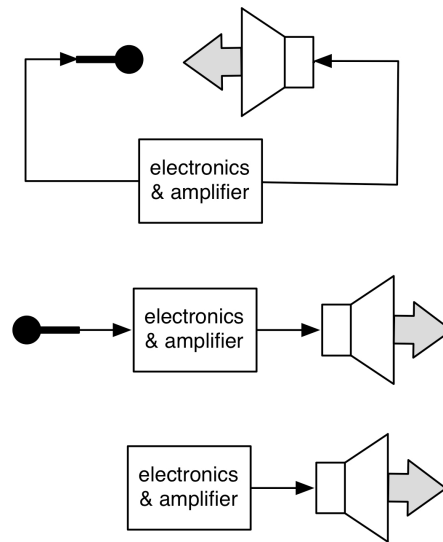


Annea Lockwood *Three Short Stories and an Apotheosis*: a Sound Ball with six loudspeakers is thrown by the audience.

performances with dancers and she performed herself the piece *Three Short Stories and an Apotheosis* (1985) for Sound Ball and pre-recorded sounds. In this piece, the Sound Ball is given to the audience, the members of which also become performers, by taking the Sound Ball and passing it on to someone else. Again a clear change in performance practice occurs here as a result of using loudspeakers as the main sound-generating element in a piece of music. The audience is "playing" with the Sound Ball, which however is not treated as a musical instrument, but as a ball in sport games. To underline this everyday aspect of the performance of the piece, Lockwood projects a double image of a woman tossing a ball which looks very similar to the ball she is using.⁷² By moving loudspeakers through space, as in these pieces by Monahan and Lockwood, they easily become identifiable as the source of the sound. The audience can clearly attribute the changes in sound to the loudspeaker movements. The presence of the loudspeakers and their role as sound-producers is revealed by having them moved by performers (*Speaker Swinging*) or by giving them to the audience themselves (*Three Short Stories and an Apotheosis*). At the beginning of this chapter, in *Quintet*, the musical instrument in the acoustic feedback set-up could not be localised; by now, the instrument has become an object that can be traced by the ears and held in the hand.

These last two pieces could best be described as using microphones and loudspeakers as a point of radiation, rather than as a circle of feedback or a line of amplification. The sound emitted by the loudspeakers could be recognised as either being part of the *reproducing* approach (the pre-recorded sounds used by Lockwood) or the *generating* approach (the sine and square wave generators used by Monahan). However, the sound is not radiated by loudspeakers, which stay "inaudible" as semantic sound producers. Whereas in the common *reproducing* or *generating* approaches, the radiation of sound waves from the loudspeakers is rather "straight", since the sound should be conveyed to the space and the listener in such a way that the loudspeaker is as inconspicuous as possible, in these two pieces the point of radiation is modified by movement. Not only are the position and direction of the sound sources modified, but, owing to changes in distance as well as speed of motion, changes also occur in the frequency spectrum as perceived by the audience. The line of amplification points towards one or more sound-producing objects which are recognised as the "beginning" of the sound, which itself is then modified by microphones and loudspeakers. By "beginning", I do not mean that it takes place earlier in time, but that it forms the primary reference for the sound. Thinking of *Mikrophonie I*, even when the sounds remind one of "animals I had never heard before", all sounds will ultimately be associated with the tam-tam, as their "original" source. A point of radiation does not include another sound-producing object in the performance, and can therefore be regarded as the starting and the end point of the sound. For this reason, microphones are excluded from the set-

⁷² The picture is by Jacques-Henri Lartigue and called *My Nanny, Dudu* (1902).



From top to bottom: a circle of feedback, a line of amplification and a point of radiation.

up (a microphone always "points" to an object). These two concepts—point and line—are united within the circle of feedback, where there is no starting nor end point.

From movement to material

At the beginning of this chapter, the microphone was facing the loudspeaker and thus generating acoustic feedback, due to proximity. The output was the input, and all elements were interconnected by a feedback loop. This set-up was played by changing the distance between microphone and loudspeaker in *Quintet*. It moved further and further away from the loudspeaker in pieces like *Pendulum Music*, *Bird and Person Dyning* and *Green Piece*. There were moments in which the distance between microphone and loudspeaker was so great that acoustic feedback no longer took place. In *Bird and Person Dyning* and *Green Piece*, the microphone was picking up another sound source alongside that of the loudspeaker(s), the electronic bird sounds and the viola playing, respectively. In *Mikrophonie I*, the microphones were turned away from the loudspeakers during the entire piece, so no acoustic feedback took place; the microphone was made "audible" through movements to and from another sounding object, a tam-tam in this case. Owing to changes in distance between microphone and loudspeaker, caused by movements of the performers, the acoustic feedback disappeared, and other objects instead were amplified through the loudspeakers. Slowly the acoustic feedback circle was opening and developing towards an instrument which might be described in terms of a linear process of amplification, resulting in a single source for the radiation of sound. This linear process emphasises the *material* quality of the semantic sound source, either because it is amplifying a specific sound-producing object (bird, viola or tam-tam in the examples above) or because the presence of the commonly "inaudible" sound source, namely the loudspeakers, is exposed.

Following this development from circle of feedback to line of amplification and radiation of sound, the next step would be to approach the amplified object even closer, until object and microphone are as close as possible. A way of achieving this is by the use of a contact microphone,⁷³ since this is, as its name indicates, "touching" the material that it is amplifying. There is no longer any air between diaphragm and object. The *interaction* between performer, and microphone and loudspeaker can no longer be revealed through movements of the microphones, since the microphones are attached to the material of the object itself. It is the material of the diaphragms themselves as well as the material that they are touching which makes the microphones or loudspeakers audible. Microphones and loudspeakers do not move anymore, but reveal their instrumentality in response to the sound characteristics of their material. This is the second parameter of musical instrument playing I mentioned at the beginning of this chapter: modification of the physical characteristics of the vibrating body of the musical instrument.

⁷³ There are different types of contact microphones, but I won't discuss them all here. By "contact microphone", I mean here every type of microphone that is literally making "contact" with the material it amplifies by touching, through pressure or adhesives, the material.

MATERIAL

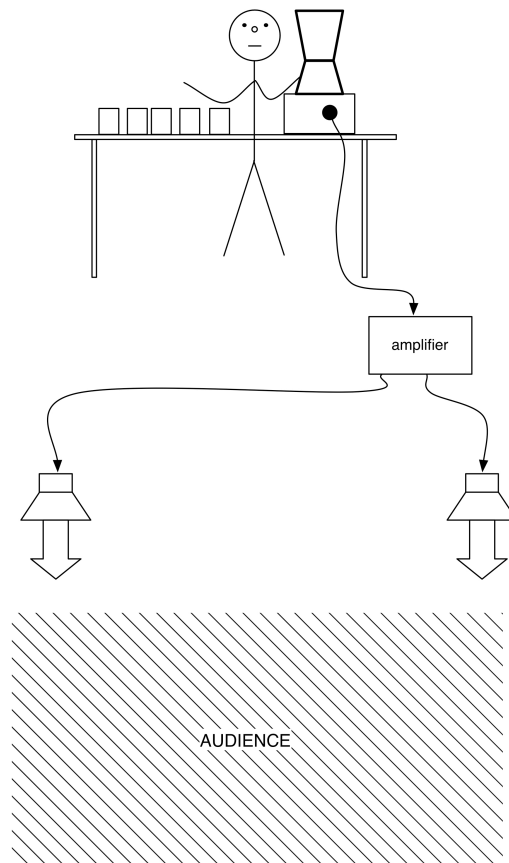
Material 1: everyday actions amplified: coffee making by Valerian Maly and 0'00" by John Cage

Once every year, Valerian Maly* makes coffee for his new students. An activity known from everyday life, with a small change: a contact microphone is attached to the coffee-making set-up, amplifying the vibrations of this set-up through loudspeakers (see scheme *Cooking Coffee*). The sounds made during this coffee-making process therefore differ from what is usually heard, thus attracting the attention of the students waiting for their coffee, who then begin to listen to and look at this well-known action in a different way. The use of contact microphones results in Maly's coffee-making becoming a (musical) performance instead of an everyday action.

Maly's coffee-making performance could be seen as a performance of *0'00"* (1962) by John Cage*. The main instruction for this piece in the text score is: "In a situation with maximum amplification (no feedback), perform a disciplined action" (Pritchett 1993, 138). Cage himself describes this piece as being

Nothing but the continuation of one's daily work, whatever it is, providing it's not selfish, but [...] the fulfilment of an obligation to other people, done with contact microphones, without any notion of concert or theatre or the public, but simply continuing one's daily work, now coming out through loudspeakers (from an interview with Lars Gunnar Bodin and Bengt Emil Johnson, 1965, cited in (Kostelanetz 2002, 74)).

Cage makes two important discoveries for his work during the 1950s: all sound has the possibility of being part of a performance (resulting in the composition *4'33"*), and sound is always present, as he discovered by entering the anechoic room and still hearing the sounds of his own body (Kahn 2001, 158–159). The full title of *0'00"* is *0'00" (4'33" No. 2)*. *0'00"* can be seen as a second *4'33"*, this time not about "all sound", though, but "always sound". Cage describes the aim of amplifying an everyday action as following: "What the piece tries to say is that everything we do is music, or can become music through the use of microphones; so that everything I'm doing, apart from what I'm saying, produces sound. When the sounds are very quiet, they become loud through the use of microphones." Cage expands this idea of always sound and claims that amplification transforms all sounds into music: "The only reason for amplification is that it's in the field of music. By means of electronics, it has been made apparent that everything is musical" (both citations of an interview with Lars Gunnar Bodin and Bengt Emil Johnson of 1965, cited in (Kostelanetz 2002, 74)).



Valerian Maly cooking coffee: a contact microphone picks up vibrations of the set-up used for cooking coffee.

Some remarks on the sound of contact microphones

Cage's idea that amplification of sounds would implicitly make them musical is interesting in the context of *interaction* with microphones and loudspeakers, since this idea might imply that the simple use of amplification could turn every possible object into a musical instrument.

Amplification, whether with contact microphones or other microphones, condensers for example, is a common practice in Cage's work. Pieces such as *Cartridge Music* (1960), *Child of Tree* (1975) and *Branches* (1976) use amplification as one of their main compositional elements.

Contact microphones as used in Maly's coffee-making performance pick up vibrations from solid material at the point of attachment to that material. These vibrations are quite different from the

vibrations radiated into the air by the whole object. Contact microphones are especially suitable for objects which can support strong vibrations in their material, but which do not radiate these vibrations into the air very well: solid objects, such as a table. The vibrations of the table stay inside the table, since the table is not flexible enough to transport these vibrations to the air. Musical instruments could be seen as revealing the opposite characteristic: they tend to radiate their vibrations very well into the air, which is why they produce relatively loud sounds. Owing to the high amount of vibrational energy which remains inside the object, many everyday objects, like chairs, tables or kitchen utensils, are well suited to amplification with contact microphones.

Since contact microphones are connected to a specific point on the solid material, only the vibrations at this point will be amplified. These vibrations can vary extensively at different points on the object, and can also differ considerably from how the object sounds in its entirety. There will probably be fewer frequencies present in a specific point of contact with the material, picked up by the contact microphones, than there are in the total sum of vibrations radiated by the object into the air. Thus the amplified sound contains fewer frequencies and a stronger presence of pitched material compared to the unamplified sound, which reveals a wider variety of frequencies in its spectrum and therefore a noisier sound. Apart from that, contact microphones themselves often have pronounced resonance peaks of their own at specific frequencies (Hopkin 2002, 7), so the pitched character of the sound is further accentuated by the material of the microphones themselves as well. Besides, the vibrations of an object might be difficult to transmit to the air, and thus sound quite softly without amplification, but becoming loud, when a contact microphone is used. Contact microphones are for these various reasons often described as not of very high quality or even unnatural (Hopkin 1996, 164) or as "colouring" the sound to an extreme degree (Emmerson 2007, 132). This process is very similar to what happens when a musical instrument is played—it filters the energy supply of the performer and amplifies these filtered waves (often this filtering by musical instruments is so strong that only a harmonic spectrum is left). The contact microphone fulfils the same role in the coffee-making performance: it filters the input energy and amplifies the remaining frequencies.

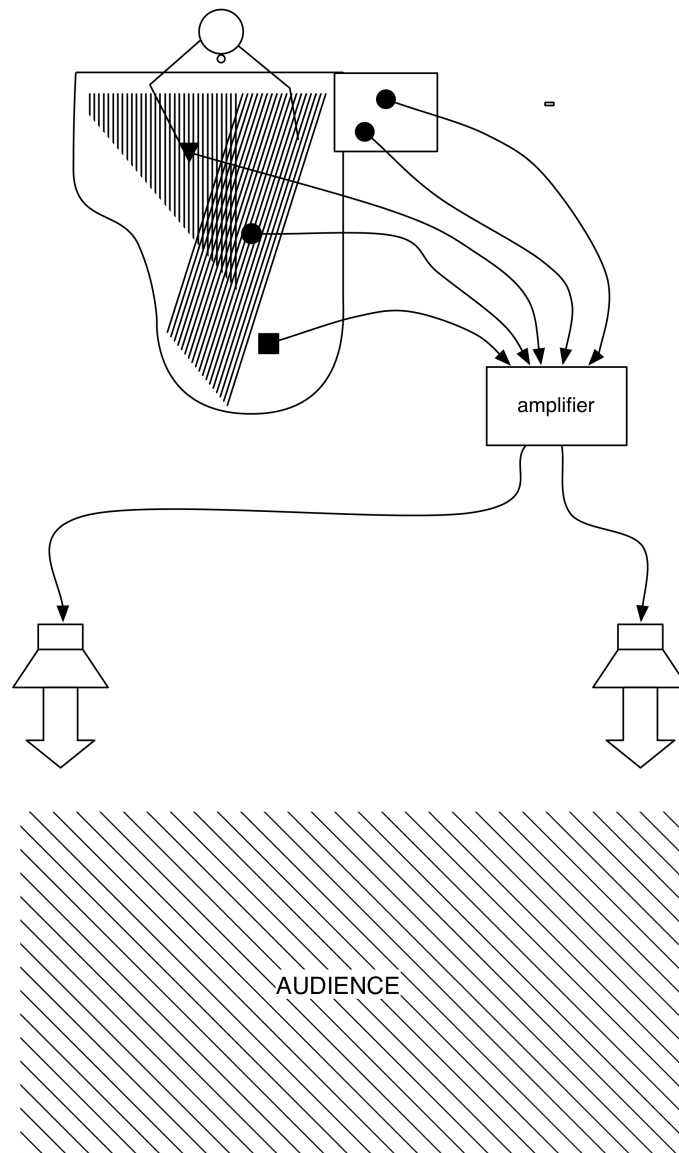
This process of filtering and amplifying adds a resonating body to material which lacks one of its own. Unusual material, like a coffee-making set-up, therefore behaves similarly to a musical instrument. Owing to the resonating "body given to the sounds made by ordinary objects and ordinary actions, the actions are unified through sharing common resonant characteristics, acquired as a result of their amplification with contact microphones. Amplification of certain frequencies has a very long tradition in our musical culture, and it might be useful to take a short look at this tradition in order to understand why this resonance might be perceived as musical. Early humans tended to hold music performances in caves, the resonances of which amplified certain frequencies in the sounds they produced. Apparently these older cultures "made no

distinction between objects actively producing sound, such as bells, and objects passively modifying those sounds, such as a cave" (Mithen 2007, 75). They probably regarded the sounds added in caves as a result of the reflections of the walls as voices or spirit from a world beyond the cave wall (Mithen 2007, 75). The object seems to become supernatural, because of this added voice, and it suddenly becomes a resonating body instead of a normal everyday sound. Through the use of contact microphones, all objects can acquire a voice which seems much larger than that of the object without amplification. Due to amplification, these objects can be recognised as producing musical sounds, instead of ordinary sounds known already in everyday life. The extensive use of amplification, filtering and reverb (all three, in fact, take place with the use of contact microphones) in many forms of music nowadays could therefore be seen as a form of merging the different sound colours of the source material. This does not mean, though, that every sound is considered to be music, simply through the use of amplification. A person talking through a microphone is often not associated with music at all. Concerning the pieces by Cage which use amplification as the main means of making music out of everyday material, it becomes clear that much more is needed to make "music" out of it. One of the main arguments might be that Cage is largely exploring sounds which are perceived very differently when they are not amplified, and incorporating these sounds within a musical performance context. The amplification should not be understood as underpinning a mere *supporting* approach towards what is sounding, but as an element that reveals new aspects of the objects by enabling the production of previously unheard sounds with them.

Material 2: musical instruments and contact microphones: Inside Piano by Andrea Neumann

Contact microphones transform ordinary objects into potential musical sound producers owing to the "colour" they add to the sound sources when used for amplification. I will look now at some examples of how several composers and musicians have used contact microphone amplification and how in these approaches the *material* is part of the *interaction* between performer and microphones and loudspeakers.

My first example illustrates how musical instruments themselves change as soon as amplification is added to the instrument. Just as everyday objects experience a dramatic change in their sonic nature as soon as a resonant body is added to them through amplification, it is logical that a conventional musical instrument itself also changes as soon as amplification is added. I mentioned already in chapter 2 that the *supporting* approach did not function as transparent as it theoretically should, taking into consideration, for example, the fact that the construction of the (electric) guitar changed completely once amplification was added (see chapter 2). A good example of a change in a conventional instrument owing to the use of contact



Andrea Neumann *Inside Piano*: the sound board of a piano is picked up by contact microphones and diffused by loudspeakers

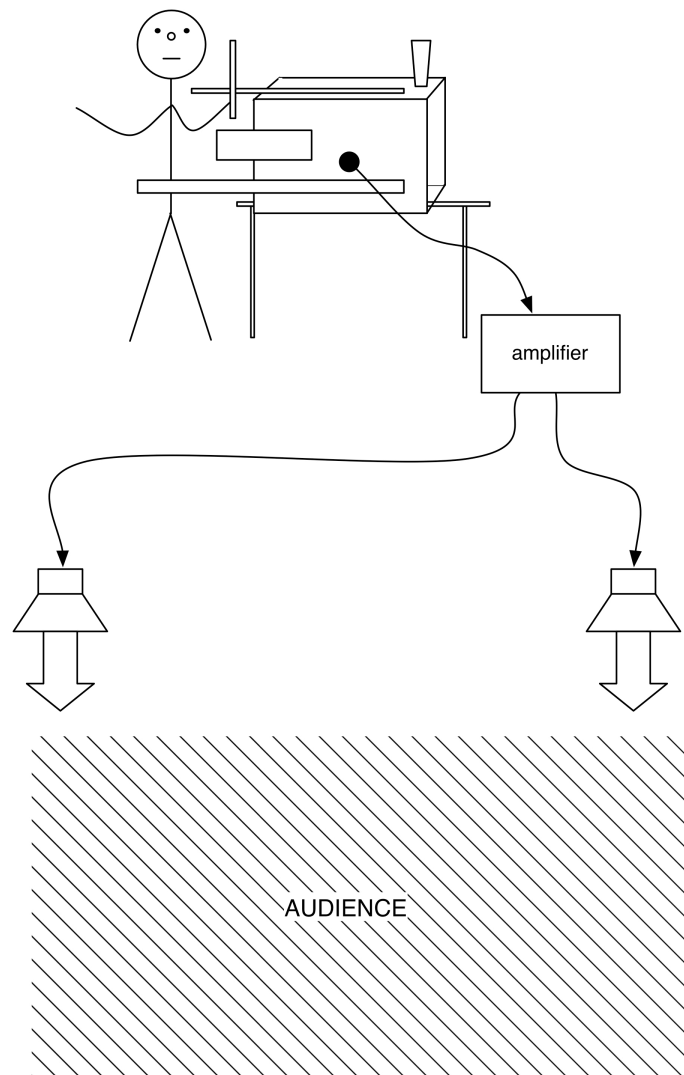
microphones is the work of Andrea Neumann*. She is involved with experimental piano techniques, mainly on the inner parts of a grand piano, and amplifying these actions with contact microphones. Over a period of years she discovered that the use of contact microphones changes the sound of the piano extensively, functioning as a kind of soundboard; the physical build of the grand piano was not even suitable for her way of performing and thus no longer necessary (see scheme *Inside Piano* as well as video *Inside Piano*). As a result, a special piano was designed for her by Bernd Bittmann, much lighter, without any keys or legs—another example of the distinctions between the four approaches of *reproducing*, *supporting*, *generating* and *interacting*

becoming blurred. Neumann developed a very elaborated amplification system for this piano, using five microphones. Two different contact microphones (an AKG C411 for a "natural" amplification, as Neumann describes, and a Schertler Dyn-B for more volume and warmth in the bass register) are picking up the vibrations of the soundboard, two other contact microphones (both AKG C411 as well) are used for picking up the shelf, which was originally built only as a place for keeping the piano preparations when they were not needed. A mobile guitar pick-up (Dean Marclay) is used for amplifying all kind of small metal objects as well as creating an acoustic feedback loop by placing it close to the contact microphones and turning up the volume. Neumann underlines that she wishes to discover by using these different microphones the many different sound characteristics of the instrument. The microphones influence what sounds she discovers on her instrument and are therefore an essential part of her set-up. She composes with different sound colours, by exchanging which microphone is emitted through the loudspeaker, having a large palette of possible combinations of these five microphones as well as the possibility to emit their sounds at different places in the stereo panorama. In this way the same sound source can be projected in different versions. She compares her use of microphones with differently coloured glasses, or with five people all reporting in a different way about the same event (Neumann 2013). As she suggests:

A soft scraping noise—created by moving a small metal plate on the guitar pick-up—can be emitted through the left loudspeaker. At the same time an up and down vibrating fork between the strings creates quite high metallic sounds, amplified by the AKG on the soundboard through both loudspeakers, and the sound of a small propellor amplified through the AKG beneath the shelf is diffused by the right loudspeaker.⁷⁴

The amplification of instruments is very common, and performances are part of the *supporting* approach as I defined it in chapter 2 as long as, for example, the conventional grand piano is what should be recognised as the main instrument. In Neumann's performances, however, the grand piano has been changed into a different instrument which can only function properly by *interacting* with microphones in order to obtain a specific sounding result. Elements of the piano which would not normally emit much sound in themselves become audible in this instrumental set-up.

⁷⁴ This is my translation and reformulating of: "So kann ein leises schabendes Geräusch ganz links (Metallzunge wird langsam auf dem Dean Marclay Gitarren Pick-up hin und her gezogen) neben einer höhenlastigen zwischen den Saiten auf und ab wippenden Gabel in der Mitte, (verstärkt durch das AKG unter den Saiten), neben einem rhythmischen Tuckern ganz rechts (Propeller auf Ablage, verstärkt durch AKG unter der Ablage) stehen" (Neumann 2013).

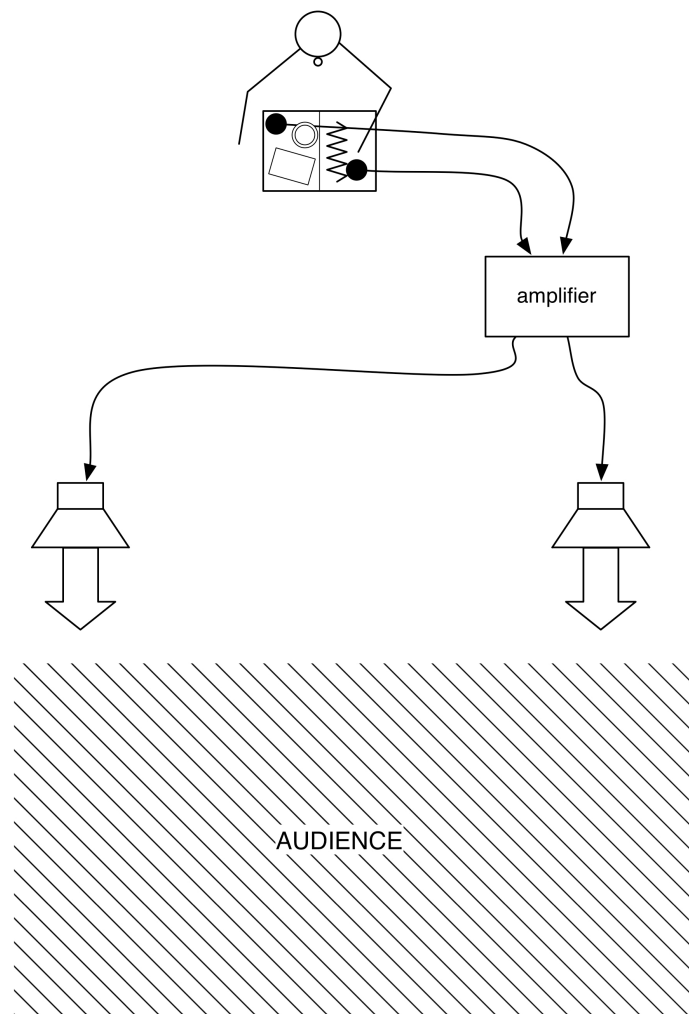


Pauline Oliveros *Apple Box*: a contact microphone is attached to an applebox and amplified through loudspeakers. The performer is playing objects attached to the apple box.

Material 3: new instruments through amplification:

***Apple Box Double* by Pauline Oliveros and *Shozyg* by Hugh Davies**

Many composers and musicians also employ contact microphones for another purpose: developing new instruments from scratch instead of transforming conventional ones. The *Apple Box* pieces by Pauline Oliveros* all use, as the titles indicate, wooden boxes in which apples have been stored, and contact microphones to amplify them (see scheme *Apple Box Double*). These apple boxes were literally everyday objects for Oliveros, since she used them to furnish her home. She has used them as resonators for all kinds of objects (Duckworth 1999, 171). Every apple box is prepared with various objects. Each player decides what kind of objects he or she



Hugh Davies *Shozyg*: two contact microphones amplify a set-up of everyday objects through two loudspeakers.

will use (Bernstein and Payne 2008, 89–90). In a performance in 2004 of *Apple Box Double* (1965), Oliveros improvises together with Seth Cluett (see video fragment *Apple Box Double*). They attached pieces of wood and metal to their apple boxes and use glasses, cups, bows, metal chains and several other objects to play them. The material played will always sound via the resonance properties of the apple box, since the contact microphone is attached to it. The apple box together with its contact microphones functions as a kind of filter, amplifier and reverb, giving the different types of material a similar sound colour, resembling, in effect, the resonance body of an instrument, and producing a unity in sound colour similar to that achieved by an instrument, emphasised by the use of contact microphones for amplification. Whereas Oliveros' apple boxes still convey an improvisatory and quotidian quality (although much less than Maly's

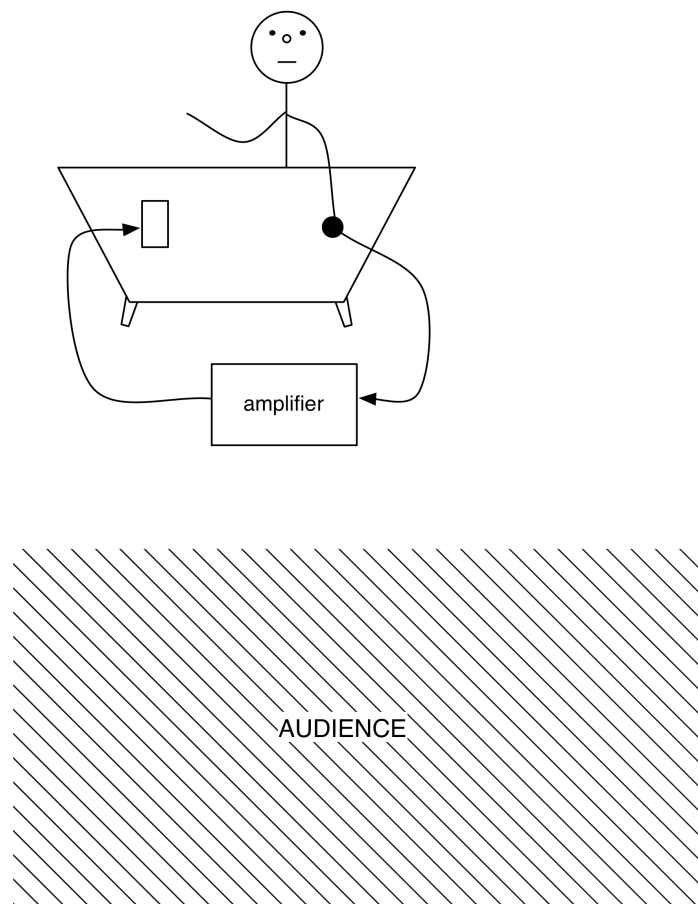
coffee-making or the aforementioned pieces by Cage), more elaborate musical instruments have been invented by other composers. Hugh Davies, for example, created some very refined instruments, such as his *Shozyg* (1968), based on amplification with contact microphones and other close miking technologies, such as pickups (see scheme *Shozyg* and listen to the audio example *Shozyg*). Davies often uses two or more different types of contact microphones, with differing frequency responses, since this offers the possibility of filtering the vibrations of the same object in different ways (Davies 2001, 59). The *Shozyg* is built on the cover of the final volume of an encyclopaedia out of which all the pages have been taken. Since the original encyclopaedia volume covered everything from "shoal" to "zygote", "sho zyg" was printed on its spine. Davies decided to use this as the name for his instrument. Inside the cover he glued objects, such as a furniture castor, a 3D postcard and a small spring. The objects in the hard cover were amplified by means of two contact microphones, isolated from each other by being placed on two isles of felt. Once these were plugged into a stereo amplifier, the instrument was ready for use. Upon finishing, the volume just needed to be unplugged and closed again, and it was ready for transportation. Looking back at this instrument from a contemporary perspective, it could definitely be associated with a laptop performance *avant la lettre*.

The multiple ways of inventing music performance through the use of contact microphones—making music out of everyday life actions (Maly), transforming conventional instruments (Neumann) or developing new instruments (Oliveros and Davies)—reveal that these set-ups can indeed be seen as one integral sound system or, in other words, as a musical instrument. In contrary to the acoustic feedback set-up systems mentioned at the beginning of this chapter, these musical instruments consist of much more than a microphone and a loudspeaker, comprising a system which, in its totality, exhibits properties comparable to a musical instrument, with loudspeaker and microphone as interdependent components. A clear *interaction* takes place, but microphone and loudspeaker seem to be more at the edges of these interactions: although the instruments by Neumann, Oliveros and Davies could not exist without microphone and loudspeaker technology, the microphone and loudspeaker function no more extensively than as a resonating body for the objects played. Whereas the line of amplification in *Mikrophonie I* would constantly take on different forms, these last-mentioned examples could be described as having a line of amplification, with various curves and twists, which essentially remains the same line during the whole piece. The microphones and loudspeakers are important parts of these instruments, but *interaction* with them does not differ greatly from that with conventional musical instruments. In comparison with the earlier examples of microphones and loudspeakers presented in this chapter, the performance situation here is comparable to a performance with conventional musical instruments. When Davies played his *Shozyg*, his movements are identified as "needed for making this music" instead of being related to everyday movements, whether executed by the performer, as in Maly's coffee-making, or by the audience, when playing with Lockwood's Sound Ball. There is also a clear interaction between movements

and sounding results, similar to conventional performance practice, and contrary to *Pendulum Music*, for example, during which the active part of the performers is limited to starting the process. The *Shozyg* is furthermore a tangible instrument, unlike the other set-up by Davies for the acoustic feedback piece *Quintet*. Neither are there any unexpected sound characteristics revealed, since the construction of *Shozyg* is of such complexity—and the audience most likely has very little prior knowledge of the sonic characteristics of many of its parts—that there are no direct expectations regarding their sound, as would be the case with the tam-tam in *Mikrophonie I* or the everyday actions as in *0'00"*. It is primarily by reason of this last element that a *Shozyg* performance differs from performances with conventional instruments. Most of the audience attending a violin recital will probably be acquainted with the instrument, whereas an important element of a *Shozyg* performance is the discovery of the sonic possibilities of this uncommon instrument. This is evidenced by the use of a close-up video projection of the interaction between Davies and the *Shozyg* during performances, so that the audience can assign his movements to the sonic outcomes.

Material 4: acoustic feedback through different materials: *Nodalings* by Nicolas Collins

Attaching a contact microphone to an object, as in the *Shozyg*, could be interpreted as an enlargement of the diaphragm of the contact microphone. The diaphragm is prepared with an object, whether a coffee machine, an apple box or the frame of a piano. This diaphragm of the microphone could be extended to such an extent that it touches the diaphragm of the loudspeaker, which would in this way share its diaphragm with the contact microphone. The loudspeaker used for this purpose possesses no diaphragm of its own. Such a loudspeaker is named "tactile transducer" since it drives or shakes other bodies. The result of turning up the volume in this set-up would be similar to those arising from the acoustic feedback set-up, where there was air between microphone and loudspeaker. The microphone picks up the vibration of an object, and these vibrations are amplified and sent back through the loudspeakers attached to the same object. What happened through air is now happening through a solid material: acoustic feedback becomes audible, filtered this time not by the performance space and the distance between loudspeaker and microphone but by the object the loudspeaker and microphone are connected to. Nicolas Collins* describes this kind of feedback possibility in his score *Nodalings* (1974). This score is written for either acoustic feedback through the air or acoustic feedback through objects, but I will focus here only on the feedback produced through objects. During a performance of this piece, various sonic representations are created of the characteristics of an object through the process of moving microphone and loudspeaker to different positions and in this way creating different feedback sounds (see scheme *Nodalings*). The objects proposed by Collins are as diverse as a bathtub, a rock, a tree or a balloon. The only parameter that is modified



Nicolas Collins *Nodalings*: a contact microphone picks up vibrations caused by a tactile transducer. Acoustic feedback through a solid object occurs.

during this piece is the amount of *material* between driver and microphone, resulting in what Collins terms a sonic "topography" of the object (Collins 1974, 1). "Feedback conveniently mapped the acoustical characteristics of any space (its resonant frequencies, reverberation time, frequency balance) into a sonic portrait [...]" (Collins 2002, 6).

Not many pieces have been written for acoustic feedback through a solid object, probably because the system needed to produce this kind of feedback proves to be much more rigid than one in which feedback is generated through air pressure waves. This kind of feedback has been more popular in sound installations in which no performer movements are required. Active performing with a solid object feedback set-up would imply either changing the position of microphones and loudspeakers or altering the physical conditions of the solid object. To adjust contact microphone positions is quite difficult, since the loudspeaker and microphone must be attached firmly—screwed, clamped or glued onto the object—for optimal vibratory

transmission. Likewise, the physical condition of an object cannot be easily modified. For these reasons, feedback through a solid object has been used more extensively in sound installations, the installation *Schlingen* (2006) by Andre Bartetzki being one example. Contrary to acoustic feedback through air, which has been used extensively by many artists and which has resulted in performances with extensive and varied movement techniques for influencing the sound, the use of acoustic feedback through solid material results primarily in stationary installations. This does not mean, however, that this kind of feedback through objects could not be valuable for performances as well. This is a field where there are most likely many possibilities to be discovered.

Back to a circle of feedback

The set-up devised by Collins is very similar to that devised by Davies for *Quintet*, discussed at the beginning of this chapter. Here again, the set-up is designed to produce all sounds by itself, without adding any sounds related to an object or action outside of the feedback set-up. As Collins demands in the score: "Avoid intentionally producing any noise other than the feedback—if the movement of a contact mic along a surface produces a noticeable scraping sound, lift it to move it; raise and replace it as quietly as possible" (Collins 1974, 2). The big difference lies in the *materiality* of the musical instrument. In *Nodalings* the musical instrument is a perceptible object. Unlike the microphones in *Quintet*, it has a clear location in the performance space and can be touched. Instead of playing the instrument by means of *movements* in the air, this time the amount of *material* in between microphone and loudspeaker is the main parameter. The line of amplification, illustrated by means of several examples mentioned earlier, not only provides a start and end point for the sound, but also serves to create distance between the sounding object and the audience. In *Quintet* the audience is seated in the middle, and the performers as well as the microphones and loudspeakers are placed around the audience. There is no central point of focus for the performance, since the instrument cannot be localised; the instrument is everywhere, and the audience is situated "inside" this musical instrument. The instrument is gradually allocated a certain spot in the performance space. In *Pendulum Music* the set-up is limited to a more stage-like situation, with the three pairs of microphones and loudspeakers serving as the main focus. The audience no longer sits in the middle of the performance, but in front, facing it. In the pieces that follow, the object used to generate input for the microphone is also the site where the shaping of the sound begins. All pieces that use amplification with the help of contact microphones exhibit a clear start and end point in the sound-shaping process. Since the audience is always confronted with the end points (the sound emitted by the loudspeakers in the performance space), they are placed "outside" the musical instrument. In *Nodalings* the line of amplification is closed again into a circle through the act of connecting loudspeaker and microphone to the same material. The distance from the audience remains,

however, since the audience is situated "outside" this musical instrument. The circle of feedback takes place this time within an object instead of in the whole performance space.

Some remarks on the materiality of microphone and loudspeaker diaphragms

Using a solid material as diaphragm for a microphone and loudspeaker is closely related to the tuning fork oscillator and the Dieckmann-piano system, in which a piano string is involved in the functioning of both microphone and loudspeaker (see chapter 3). When a microphone and loudspeaker are connected to the same object, this material serves both as a sound shaper as well as a sound diffuser. Characteristics of these kinds of diaphragms evidently are not aligned with the ideal characteristics of diaphragms used for approaches that form part of the tympanic principle (*reproducing, supporting and generating*), since the loudspeakers used for the latter principle should be in general neutral transmitters of sound. With feedback through an object, I am once again returned to the tuning fork principle. The material shapes and radiates the sound.

Probably one of the most important questions regarding music which uses the *material* of the microphone and loudspeaker diaphragm as a starting point is how the audience perceives this *material*. When listening to a sounding object like a violin, a piano or metal bowl, we have some awareness of the nature of the material that is involved in producing the sound as well as the technique used to produce the sound, owing to our experiences with sound. We have learned how strokes on metal, a bowed string or a breaking glass sound. What makes recognising sounds even easier during musical performances with conventional musical instruments is the possibility to also see what causes the sound. As discussed in chapter 2, any sound can, theoretically, be transmitted by loudspeakers. There is no sonic expectation raised through the sight of a loudspeaker, as the situation with a piano. In the pieces discussed so far which use *material* as the main parameter of variation, actions of the performers often reveal relationships between material and sound. Contact microphones are used to pick up the vibrations of the material and diffuse them through the loudspeakers. But what if there is no performer bringing the material into vibration? How can we hear that it is the material which is influencing the sound, when a loudspeaker can, in theory at least, reproduce every sound? In the following, I look at how this problem is solved by several artists working with the *interaction* between loudspeakers, sounding material and the audience.

Material 5: every loudspeaker a different voice: *Rainforest* by David Tudor

Acoustic feedback through objects thus forms what one might term a closed circle, initiated at some distance from the audience. To bring this musical instrument closer to the audience again,

as was the case in Davies' *Quintet*, a solution might be to open the circle. This is done in the project *Rainforest*⁷⁵ by David Tudor*. A line is developed which extends beyond the feedback circle. The pieces by Lucier, Wellmer and Stockhausen opened the feedback circle through the act of inserting a sound source in between microphone and loudspeaker. In *Rainforest* the connection between driver and contact microphone, instead of the connection through air between microphone and loudspeaker, is opened. Rather than adding a sound source in the performance space, Tudor constructs elements of variation in the electrical signal and opens the feedback circle between microphone and loudspeaker instead of between loudspeaker and microphone.

Rainforest is clearly based on *interaction* between loudspeakers and all kinds of *material*. Tudor describes the aim of his project *Rainforest* in the following words: "[...] what I would like to do would be to make an orchestra of loudspeakers all having different "voices" which would all receive a common input" (Fullemann and Tudor 1984). Developing loudspeakers which are as unique as any musical instrument was one of his main aims for this project (Driscoll and Rogalsky 2004, 26). To achieve this he attaches all kind of different objects to the drivers, resulting in one-of-a-kind loudspeaker sculptures. *Rainforest* performances are the creative sound-generating result of workshops in which many artists participate. Every participant has made his or her own loudspeaker sculpture during a preceding workshop. The sculpture should reveal its resonating characteristics, made audible through the vibrations of the driver. Once again, the various objects used in the loudspeaker sculptures filter the sound. Certain frequencies are radiated much more strongly, and others much more softly, by the sculpture in response to the driver. John Driscoll*, who took part in the first performance of *Rainforest IV* in 1973, describes this influence by the sculpture on the sound: "The resonance nodes of the sculptural speaker contribute to what is heard as much as do the original sounds and in some cases influences the result even more. It is possible to input a sound that is unrecognizable coming out of the sculpture" (Driscoll and Rogalsky 2004, 29). Regarding the input sound, everything, with the exception of pre-recorded material, was allowed. The tactile transducer's input is no longer connected to the microphone input, as is the case in *Nodalings*, but in the form of an electrical signal, which is shaped by the participating artists. Material for loudspeaker sculptures could be almost anything, and consisted of objects found by trial and error in a search for "good" resonances. Examples of material used during a performance in 1973 are a metal bedspring, a huge wine barrel and a Styrofoam box (Driscoll and Rogalsky 2004, 29). These loudspeaker sculptures were amplified using contact microphones. The result would be played through "neutral" loudspeakers, that is to say, loudspeakers that would add the least colouring

⁷⁵ I would like to discuss all *Rainforest* pieces here as being a continuum. As Matt Rogalsky* underlines, the *Rainforest I-IV* pieces (1968-1973) and also the piece *Bandoneon!* (1966) and *Forest Speech* (1976-79) can be seen as a part of the same project. The title of the piece is coming from the title of a Merce Cunningham choreography *Rainforest I* was commissioned for (Driscoll and Rogalsky 2004, 25-26).

possible (thus functioning according to the *supporting* approach). The performance of *Rainforest* includes therefore not only the sounding sculptures, but sonic images of these vibrating sculptures as well, diffused by loudspeakers from another area of the performance space (see video *Rainforest*). As Tudor formulates:

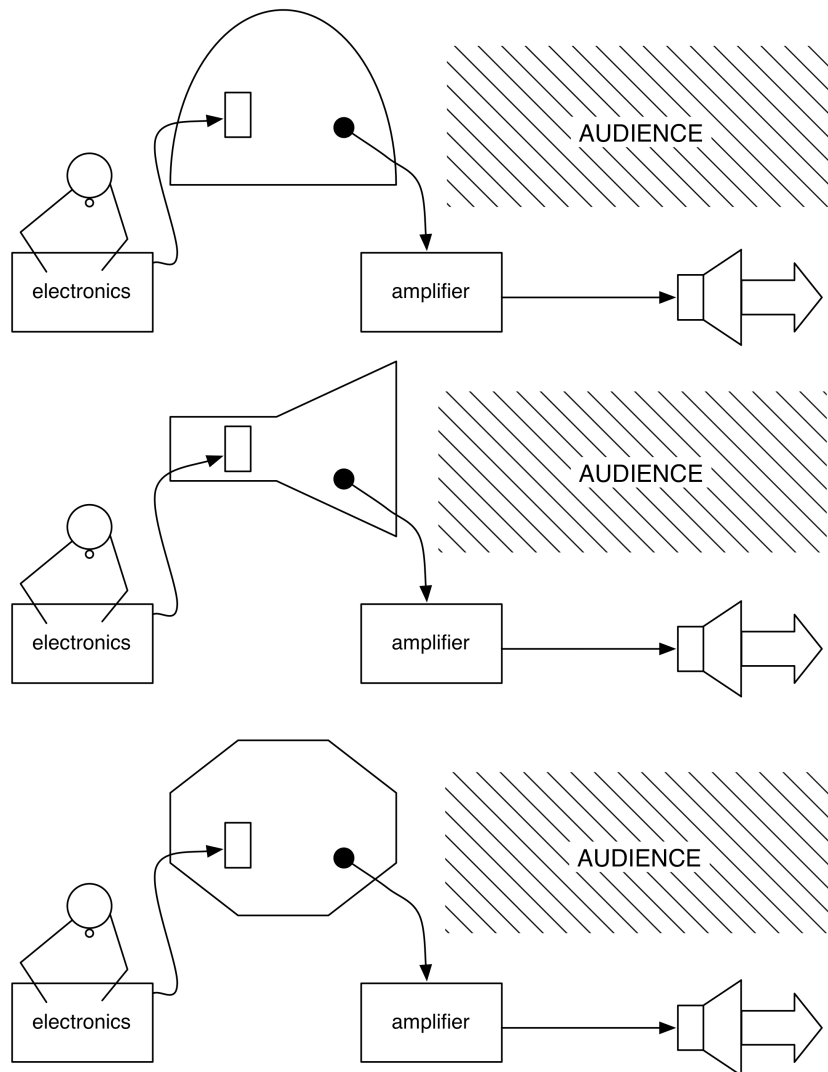
the purpose of the contact mike is to take the resonant frequencies which you hear at best very close to the sounding object; to take those into an ordinary loudspeaker which you can consider not as auxiliary but as enhancement. What that does when you establish the proper tonal balance is that you've got a reflection of the sound which you can distance in space (Fullemann and Tudor 1984).

In this manner *Rainforest* uses both a point of radiation (the loudspeakers prepared with objects) and a line of amplification (from the contact microphones picking up the vibrations of the loudspeakers to the "ordinary" loudspeakers). Tudor professes to search for loudspeaker sculptures which are as unique as any musical instrument. Their unique sound should not be forced upon them by the performer or instrument builder, as is the case for conventional instruments; the loudspeaker sculptures should themselves decide what sound they "want to" produce. Tudor is not only giving the loudspeakers their own voice, but also seeking to give them the freedom to discover this voice for themselves. The loudspeakers might be thought of as musicians, playing the objects and finding the resonances of the objects. Tudor wants the objects to reveal their own resonant characteristics, rather than to be used as instruments to be played manually. As he said in an interview in 1972, one year before the big *Rainforest IV* performance: "I try to find out what's there—not to make it do what I want, but to release what's there. The object should teach you what it wants to hear" (Collins 2004, 1). The human performer therefore no longer functions as an interpreter, but much more as a listener who carefully attends to what the object can teach him or her.⁷⁶ The performer's attitude here is similar to that of the viola

⁷⁶ The search for these kind of resonances through the objects has been described in detail by artist Bill Viola, who took part in *Rainforest* workshops and performances as a student. David Tudor introduced the basic principles of the piece to the students during the workshop. Tudor used a simple sine wave oscillator that emitted a sine wave through the loudspeaker without diaphragm. He began with a very low frequency and performed one long glissando increasing in frequency. The object excited by this loudspeaker would respond to certain frequencies by vibrating and rattling, and the result was a much more complex sound, containing many more frequencies than the sole, initiating, sine wave. At other frequencies, however, the object would react by simply reproducing the sine wave (Viola 2004, 48). What Tudor revealed with this simple experiment are the nonlinear response potentials of the objects used and the wide disparity in vibratory reaction, according to the physical characteristics of the objects. Every object will evidently react differently to the oscillator frequencies, since they all have differing resonating properties. To discover the sounds that were "asked" for by a certain object, many experiments with different kind of audio signals were conducted by the *Rainforest* participants, until they came across the sounds that they felt suited the object best. The participants often looked for atypical ways of connecting the loudspeakers to the object in order to cause unexpected resonances. One example of this is the connection of two out-of-phase loudspeaker coils to a single object, thus engendering peculiar vibrational patterns (Driscoll and Rogalsky 2004, 28).

player in Wellmer's *Green Piece*. The violist does shape the microphone input, however, whereas in *Rainforest*, the performers are shaping the loudspeaker output,

Rainforest is an example of a piece in which the material is not brought into vibration through direct contact between performer and objects, as was the case, for example, with the performances by Maly, Neumann or Oliveros. There are several reasons, however, as to why I identify the loudspeakers in *Rainforest* as not being "neutral" loudspeakers but as what might be called "prepared loudspeakers". First of all, since the audience is allowed to walk through the performance space, they will be able to trace the different sounds to the different loudspeaker sculptures. At the same time, Tudor is even more involved with the way the sound produced by the loudspeaker sculptures is apprehended by the audience: during this performance the audience is encouraged to interact directly with the loudspeaker sculptures. They are allowed to walk among and to interact physically with the sculptures by placing their ear against them, taking them in their hands, using a stethoscope or even biting into them (Driscoll and Rogalsky 2004, 28). The tactile sense becomes an important part of the perception of this performance. Instead of only hearing the sounds, with the membrane of the ears as interface, the vibrations are now perceived as well by the skin and teeth as well. Owing to the direct tactile perception of the sound vibrations, a kind of listening independent of any use of the tympanic membrane of the ear can take place.

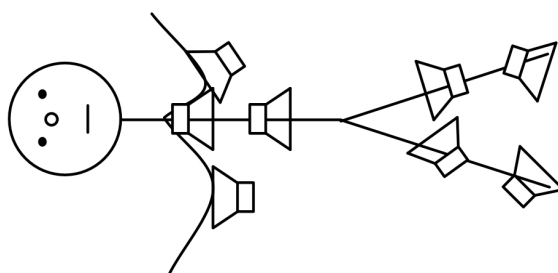


David Tudor *Rainforest*: an electronic signal is emitted by a tactile transducer. The tactile transducer brings an object into vibration. These vibrations are picked up by a contact microphone and diffused by an "ordinary" loudspeaker.

Material 6: the audible becomes feelable: *Aptium* by Lynn Pook, and Merzbow

When the audience in *Rainforest* perceives the vibrations of the loudspeaker sculptures through the act of touching them, what role does the audience then play in the musical performance? In fact they become prolongations of the loudspeaker-instrument, since by touching it they alter the vibrations of these objects; the audience is touching the extended loudspeaker diaphragm. Lynn Pook* has utilised this physical connection between loudspeakers and audience members in an even more radical manner. In her work, the vibrations of loudspeakers are no longer

communicated in the form of air pressure waves at all, but rather as mechanical vibrations on the bodies of the audience members. Due to bone conduction, the vibrations are transmitted directly to the inner ear. Pook seeks to reduce the distance between the sound of the performance and the body of the audience. In her work *Aptium* (2004) the music performance is given for one audience member only. The visitor is invited to lie in a hammock equipped with several loudspeakers. The loudspeakers in the hammock are in contact with the back of the audience member, and several other loudspeakers are attached to places of the body well suited for bone conduction, such as elbows and knees. The vibrations of the loudspeakers are thus only audible for this specific audience member (see scheme *Aptium*). The connection between loudspeaker and body is uninterrupted, since the loudspeaker literally touches the listening body. Pook calls this an audio-tactile experience (Pook 2012, no page numbers).



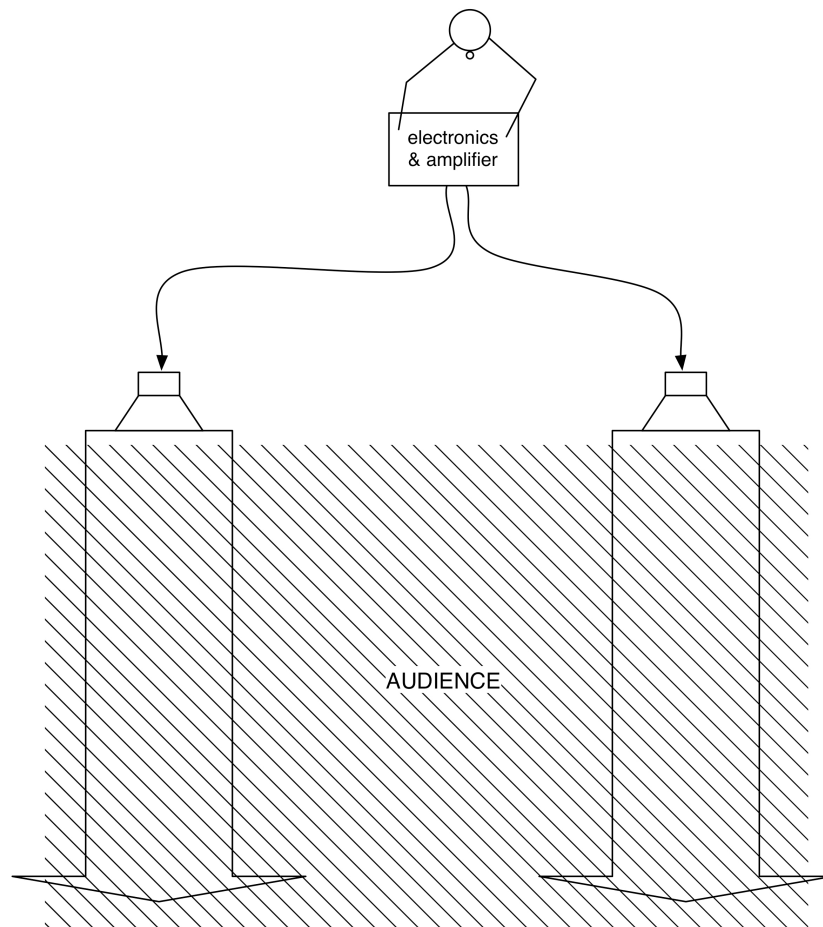
Lynn Pook *Aptium*: small loudspeakers are attached at several points of the body of the audience member. An electro-acoustic composition is diffused through the loudspeakers, perceptible for the audience member through bone conduction.

Similar to the way a contact microphone picks up sound, listening through bone conduction is very localised: the knee can receive the vibrations for a certain sound, whereas at the same time the elbow is excited by completely different frequencies. All these frequencies become audible for the audience member through bone conduction to the skull, which transfers the vibrations directly to the inner ear. The same sound would be conveyed differently from another part of the body, since the different bones resonate at different frequencies. The conceptualisation of human listening, with the ear as its primary organ, has served as the model for the *tympanic principle*, as I argued in the last chapter. But as demonstrated in *Aptium*, the ear itself is already "tuned": our tympanic membrane and all other parts of the ear (the outer ear of every human being is shaped uniquely, for example) do not resonate linearly at all frequencies. For this reason, the ear itself

cannot be seen as the perfect embodiment of the tympanic principle. The listening human body is unable to perceive anything other than its own vibrations, whether these are produced by the tympanic membrane of the ear or by bone conduction through the whole body. In this performance by Pook, the audience member might be regarded as taking the place of the object attached to the loudspeaker in *Rainforest*. The audience member has to touch the musical instrument, and in a way seems to even become a part of the musical instrument, in order to experience the musical performance—a situation uncommon in musical performances with conventional instruments.

Feeling sound vibrations, as in *Aptium*, is of course also experienced during rock concerts, due to the very high amplification of bass frequencies, and can be encountered in an extreme form in noise music. The music of Merzbow* is not only audible, but tangible as well. Staging performances in small spaces with enormous sound volumes creates standing waves of low frequencies that fit in the performance room (Hegarty 2007, 142). The performance space itself thus functions as a large resonator. These low frequencies are amplified to such an extent that the movements made by the diaphragms of the loudspeakers produce airwaves powerful enough to cause the clothes of the audience to vibrate (see scheme *Merzbow* and listen to audio example *Degradation of Tapes by Merzbow*). These vibrations are tangible to the audience's bodies and create the impression of engaging sound in fluid form. The audience experiences what they express as being "really touched" by the sound (Friedl 2002, 30). Here again, the bodies of audience members are put into vibration, this time not through direct physical contact with the resonating material but through very powerful air pressure waves. The material exposed in these kind of performances is neither the sonic qualities of physical objects (as with Tudor's *Rainforest* performances) nor the conductive properties of the body of the audience member herself (as in Pook's *Aptium*) but the *material* of sound itself: air pressure waves, often only perceptible by the ear, now become tangible. In a very restricted way, the loudspeaker reveals its own function: causing air pressure waves.

The pieces by Tudor, Pook and Merzbow reveal that sound perception itself is related not only to the sense of hearing, but is also connected directly to our tactile sense. The *material* aspect of sound is (re)discovered by the experience that, when we are listening, our whole body is resonating. The *interaction* does not take place anymore between performer and loudspeaker, but the audience members themselves *interact* directly with the loudspeaker sound to discover what *material* is sounding. Whereas musicians are commonly the only ones who touch their instruments, the audience is now allowed or even forced to be touched by the sound, which reveals itself through body parts other than the ear membrane. Also based on points of radiation, these pieces differ from *Speaker Swinging* by Monahan and *Three Short Stories and an Apotheosis* by Lockwood owing to their focus on the audience's body. There is no change in distance, neither is there any movement of the sound-emitting object. Instead of treating the musical instrument



Merzbow: due to performing with very high volume levels and low frequencies, the air pressure waves become feelable for the audience.

as a limited object, these set-ups have no clear borders between musical instruments and audience members. In the works by Monahan and Lockwood, the locations of sound emission are constantly changing due to the motion of the loudspeakers; because of the audience's capability of localising the sound-producing object in the performing space, the object-character of the loudspeakers used is underlined. The audience experiences these loudspeakers as being points in space, outside of their own body. The pieces by Tudor (when the sculptures are actually touched by the audience), Merzbow and, especially, Pook are characterised by transferring the sound wave vibrations onto the body of the audience. The skin of the human body seems to become itself a membrane that is brought to vibration. Contrary to set-ups using contact microphones as well as the moving loudspeakers, the audience does not remain outside the set-up; neither are they located inside the set-up. Instead, the audience is a part of the set-up.

SPACE

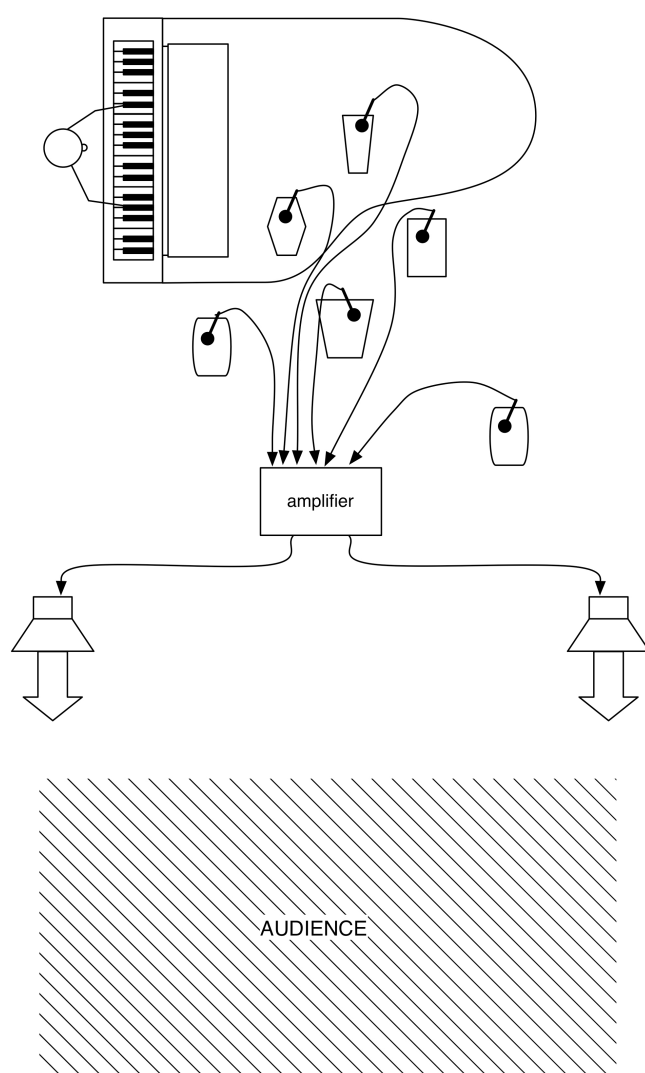
The Merzbow performance makes clear that sound touches objects, in his case human bodies, at a distance. Sound itself is influenced by the human bodies perceiving the sound as well as by all other material the sound waves are meeting. Musicians notice the acoustic difference between rehearsing in an empty concert hall and performing in the same hall filled with the sound-absorbing bodies of the audience members. Sound waves are travelling through space and therefore *interacting* with this space. There is a constant interaction between microphones and loudspeakers, the sound waves they emit and pick up, and the space they are placed in. *Space* is therefore the third parameter, after *movement* and *material*, that I consider here.

Space 1: interaction between microphones and small spaces: *Music for piano with amplified sonorous vessels* by Alvin Lucier

In the piece *Music for piano with amplified sonorous vessels* (1990), Alvin Lucier puts microphones into different vessels, such as wine glasses, seashells and bamboo cups. These objects are placed close to or inside a grand piano so they can pick up the sounds that are played on it (see scheme *Music for piano with amplified sonorous vessels*). These vessels resonate at certain frequencies according to their shape (similarly to the resonance frequencies heard when blowing on a bottle). These resonance frequencies are picked up by microphones that are inserted into the vessels and subsequently amplified through loudspeakers. Every microphone renders a different sound of the piano, coloured by the resonant properties of its vessel. The vessels often resonate at slightly different pitches than the frequencies played by the piano. This creates audible beats resulting from the interference between the amplified slightly "out of tune" frequencies from the vessels and the piano tones (Lucier, Kleeb, and Dahinden 1997, no page numbers). Now the various simultaneously resonating bodies become audible. Normally the strings of a piano are amplified by means of the instrument's own resonating soundboard; with this set-up the multiple vessels take over the function of a soundboard, and an unusual instrument is created with one point of excitation, namely the piano string, which resonates through several small bodies (the vessels).

Changing the sound of a piano is often accomplished by placing all kinds of so-called preparations, such as screws, in between the strings. This piece by Lucier should not, however, be considered a composition for piano with some (quite elaborate) preparation. The main set-up is formed by the combination of the piano with the microphones in the vessels—which may be viewed as small reverberating spaces—functioning as resonators. The microphones in the vessels here fulfil a function similar to that of the resonant body of conventional musical

instruments: they are clearly shaping the sound, since the audience knows how a "normal" piano sounds and will recognise the resonances added through the amplification of vessel frequencies by microphones (listen to audio example *Music for piano with amplified sonorous vessels* by Alvin Lucier).



Alvin Lucier *Music for piano with amplified sonorous vessels*: the resonance of the piano sound in different kind of vessels is picked up by microphones. The signal of these microphones is radiated through loudspeakers.

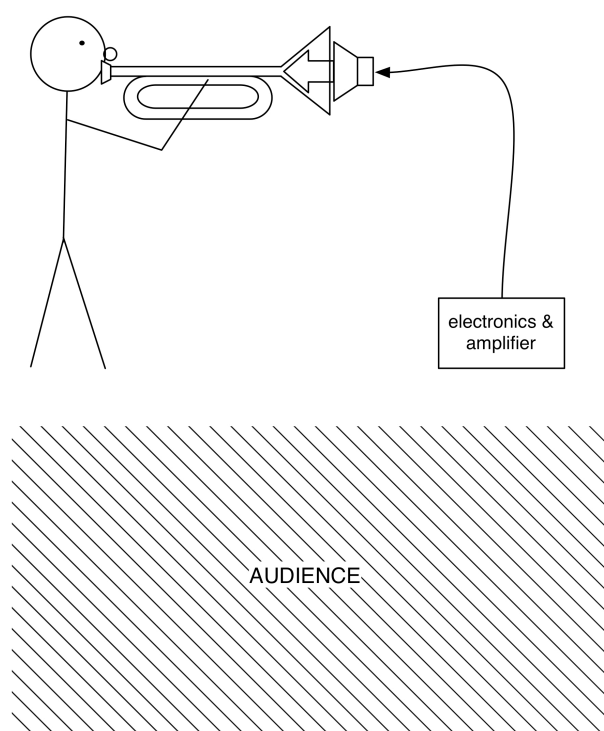
This piece is based on lines of amplification, which all begin from the same origin, namely the piano, but all seem to end at, and thus emit sound from, another location. These lines are no longer attached to the material, either by contact microphones or by drivers. The microphones are prepared with objects, similarly to the loudspeakers of *Rainforest*. This preparation is not accomplished by connecting objects to the diaphragm, but by placing the microphones inside different objects, vessels in this case. It is not the vibrations of the *material* of the vessels that are picked up by the microphones, but the vibrations of the air in the vessels, of the *space* inside. Whereas in the pieces by Tudor, Pook and Merzbow the body of the audience formed part of the material set-up, in *Music for piano with amplified sonorous vessels* the audience is outside once again. The sounds interact with different spaces, but the audience perceives these spaces from a position outside of the set-up itself.

Space 2: interaction between loudspeakers and small spaces : Loudspeakers in brass instruments and focused loudspeakers

In a comparable manner to Lucier placing microphones inside vessels, loudspeakers have also been put in small spaces to evoke colourations of the sound they diffuse. It has become common practice for brass players, for example trumpet player Birgit Ulher* or trombonist Hilary Jeffery*, to use a loudspeaker to project sound inside the bell of their instruments. Instead of a mute, which changes the sound colour of the instrument, a small loudspeaker is placed inside the bell, and the sound emitted by the loudspeaker is coloured by the resonances of the construction of the brass instrument (see scheme *Loudspeakers in brass instruments*). Moving the loudspeaker in and out of the bell again changes the colour of the sound coming from the loudspeaker (listen to audio example *Birgit Ulher*). An early example of this kind of playing technique can be found in the piece *Acustica – für experimentelle Klangerzeuger und Lautsprecher* (1968-1970) by Mauricio Kagel* (Kagel 1970). Both a trumpet and a trombone use so-called loudspeaker mutes.⁷⁷ When a loudspeaker is used as a mute for brass instruments, in this set-up the loudspeaker could be regarded as a point of radiation. In this case, in contrast to the other examples with conventional musical instruments I described earlier (Wellmer's *Green Piece*, Stockhausen's *Mikrophonie I*, Neumann's *Inside Piano* and Lucier's *Music for piano with amplified sonorous vessels*), the sound of both musical instrument and loudspeaker are altered by moving the loudspeaker in and out of the bell. In all other pieces the musical instrument was the starting point of the line, ending at a loudspeaker emitting the sound. As a result of these necessarily synchronous changes, the sound

⁷⁷ Kagel uses a variety of techniques that transform the loudspeaker and microphone into musical instruments. In *Acustica*, Kagel asks for a microphone placed inside the mouth (Kagel 1970, 74–75). Kagel mentions as well in the score that the diaphragm of the loudspeaker should be "prepared" with all manner of small objects, such as marbles, paper-clips and tissue paper (Kagel 1970, 74–75).

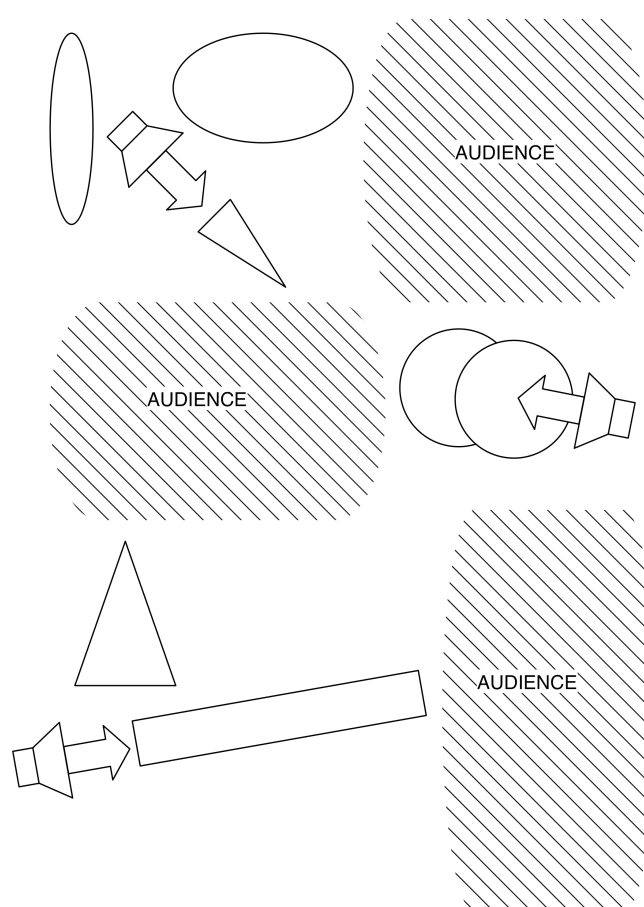
emitted by the loudspeaker and the sound of the trumpet are strongly connected to each other: when the loudspeaker sound is muted, the trumpet sound will be muted as well.



Loudspeakers in brass instruments: a small loudspeaker is used as a mute for a brass instrument. By moving the mute the sound diffused by both trumpet and loudspeaker is modified.

Another way of influencing the sound emitted by loudspeakers was researched by the group *Composers Inside Electronics* in 1977 (Driscoll et al. 2012). The participating group members, who had met at a workshop on David Tudor's *Rainforest*, were Tudor himself, Martin Kalve, Ralph Jones and John Driscoll*. Their aim was to develop loudspeaker objects which would have maximum directional characteristics, and which therefore would be easily localisable in space. Instead of using the kind of phantom sources between the loudspeakers which are characteristic of stereophonic technology, the aim was to make distinguishable sound sources out of the loudspeakers themselves. By mounting all kinds of objects like horns, plates or parabolic structures around the loudspeaker, the sound is projected in a single direction instead of being emitted in all directions (see scheme focused loudspeaker research). Since all of the

collaborators on this project had worked on *Rainforest* it is no surprise that these set-ups look like a deconstructed *Rainforest* loudspeaker sculpture. The objects used to modify the sound, such as horns and tubes, are related to the construction of acoustical wind instruments. These forms are advantageous as resonant spaces for air pressure waves. Driscoll in particular continued to use these kinds of loudspeakers in his performances and installations.



Composers Inside Electronics focused loudspeaker research: the radiation characteristics of loudspeakers are modified by adding objects like horns, tubes and lenses.

This research project on focused loudspeakers underlines the difference between common scientific acoustic research and artistic research. In acoustics it would be possible to calculate the characteristics of the loudspeakers, the sounds they diffuse and the influence on the sound waves caused by the added elements (horns, tubes, plates and so on) as well as by the performance space itself. This would generate an enormous amount of data, without however

bringing to light any relevant information which might be useful for a musical composition. It would be also very time-consuming to calculate all the aforementioned possibilities, and as soon as an object would be changed, the calculation would have to be done again. The goal of research projects like this one on focused loudspeakers is not a calculable outcome, but to discover previously unknown possibilities of composing sound. Composers may then make musical decisions based on an auditory assessment of the influences made by the various objects on the sound of the loudspeakers. By trying out different objects in different positions, the artist gains knowledge much more rapidly about what kind of set-up might be useful, than when conventional acoustic calculations are employed. This aspect of research through practice is an important element in many of the pieces I discuss here, in contrast, for example, to the procedure for developing a technology like Ambisonics, in which the intention is to reproduce an image of a sound field. This kind of technology is typically based on mathematical calculations instead of artistic empirical decisions and using neutral loudspeakers, all diffusing sound waves in a very similar way.⁷⁸ The focused loudspeakers are build to create each a specific spatial effect, and thus all radiating their sound differently.

Some remarks on spatialisation with loudspeakers

Commonly, when referring to space in relation to microphones and loudspeakers, what is intended is not so much the kinds of small spaces in the examples mentioned above (vessels, brass instruments or horns and tubes), but instead "spatialisation" techniques which, especially in electroacoustic music, are used to diffuse sound throughout the performance space. Over the last 80 years many forms of loudspeaker-based sound spatialisation have been developed, an early example of which was a concert in Berlin in 1930 where Paul Hindemith's *7 Triostücke für 3 Trautonien* was performed with a separate speaker for each instrument, suspended in the middle of the hall above the audience. Apart from such incidental experimentation in concert with loudspeaker spatialisation in the first half of the twentieth century, the movie industry also developed several sound systems which could project sound in space, one of the first being Fantasound developed for the movie *Fantasia* (1940) by Walt Disney, which was intended to function as an orchestra concert in the cinema, so that good sound quality was extremely important. The conductor Leopold Stokowski not only conducted the piece, but was engaged in the production process as well. During the premiere in Broadway Theatre in New York, 90 loudspeakers were placed throughout the room to offer the possibility of projecting the sound from different directions (Kletschke 2011, 74).

⁷⁸ This does not imply though, that artistic research is not possible with Ambisonics technology, it is just not possible to develop the system without relying mostly on acoustic research. Applications of the system can of course be subjected to artistic research.

Most of these spatialisation systems using loudspeakers either focus on kinds of spatialisation which could not naturally exist (this is often the case with systems like Ambisonics and Wave Field Synthesis), or try to copy known spatial sound situations (often realised with a stereophonic sound system for the living room and the 5.1 surround sound system for the cinema). These kinds of spatialisation systems are consequently related to the *generating* and *reproducing* approach: the loudspeakers should not be audible, and virtual spaces which have no relationships with the loudspeakers are generated. The spatialisation in these systems takes place before the sound is emitted by the loudspeaker. There is no *interaction* between loudspeaker and performance space. On the contrary, often the loudspeakers are placed in a set-up that avoids this kind of interaction as much as possible, being placed, for example, symmetrically in a circle, all at the same distance from the audience. The air pressure waves are radiated as directly as possible towards the audience, avoiding as much as possible any influence of the performance space on the sound. The loudspeakers should *generate* or *reproduce* a spatial image in this set-up. Although these spatialisation systems are very interesting and inspiring (*generating* new spatial experiences in sound especially is very challenging for composers, due to the "inaudible" loudspeakers in those systems) I will not discuss these systems here in more detail, since they do not belong to the *interacting* approach.

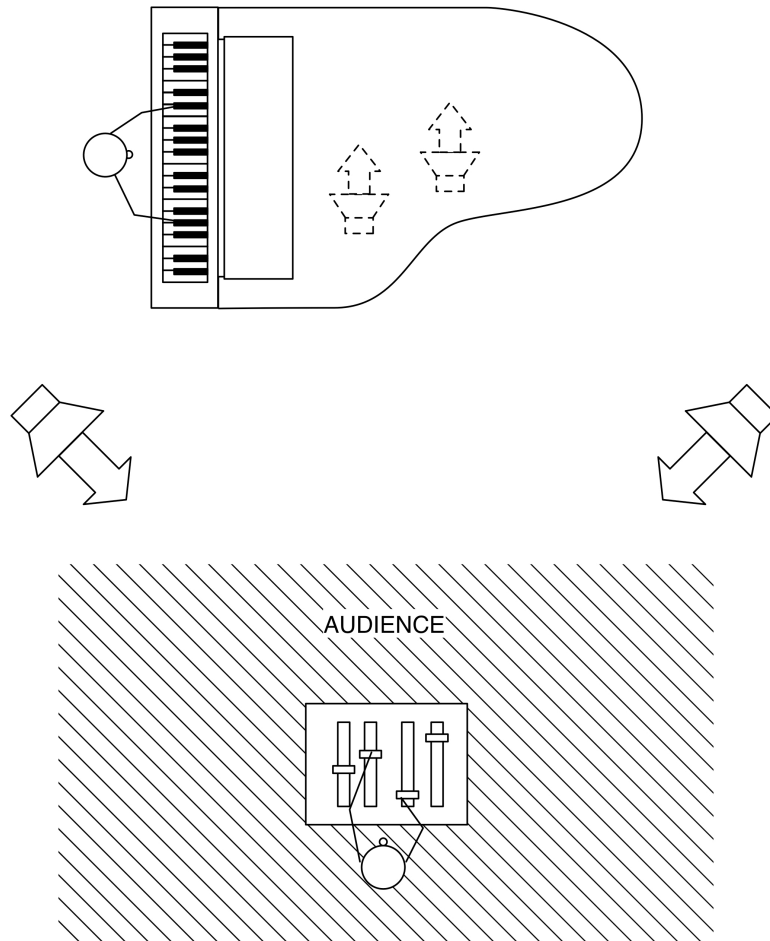
Space 3: interaction between loudspeakers and performance space:sofferte onde serene... and Guai ai gelidi mostri by Luigi Nono

As is the case in both the *movement* and *material* parameter, the *space* parameter offers the additional possibility of positioning the audience inside or outside the set-up. Sounds emitted by loudspeakers may be shaped not only by small objects but also by the performance space itself. Luigi Nono* was interested in exploring the different spatial qualities of sounds, and an important element of many of his compositions is the placing of sounds in order to reveal these spatial qualities, of both the acoustic space and the sound as it changes. These changing spatial qualities in the sound should not be confused with changes in its location of the sound. Spatial changes in Nono's work are not simple sound movements, in which a sound moves from right to left or from front to back. These kinds of movements are most easily achieved without any interaction between loudspeakers and performance space, for example by means of the Ambisonics technology. Nono was very keen on placing the loudspeakers in such a way that a change in the positioning of the sound emission also meant a change in sound quality. This implies that the loudspeakers should all have a different relationship with the concert hall they are placed in, so that each loudspeaker has its own way of radiating sound. Contrary to systems that ask for inaudible loudspeakers, Nono's music proposes that loudspeakers should be in dialogue with the concert hall. Many of the loudspeaker set-ups devised by Nono involve these

kinds of relationships between loudspeakers and space, and all of the spatialisation set-ups used in his work shape the final sound result.

A good example of this method is *.....sofferte onde serene...* (1976), for piano and tape. As described in the score, two small and two large loudspeakers should be used to play the monophonic tape. The two large loudspeakers should not be pointed directly at the audience, but should first radiate their sound to the wall or ceiling of the concert hall. Instead of coming directly from the loudspeakers, the sound will seem to come from the walls and ceilings of the performance space. As described in the score by Alvise Vidolin*, who assisted at many of Nono's performances, these loudspeakers should be used to "highlight separation and dialogue between the tape and the piano" (technical notes in the score of *.....sofferte onde serene...*, Nono 1992). The two small loudspeakers should be placed underneath or behind the piano in such a way that their sound is projected on the soundboard of the piano (see scheme *.....sofferte onde serene...*), causing the soundboard of the piano to resonate, and should be used for mixing the sound of the live piano playing with the sound of the tape. Decisions about where the monophonic tape signal should be sent—either towards the larger loudspeakers, towards the piano loudspeakers, or both—are made by the person "playing" the tape. There is no fixed score for the sound diffusion mix, since the loudspeakers will sound differently depending on the performance space and the piano used; for this reason, sound diffusion as well as loudspeaker placement should be adapted to their characteristics. As Hans Peter Haller*, who collaborated intensively with Nono at the *Experimentalstudio der Heinrich-Strobel-Stiftung des Südwestfunks* in Freiburg, mentions, the published scores by Ricordi do not reflect Nono's performance practice. Haller points out that the loudspeaker should be regarded as a musical instrument, constantly interacting with the concert hall (Haller 1995a, 100). The quality changes in spatialisation are audible, but there is no possibility of notating these as quantitative parameters for sound projection (Haller 1995b, 154).

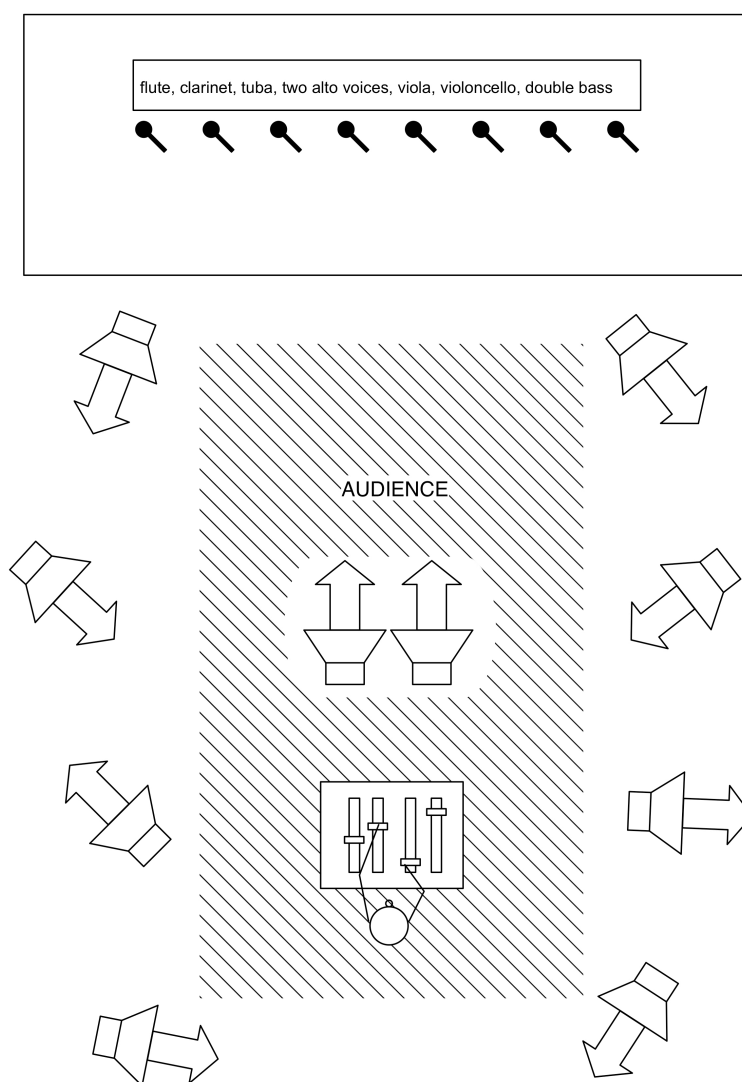
In the later works by Nono, developed at the Experimentalstudio in Freiburg, the use of multiple spatial perspectives of a single sound undergoes further evolution. *Guai ai gelidi mostri* (1983) is written for flute, clarinet, tuba, two alto voices, viola, violoncello, double bass and live electronics and uses ten loudspeakers. The instruments and voices on stage are played live and their sound is simultaneously diffused in the concert hall, sometimes processed by live electronics. The live electronic processing schemes made for different concerts of *Guai ai gelidi mostri* demonstrate that this processing was changed for every concert and adapted to each performance situation (Vidolin 2006). Whether filters, pitch shifters or reverb were used was partially dependant on the interaction between loudspeakers and performance space. Evidently, the spatialisation of the sounds in a particular space, in combination with the specific placements of the loudspeakers, changed the resulting sounds. The live electronic processing was modified in response to these changes in sound due to the acoustics of the performance space.



Luigi Nono*sofferte onde serene*...: the tape in this piece is played through two loudspeakers in the hall as well as through two loudspeakers underneath the grand piano. The person at the mixing desk has to "play" the tape by deciding through which loudspeakers the tape is sounding.

Nono often utilises the indirect sounds of the loudspeakers, by placing two loudspeakers above the audience and pointing towards the ceiling in *Guai ai gelidi mostri*, for example. The voices are amplified through these two loudspeakers. As Nono mentions in his score, the aim of positioning the loudspeakers in this manner is that the audience members are unable to determine where the sound is coming from (Nono 1983, 112). In preparation for a concert, Nono and his colleagues experimented for hours, searching for the right position and diffusion direction for each loudspeaker in the concert hall (Haller 2003, no page numbers). Nono explicitly mentions in the score that the loudspeakers should be placed asymmetrically around the audience on different levels (Nono 1983, 112). The whole set-up of performers with their instruments,

microphones, all devices for the live electronics, loudspeakers and the concert hall are part of one large musical instrument.



Luigi Nono *Guai ai gelidi mostri*: the sounds of the musical instruments on stage are processed live and diffused on ten loudspeakers in the hall. The loudspeakers are positioned in such a way, that they emit their sound often to the walls or the ceiling. In this way they interact with the acoustics of the performance space.

I would like to examine the difference between changing an element at the starting point of the line of amplification or at the end point. To investigate these differences, Nono's set-up for a piece such as *Guai ai gelidi mostri* could perhaps best be compared with *Mikrophonie I*. Stockhausen makes changes close to the starting point of the line, through microphone movements, whereas Nono modifies the end of the line, through loudspeaker placement. In both cases, several sonic representations of the same instrument(s) are projected in space, altering the sonic perspective of the instrument(s). Both Stockhausen and Nono use live electronic processing such as filtering, reverb and pitch shifting in their pieces as well, but in comparing the two pieces and the effect microphones and loudspeakers have on the sound, I will exclude this aspect. In *Mikrophonie I*, changing the distance between the microphone and the tam-tam, or between the microphone and the object which sets the tam-tam in vibration, not only results in a louder or softer sound but also in a change in the frequency spectrum (commonly called sound colour), as well as in a change in the balance of direct and indirect sound. The loudspeakers in *Guai ai gelidi mostri* modify the sound according to their place in the performance space. Changing the loudspeaker through which the sound is radiated results in a change of localisation of the sound in space as well as a change of frequency spectrum. In *Mikrophonie I*, the sounds fade in and out not only in volume but also in sound colour—the sound of the tam-tam varies between sounding very close and very far away. In *Guai ai gelidi mostri* there are modifications in sound colour, as in *Mikrophonie I*, but also in direction—the implementation of and interaction with loudspeaker positions in space results not in a variation in distance between listener and sounding object (as is the case in *Mikrophonie I*), but rather in a less hierarchical variation between different sonic presentations. The audience's sonic perspective in *Mikrophonie I* is constantly changing, approaching or retreating from the tam-tam. In *Guai ai gelidi mostri*, the distance between audience and musical instruments on stage remains the same, but the musical instruments are heard in different acoustic configurations.

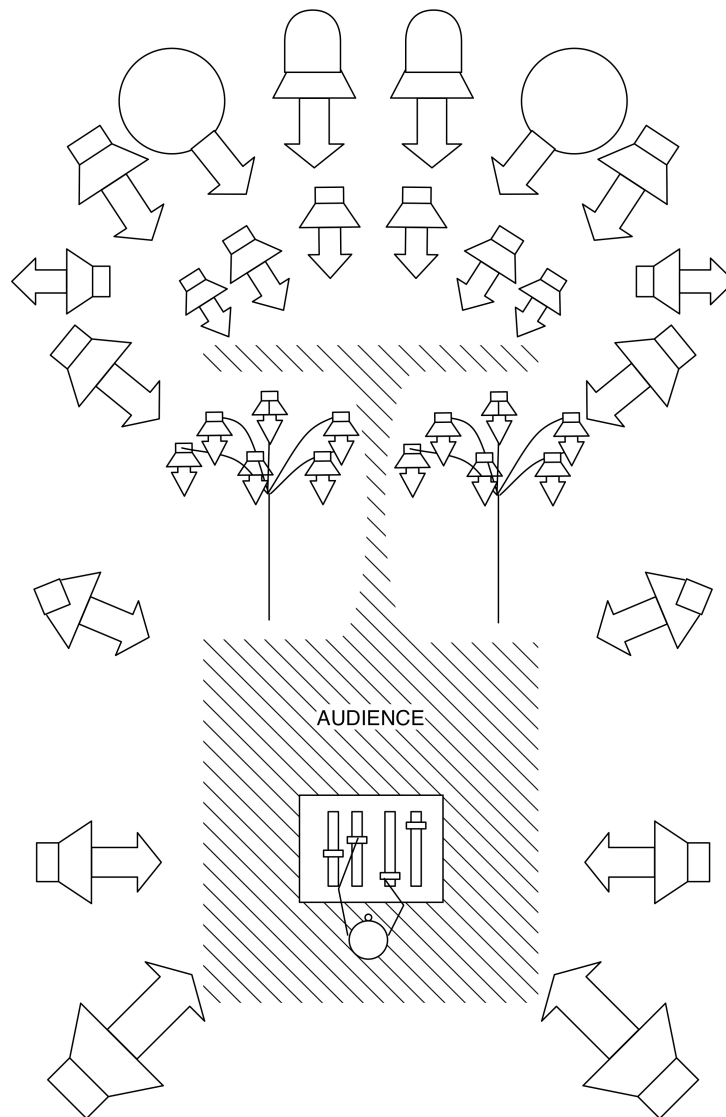
Space 4: loudspeaker orchestras: *Acousmonium* by François Bayle

Over the last 70 years many other experiments, apart from the work by Nono discussed earlier, have been performed to investigate the *interaction* between loudspeakers and performance space, one of them being the so-called loudspeaker orchestras. The first loudspeaker orchestra, called Acousmonium, was developed by composer François Bayle* in 1974. This consists of dozens of different loudspeakers, often as many as 80, arranged in the performance space in a symmetrical set-up, so that all loudspeakers come in pairs (see scheme Acousmonium). Many different types of loudspeakers are used for the orchestra, in contrast with, for example, Ambisonics or Wave Field Synthesis loudspeaker systems, in which all loudspeakers should be identical. The different loudspeakers comprising the Acousmonium all have their own individual characteristics, such as frequency range (there are for example special tweeter trees, which are

often placed among the audience), amplitude range, sound dispersion pattern, and so on. Some of the loudspeakers are pointed towards the audience, whilst others are pointed at the wall or the ceiling for a more "indirect" sound. Although the loudspeakers are distributed all around the audience, a sonic focal point is formed in front of the audience, as is traditionally the case in concert performances. Some of the loudspeakers are intended to reproduce all frequencies, whilst others are used for amplifying the bass (the subwoofers) or adding some extra reverb (such as the loudspeakers pointing towards the ceiling). The music composed for the Acousmonium is in stereo format and is mixed live during the concert by moving the faders controlling the volume of the different loudspeakers. This set-up, consisting of multiple points of radiation and the person performing the mix, thus produces a changing sonic output during the performance, depending on which of these points of radiation are active. Due to the combination of just two audio tracks and many different loudspeakers, manifold possibilities for diffusing the sound in space come into being. It is not only possible to move sound from one loudspeaker pair to another, but also to enlarge it by playing the stereo track back through several loudspeaker pairs (Teruggi 2005, no page numbers).⁷⁹

Composer Michel Chion* calls this live spatialisation of the stereo track the "espace externe" of the composition. The "espace interne" is the space which is already on the recording itself, for example how the sounds are placed in the stereo panorama or how much and what kind of reverb is used. This "espace interne" is fixed, whereas the "espace externe" changes for every performance, depending on, for example, the acoustics of the hall or the amount and kind of loudspeakers (Chion 1998). Performing two-channel works on the Acousmonium is therefore understood as performing an interpretation of the musical work. As a consequence, the same piece can be performed on the same Acousmonium but interpreted in a totally different way by using other loudspeaker combinations and changes in the spatialisation of the sound. The interpreter rehearses on the system and needs to know the piece he or she performs very well to be able to conceive a strategy for the spatialisation. The advantage of playing a piece on such a set-up is not only the possibility to "interpret" it, but to adapt the set-up of the Acousmonium differently to each space as well. For this reason, a composition written for this kind of performance practice can be performed on different Acousmoniums, consisting of a different number and different kinds of loudspeakers. Most set-ups I have discussed in this chapter are used only for a single piece, but the Acousmonium is intended as a universal instrument which can be used for all pieces written in the acousmatic tradition. Compositions for two channels by composers as divergent as Pierre Henry, Luc Ferrari, Christine Groult, Bernard Parmegiani and Åke Parmerud can all be interpreted using this system.

⁷⁹ Jonathan Prager has written a detailed account on Acousmonium performance practice (Prager 2012).



Acousmonium: an orchestra of loudspeakers is placed in the performing space. A two channel sound file is diffused on this system by an interpreter.

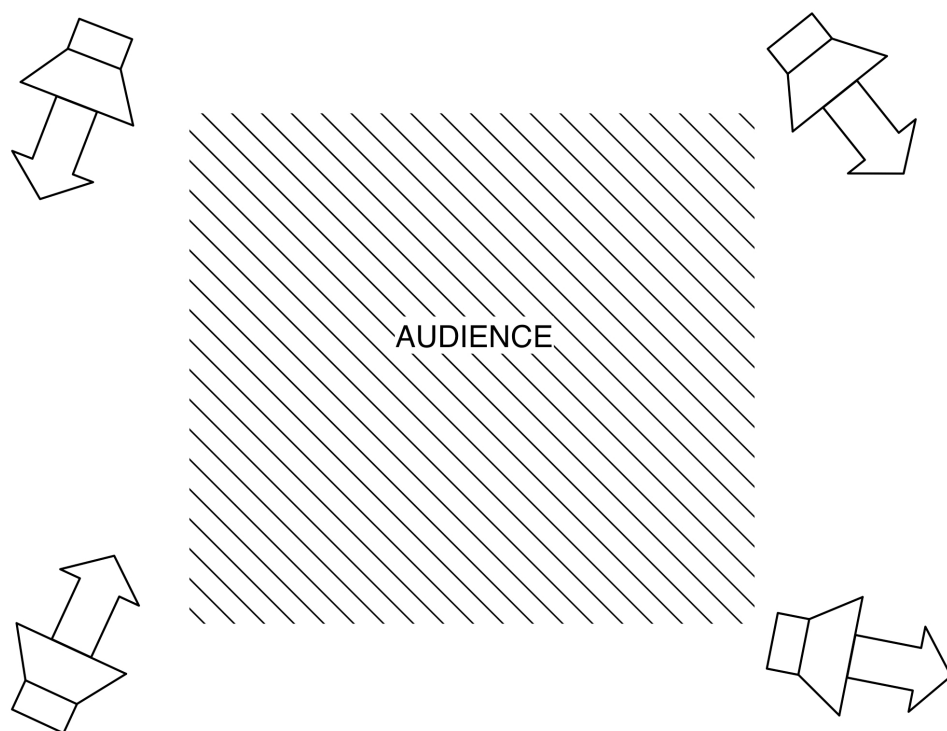
Space 5: sound unified in space and dispersed in space

Performances by Eliane Radigue and *Der tönende See* by Kirsten Reese

Regarding the potential of space in relation to microphones and loudspeakers, all the examples I have mentioned until now either use one or several closed spaces (vessels, brass instruments, horn and tubes), or acoustic spaces created through loudspeaker placement and/or loudspeaker type (Luigi Nono and the Acousmonium performance practice). Several examples of the use of the loudspeakers as a point of radiation have been mentioned during this chapter. While the use

of *movement* (swinging loudspeakers) or *material* (loudspeaker sculptures) as parameters for interacting with loudspeakers as points of radiation are quite exceptional, almost all music utilising loudspeakers must deal with the influence of the performance space on the sound emitted by the loudspeaker system. While for many systems (those discussed earlier, such as 5.1 surround sound or Ambisonics) it is considered best to try to prevent the performance space acoustics from influencing the sound diffused by the loudspeakers too much, many composers use the performance space as a part of their set-up. The next two examples should demonstrate to what kind of extremes sound can incorporate the performance space, and, conversely, how the performance space can incorporate the sound.

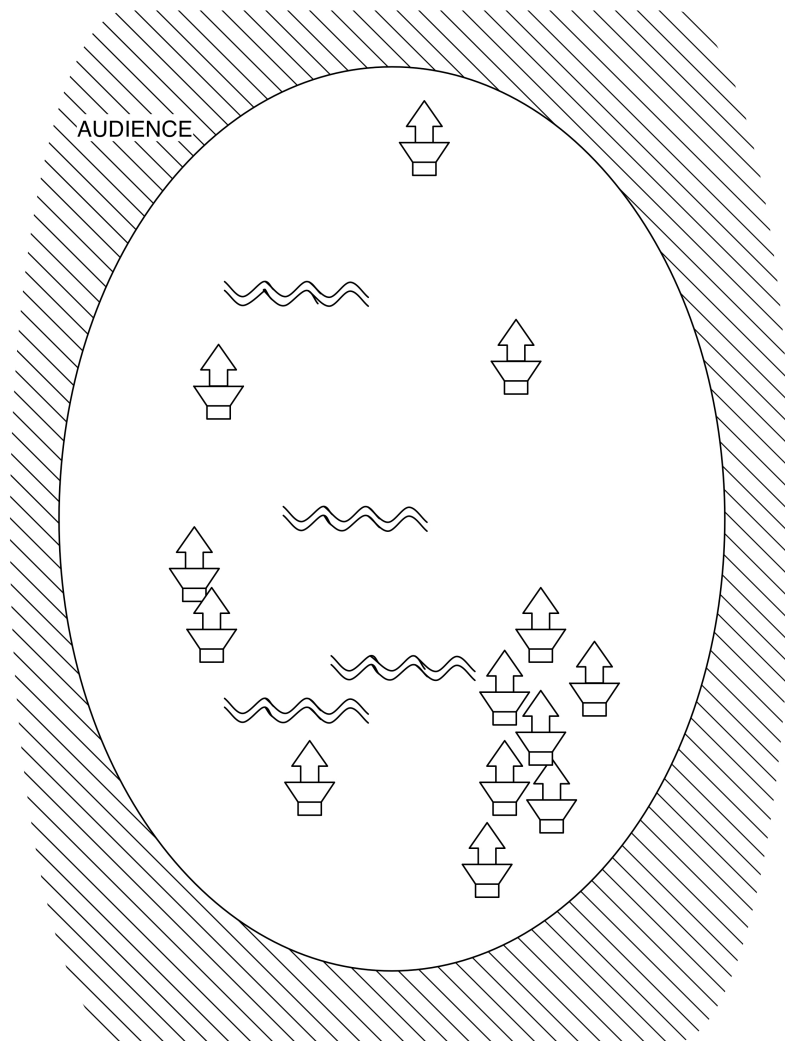
Eliane Radigue* uses only four loudspeakers and aims for diffusion of her music in such a way that the room is filled with sound like a "musical bath". Unlike the other works I have discussed up to now in connection with the relationship between microphones, loudspeakers and space, this music does not aim to create a clear sonic perspective. The spaces cannot be localised (as in Lucier's *Music for piano with amplified sonorous vessels* or the loudspeakers in the bell of a brass instrument, or the focused loudspeakers project), and neither are several acoustic spaces



Eliane Radigue: the four loudspeakers should be placed in such a way that the whole space is filled with sound.

revealed during the piece (as with Nono's compositions as well as the Acousmonium). In Radigue's work, centrally-located areas in the performance space should not sound any better than other places in the room. She uses a stereophonic tape, but sends the tape signal out to four loudspeakers in a cross set-up, so no real stereo image of the sound is reproduced. She points the loudspeakers in different directions according to the acoustic response of the room in order to avoid directionality of sound for the audience (Primosch and Swarowsky 2006, no page numbers) (see scheme Radigue). There is an interaction with the space, but this time it is not concerned with creating different spaces through which the sounds can travel, but the aim is to create a single sound bath, in which one can no longer differentiate between sound sources. The sound seems to be everywhere, and there is no longer any distinction between space and sound. The audience is inside the sound, and the diffusion of sound by loudspeakers could best be compared to the performances by Merzbow, although their differing performance aims result in two different performance practices. The main difference is in the volume of the sound. Due to the high amplitudes of low frequencies in Merzbow's performances, one has the impression that the sound itself has materialised in the performance space and is thus bringing the audience into vibration. The sound source seems to be everywhere. In Radigue's performance practice, sound seems to have dematerialised, since the sound is disseminated by the loudspeakers in such a way that there seems to be no starting point in the form of a sound source at all.

In *Der tönende See* (2000) by Kirsten Reese*, loudspeakers travel through the performance space. Unlike the unification of sound and space as achieved in the pieces by Radigue, during which sound is everywhere in space—with the sound sources impossible to locate—in Reese's piece the sound sources are all very well distinguishable from each other and in their different locations in space. She places small loudspeakers and cassette players into 22 bowls and sets them adrift from a small boat in a lake. Due to the water movements of the lake, the bowls slowly move away from each other, each taking its own direction (Reese 2010, 100) (see scheme *Der tönende See*). The *interaction* with the *space* is achieved through the movement of the different loudspeakers. The path followed by the loudspeakers—playing back a composition with voices telling fairy-tales, sine waves and environmental sounds—might be said to be guided by the performance space itself. Contrary to the loudspeaker orchestra, whose interpreter decides through which loudspeaker the music should be emitted and at what level, this time the loudspeakers simply radiate their sound while the environment brings them to random places. The audience may follow the loudspeakers by walking along the border of the lake. Since not all loudspeakers move in the same direction, it is impossible to hear all of them at once. The set-up of this piece invites the audience to walk around and to discover the performance space, but this will not constitute entering the set-up itself: if a loudspeaker is in the middle of the lake, its sound will be perceived only faintly, and there is no possibility of approaching the loudspeaker. Points of sound radiation move through the space, but listeners are not able to enter this space.



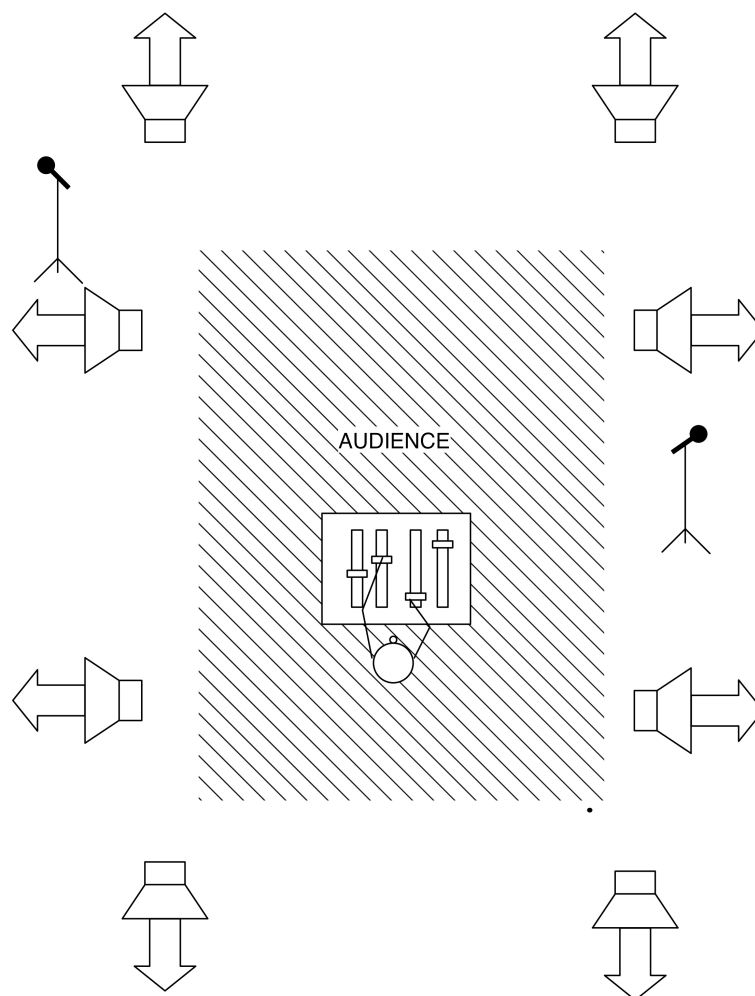
Kirsten Reese *Der tönende See*: 22 loudspeakers are placed on a lake. The waves of the lake disperse the loudspeakers in different directions.

Space 6: closing the acoustic feedback loop again: *Hörbare Ökosysteme* by Agostino Di Scipio

In Reese's *Der tönende See*, the lake—and thus the performance space—brings the loudspeakers into movement. In some pieces by Agostino Di Scipio*, the space itself could also be seen as an active contributor to the performance, only this time it influences a live electronic process and could therefore be understood as room-dependent signal processing (Anderson and Di Scipio 2005, 17). In *Hörbare Ökosysteme Nr. 3a Studie über Hintergrundgeräusche* (2002-2005), Di Scipio places several microphones and loudspeakers in the performance space. The sound in the performance space is picked up by certain microphones and analysed by the computer, and the results of this analysis control the digital signal processing performed by the computer. Since there is no purposeful sound production in the performance hall, what is being picked up is background noise.⁸⁰ The resulting signal is sent to loudspeakers, which again project this sound into the performance space. They are placed close to the walls and emit their sound towards the wall instead of towards the audience (Meric and Solomos 2009, 64). The microphones pick up this sound once more, as well as all other background noises sounding in the hall. This piece is shaped by the interaction of microphones, loudspeakers, performance space and digital signal processing (see scheme *Hörbare Ökosysteme*). As Di Scipio mentions: "Just like the microphone, the loudspeaker is not an element foreign to the process; it's part of it, something used to generate the music, not to play it back" (Anderson and Di Scipio 2005, 17). He also points out that all manner of acoustic situations are suitable for the piece, but, depending of the acoustics of the hall, he will place the microphones and loudspeakers differently. The microphone placements during this piece often look strange compared to more conventional microphone set-ups. The microphones are positioned, for example, pointing toward and very close to a wall or in the middle of the room or in a small corner. Depending on these positions, as well as the acoustics of the space, the sounding result will be quite different. The room itself is often processing the sound in ways known from live electronic processing, adding reverb (a sound that is played by a loudspeaker and picked up by a microphone far away will be transformed by the acoustics of the room), filtering the sound (in every room some frequencies will be amplified more than others, which also differs according to placement) and even adding delay (caused by the time it takes for the sound to travel from loudspeaker to microphone back to loudspeaker) (Anderson and Di Scipio 2005, 21–22). The placement of the microphones and loudspeakers in the performance space determines how much reverb is added, what kind of filtering occurs and how long the delay will be. The piece will probably sound quite different performed in the same space but with a different placement of microphones and loudspeakers. The *interaction* between microphones, loudspeakers and space is thus central in this piece.

⁸⁰ The title of this study: *Studie über Hintergrundgeräusche* refers to this, since *Hintergrundgeräusche* means background noises.

Di Scipio is interested in unveiling the sound character of the system instead of having sounds transmitted by the system. "It points the listener to the non-neutrality of loudspeaker technology, turning a problem in high-fidelity engineering into an element of musical experience" (Anderson and Di Scipio 2005, 22). Not only microphones, sound processing by a computer, loudspeakers and performance space act to shape the sound, but the members of the audience also, by reason of their very presence, change the resulting sound. The audience is inside the set-up, as Di Scipio explains: "Listeners are a very special kind of external observer or hearer, because their mere physical presence in the room acts as an element of acoustical



Agostino Di Scipio *Hörbare Ökosysteme*: sound waves picked up by two microphones is processed by computer software. The result is diffused back in the performance space by eight loudspeakers.

absorption. Hence they form an internal component of the ecosystemic dynamics" (Di Scipio 2003, 274).

Nr. 3a Studie über Hintergrundgeräusche can be described as a line of amplification. The starting point of this line points towards the end point of the same line. Although there is no acoustic feedback, the output is continually influencing the input. The background noise of the space is the starting point of the sound, but as soon as the loudspeakers begin to emit sound, this also becomes part of the microphone input. If the microphones or loudspeakers were placed closer to each other, or if the volume was turned up sufficiently, the sound explored at the beginning of this chapter—acoustic feedback—would be the result. This is indeed what Di Scipio does in another piece in the series *Hörbare Ökosysteme*, namely *Nr. 2a Studie über Rückkopplungen*. The main material for this piece is acoustic feedback. Similar to *Nr. 3a*, only microphones and loudspeakers are placed in a hall, again in positions chosen by the composer for their interesting acoustical characteristics. The person controlling the electronics intentionally turns the volume up high enough to produce feedback sounds. These feedback sounds are then processed by the computer and sent back into the performance space. A complicated mixture of feedback sounds and processed feedback sounds influences each other, and the whole system of loudspeakers, microphones, space and digital signal processing creates a composition that transforms and develops like an ecological system.⁸¹ But if the microphones and loudspeakers were to be placed closer to each other, with the microphones pointing towards the loudspeaker, one would come close to the set-up with which this chapter started: the acoustic feedback set-up for *Quintet* by Hugh Davies.

Overview of strategies for *interacting* with microphones and loudspeakers

This chapter ends by considering, once again, a circle of feedback. Whereas in Di Scipio's *Hörbare Ökosysteme* microphone and loudspeaker placement in the performance *space* are crucial for the resulting sound, in Collins' *Nodalings*—a similar acoustic feedback performance—it is the amount of *material* in between microphones and loudspeakers. In Davies' *Quintet*—again an acoustic feedback piece—the *movements* of microphones are means by which performers interact with microphones and loudspeakers. These parameter changes—in *movement*, *material* or *space*—are each manipulating a closed feedback loop set-up, without a clear start or end point. I began this chapter by investigating possibilities for shaping the sound of microphones and loudspeakers, taking acoustic feedback as a starting point. However, it is not only acoustic feedback, with no recognisable sound source as input, which can cause microphones and/or loudspeakers to become "audible". Such set-ups can include conventional musical instruments

⁸¹ The title *Hörbare Ökosysteme* has been translated as *Audible Ecosystemics* (Anderson and Di Scipio 2005, 11).

or everyday objects as sound sources, in addition to microphones and loudspeakers. As I outlined in the examples above, besides circles of feedback, what I have termed lines of amplification and points of radiation are systems which are able to support an active shaping of the sounding result. As I also demonstrated, the set-ups differ in their relation to the audience: the audience may be outside the set-up, inside the set-up or even taking part. These categories are not intended as rigid classifications, but attempts to isolate specific possibilities for *interacting* with microphones and loudspeakers. Almost all my examples exploit an individual set-up, with a specific parameter for *interacting* (movement, material or space), a specific set-up form (circles of feedback, lines of amplification or points of radiation), other sound-producing elements (conventional musical instruments, everyday objects or nothing at all) and the position of the audience (in- or outside the set-up or taking part). In the development of new pieces based on *interaction* between microphones and loudspeakers, one could imagine not only taking these individual strategies as a starting point, but also combining them, for example incorporating the movements in a feedback set-up like used by Davies in *Quintet* with prepared loudspeakers similar to those developed by Tudor in his *Rainforest*. The microphone movements used by Stockhausen in *Mikrophonie I* could be used with a loudspeaker setting similar to that used by Nono in *Guai ai gelidi mostri*. A self-designed instrument like the *Shozyg* by Davies could be diffused on an Acousmonium. All these possibilities remain theoretical proposals as long as composers and musicians do not try them out. I leave here the suggestion of multiple possibilities of *interaction* with microphones and loudspeakers, since all further investigations should be made in practice rather than theory.

Some remarks on composing with microphones and loudspeakers

As the aforementioned compositions and performances here reveal, microphones and loudspeakers never function exactly like conventional musical instruments. Many composers have claimed that their use of microphones and/or loudspeakers works to transform them into instruments (Nono, Stockhausen, Monahan and Tudor). However, their use of microphones and loudspeakers often results in some kind of transformation of the roles of performer, instrument and audience. Microphones and loudspeakers can, for example, become a part of an instrument and, in that way, transform previously unsuitable material into new musical instruments (Oliveros and Davies). In some cases the audience has to touch a part of the musical instrument to experience the performance (there is physical contact with the loudspeaker in the work of Tudor and Pook, or the sound itself becomes tangible, in the music of Merzbow). Microphones and loudspeakers are able to change a performance practice (listening becomes a creative act in the work of Lucier) or transform everyday actions into music (Maly and Cage). Consequently, the *interaction* discovered in all the music performances discussed in this chapter cannot be called a typical "musical instrument interaction", as understood from an analysis of interaction with

violins or pianos, for example. This implies that composing with microphones and loudspeakers is substantially different from composing for conventional musical instruments. It is exactly this effort of trying to transform microphones and loudspeakers into musical instruments, and the impossibility of really achieving this, which can produce a much more interesting performance result than that achieved when the goal of making microphones and loudspeakers "as normal as all other musical instruments" is paramount. In the next chapter I will discuss why this impossibility is so fruitful and especially how combinations of the four approaches towards microphones and loudspeakers, instead of only the *interaction* approach, can be used as a compositional strategy for making music with microphones and loudspeakers.