Universiteit
Leiden
The Netherlands

Materialisation of fixed media music

Anvaritutunchi, S.

Citation
Anvaritutunchi, S. (2024, June 25). *Materialisation of fixed media music*. Retrieved from https://hdl.handle.net/1887/3765322

Version:	Publisher's Version
License:	Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden
Downloaded from:	https://hdl.handle.net/1887/3765322

Note: To cite this publication please use the final published version (if applicable).

Chapter 3

3.1. Composing and performing in practice

In this chapter, I discuss the approach to composing and performing fixed media electroacoustic music that I have developed in recent years. I will chart how my artistic practice has informed this research, and how the research findings feed back into that practice. Since embarking on this research, I have composed many multichannel pieces, and performed them on multiple occasions and in diverse venues. Each of these experiences functions as a case study which explores the interconnection between composition process and performance practice. I will explain how working with the electroacoustic medium transformed the role of instruments in my composition process, resulting in what I describe as '(extended) instrumental music for loudspeakers'. The practice of using the sound of instruments as musical material led me to the idea of the *Broken Ensemble* project, in which (broken) instruments themselves, instead of conventional loudspeakers, become the actual sound sources to project electroacoustic music in space. *Broken Ensemble* problematises the acousmatic situation by rendering the sound sources visible (although not 'played' as such). This approach also extends the composition and performance of electroacoustic music beyond the idea of loudspeakers as visually and acoustically transparent and neutral sound sources. I will explain the importance of space as a critical parameter in the composition process, as well as in the performance practice of electroacoustic music. In that light, I will chart the concept of *spatial polyphony* as a compositional strategy, and discuss various approaches to realising this concept in composing for multichannel configurations. Moreover, I will discuss the idea of *post-mix*, which involves composing in a higher number of channels to be mixed down to a lower number in performance according to the circumstances of each concert situation, facilitating the adaptability of multichannel pieces to various situations, and opening up a performative pathway for various actualisations of fixed media pieces. Also in this chapter, I discuss my experience and involvement in the Azimuth organisation, which has allowed me to gain more hands-on experience in presenting fixed media music in public.

3.2. From the sound of instruments to sounding instruments

One of the important conceptions behind *musique concrète* was the idea of opening up music to the sonic potential of 'non-musical' sounds, that is to say sounds not produced by musical instruments or voices, as well as found or specially made recordings of instruments or voices. The term 'concrete' was also used in order to emphasise the material quality of the music, as opposed to music based on the 'abstraction' of traditional notation. As the composer Denis Smalley explains, 'instrumental and vocal resources are a "subset" of the wide-open sound world which is electroacoustic music's territory' (1997, 111). Instrumental and vocal sound sources have always been present in electroacoustic music, such as in Karlheinz Stockhausen's *Gesang der Jünglinge* (1956) in which recorded voices play an important role, or *Hibiki Hana Ma* (1970) composed by Iannis Xenakis, which is based on orchestral sounds. The composer Agostino Di Scipio (2004) discusses what distinguishes electroacoustic pieces such as *Hibiki Hana Ma* from recorded orchestral music. He argues that the electroacoustic techniques such as editing, layering and processing the recorded material, transforms the result into something different

than simply recorded instruments. In other words, the resultant sounds would no longer be reproducible by those instruments or singers.[27]

From the moment I started composing electroacoustic music, instrumental sounds have been the exclusive source of material for my pieces. I have always been fascinated by musical instruments, and was involved in the composition of instrumental music before I developed an interest in shaping and transforming – or, better, *extending* – instrumental sounds by electronic means. I therefore began to record instruments in order to provide myself with musical material, initially with the instruments available to me, in the first instance Persian instruments.[28] This is in distinction to the practice of Stockhausen and Xenakis in the examples mentioned above, where the sounds recorded by the voice and instruments respectively had first been composed and notated, although composers of *musique concrète* often regarded recording their own sounds as a matter of principle. For example, Pierre Schaeffer stated that he was seeking 'instruments' and 'voices' in his recordings of found objects: 'In all this wooden and tin junk and in my bicycle horns I rediscover my violin, my voice. I am seeking direct contact with sound material, without any electrons getting in the way' (2012, 7). In his local environment he found objects he could use as his 'instruments' and recorded them himself although his compositions also make extensive use of sounds he recorded on instruments such as prepared piano.

In a similar way, my own approach has often been to record short segments to be used as musical building blocks. These could include the 'conventional' sounds of the instruments, such as plucked strings, a two- or three-note motif, bowing a string, (pitched and unpitched) tremolo on the strings, and so on, as well as the 'unconventional' sounds of those instruments by using 'extended techniques' such as plucking on (or behind) the bridge of a string instrument, tapping on its body, scratching the skin of a drum; in short, all the sounds I could imagine and find by engaging with the instrument. According to Gernot Böhme

> the specific character of each musical instrument – the horn, the saxophone, and so on – is palpable in its sound. New music has pushed this further by pursuing the material character of musical instruments beyond tones – by blowing, striking, scratching, and so on. In this way, musical instruments were acknowledged, not merely as instruments generating tones as clearly as possible, but now also in the specific character they have as bodies. (2017, 140)

In other words, contemporary composition has added a dimension to acoustic instruments by treating them not only as a means of realising the music of a specific tradition, but also as 'sound objects' which can be made to sound in a variety of ways that emerge from their physical nature rather than from their traditional musical functions. The term 'sound object' here relates to Helmut Lachenmann's description of his work as 'musique concrète instrumentale' (Steenhuisen

---

[27] In the case of *Forty part motet* (2001), Janet Cardiff recreates Thomas Tallis's vocal piece *Spem in Alium* (1573) by recording the individual voices and placing each in one of 40 loudspeakers. While no editing or processing is applied to the recordings, the placement of each voice on a loudspeaker in space transforms the experience of listening to the music into something different from traditional vocal performance. Listeners are able to wander through what looks like a small forest of loudspeakers and to stand close to one or other of the single 'voices', which is obviously not possible when listening to the music performed by a physical choir.

[28] While Persian instruments and their timbre have a conspicuous presence and importance in my compositions, this aspect does not play a decisive role in this research. I happened to have them around me and am familiar with their sounds and playing techniques. These works can of course be considered in terms of the cultural significance of incorporating Persian instruments in electroacoustic music, but that is an issue outside the scope of the present research, which I focused on the processes of composition and performance rather than on the initial choice of sound materials.

2003,10). Lachenmann's conception of 'sound object' differs from that of Pierre Schaeffer. As the composer Ming Tsao explains, '*musique concrète instrumentale* refers not to Pierre Schaeffer's sense of an acousmatic music where one forgets about the source of a sound and focuses only on the sound itself, but to the contrary focuses on the concrete musical experience of producing sounds on instruments' (2014, 226). This understanding, however, does resemble Schaeffer's early description of the sound object (*objet sonore*) which originally referred to the object (the physical-material cause) that produces the sound (Kane 2019, 55). In order to bring some clarity to this situation, I will use the term 'sounding object' to refer to the physical objects used to produce sounds, and 'sound objects' to refer to the recorded segments made with them.[29] In this connection it is relevant to recall Gernot Böhme's discussion of the ideas of the German mystic and philosopher Jacob Böhme (1575-1624) in his text *De Signatura Rerum* (1651), where he models things and beings as musical instruments:

> The body is regarded as a sounding board, and its form and materiality as tuning or character (*Stimmung*, called *signatura* by Böhme), which is accountable for the characteristic expression a thing can have. […] like an instrument, each thing has its genuine character (signature) and, when it is struck, its characteristic tone reveals. (2017, 123)

This poetic conception of musical instruments is exemplified in my *Broken Ensemble* project (discussed below), where the bodies of the instruments are caused to vibrate and resonate as sound sources.

When I was studying composition, I would often meet with instrumentalists to try out some sound production ideas and explore extended techniques on their instruments. Such sessions were crucial for me as a composer in order to acquire a better understanding of the possibilities and limitations of those instruments, and they helped me to experience and listen to the sound production techniques that I had already read about in textbooks. Some of these sounds can be consistently produced using a given technique, such as many multiphonics on wind instruments (for which fingering charts and difficulty level indicators are given in textbooks). Some other sounds, on the other hand, are more delicate and unpredictable, so that reproducing them in an exact manner is extremely difficult or in some cases impossible, such as controlling the emergent melodic contour when playing overtones on woodwind instruments. While it is difficult to be specific about such unpredictable sounds when attempting to notate them in a score, recording them and using them in fixed media music presents no such obstacles. The recording sessions for my fixed media music can be considered as a similar kind of process to my learning about extended instrumental techniques from performers and textbooks. Instead of having to use notational symbols to represent these techniques and sounds in a score, I record and store those sounds directly as my actual sound material without feeling any need to make them consistently reproducible through notation. Moreover, in most cases, I play the instrument myself and try to achieve a desired sound; or I explore its sonic possibilities, bringing a performative aspect into the compositional process (see Chapter 1). This is a trial and error process full of serendipity. I am by no means a virtuoso on any of the instruments that I record,

---

[29] According to Pierre Schaeffer, '[t]he name sound object refers to every sound phenomenon and event perceived as a whole, a coherent entity'. He compares the sound object to musical notes and explains that, '[*s*]*ound object* and *musical note*: insofar as it is a unit of sound, a "gestalt", which can be made up of several micro-events bound together by a form, the sound object in classical music cannot precisely match each note on the score: a harp arpeggio on the score is a series of notes; but, to the listener, it is a single sound object' (Chion 2009, 33).

but rather a composer who tries to materialise an idea of possible new and interesting sounds which can be obtained with the instrument. This also involves improvisation: exploring the instrument in search of material which might inspire a new composition. These recordings, therefore, become unique and unrepeatable entities, having been captured under certain circumstances and in a certain atmosphere.

The recordings are then subjected to an evaluation and selection stage. This is the moment to select the most interesting sounds and isolate them as 'sound objects', ready to be further processed or otherwise structured in an eventual composition. The selection process might relate to compositional ideas I already had in advance, or to the musical potential suggested by the materials themselves during or after the recording sessions. In other words, the selection procedure is already part of the composition process. In some cases, a certain sound recording prompts the idea of a new piece – a gesture, a certain texture or quality, or what might be described as an atmosphere (see Chapter 2). For instance, in the case of *Gereh II* (2013) for eight channels, the idea of the piece came out of a recording session in which I was improvising on the *setar,* specifically exploring the technique of tremolo. In other cases, the recording process was initiated by a particular preexisting compositional idea. In *Dor* (2012), for the Wave Field Synthesis system, the main idea for the piece was conceived first, and the recording followed consequently. This main idea was based on circular movements, inspired by Sufi dance rituals. Accordingly, the sound recordings were based on a circular trajectory in which I moved the microphone in a circular pattern following the sound source (rubbing the skin of the frame drum). This is exactly how these sounds appear in the piece, moving in circular trajectories; the intended spatialisation of the sounds affected my approach to recording them. In case of *Yekhaft* (2022), recordings of bowed strings suggested the idea of using arc-shaped spatialisation trajectories on the Wave Field Synthesis system.

The recorded segments referred to above can be as short as one second, or as long as two or three minutes. Using brief sound objects allows for more flexibility in combining them to create larger structures. An important role is played by recording techniques in establishing the character of these sound materials. For instance, close-miking, which I often utilise in my recordings, functions as a magnifying glass, accentuating subtle details in the sound.[30] These might not be audible in an acoustic setting where the audience is some meters away from the instruments, so that it is as if one is listening to an instrument in extreme proximity - sometimes even nearly touching the instrument with their ears.[31] Furthermore, such closeness to the sound source isolates the sounds from their usual context, giving them a purer character without external resonances. This, in turn, facilitates their transposition to new contexts, which might involve composing a new acoustic context for them. This kind of recording technique, in combination with the use of brief recorded segments, has the effect of neutralising or reducing any sense of performative agency that might otherwise remain attached to the sound materials, for example if the listener is aware of the space in which the recording took place, or the presence of an instrumental performer executing a particular sequence of sounds. Nevertheless,

[30] Close-miking is a technique which involves placing a microphone very close to a sound source, normally with the intention of maximising the wanted sound and minimising any unwanted sounds from other nearby sound sources or the room acoustics. In classical music circles the technique is more often known as 'Accent Miking'. (https://www.soundonsound.com/glossary/close-miking)

[31] In some cases, I have also placed a miniature microphone (DPA 4060) inside the instrument. This provides a unique sonic perspective, opening up a new sound world, as if the listener is inside the instrument.

these sounds still carry the physical materiality and energy of their source. As the composer and music theorist Andrew Mead remarks:

> We as listeners can understand sound qualities in terms of the actions used to produce them, and [the] dynamic level certainly reflects the amount of energy being expended to create a sound. (1999, 4)

'Dynamic level' here refers to the perceived energy used to produce a sound with a particular sounding object, rather than its loudness when incorporated into a new context. As Smalley puts it, in listening to recorded instrumental sounds, 'spectromorphological' references may provide us with the otherwise absent cues to how the sounds were produced.[32]

> When we hear spectromorphologies we detect the humanity behind them by deducing gestural activity, referring back through gesture to proprioceptive and psychological experience in general. The listener's experience of listening to instruments is a cultural conditioning process based on years of (unconscious) audiovisual training. A knowledge of sounding gesture is therefore culturally very strongly imbedded. This cannot be ignored and denied when we come to electroacoustic music. It is particularly important for acousmatic music where the sources and causes of sound-making become remote or detached from known, directly experienced physical gesture and sounding sources. The process of increasing remoteness I refer to as gestural surrogacy. (1997, 111-112)

Instrumental sounds might be used in their raw form or, more frequently in my work, undergo various processing techniques, ranging from subtle alterations to transformations that render the original instrumental source unrecognisable. These processings can sometimes completely obscure those gestures mentioned by Smalley. For instance, *Sefrhasht* (2016) is based entirely on recorded flute sounds, although recognising these, and recognising the action of flute-playing, is rendered extremely difficult by the extensive transformation applied to the recordings, while the energy and the materiality contained in the sounds are still perceivable.

All possible sounds can potentially serve as material for composing electroacoustic music, but instrumental sounds have a peculiar status. These sounds might be regarded as 'abstract', in the sense that – unlike field recordings and environmental sounds – they do not refer to the outside world or represent an event, place or time; instead, they refer to music and thus to a different kind of listening experience. On the other hand, they are not as abstract as analogue or digitally generated/synthesised sounds. Instrumental sounds embody the physicality and materiality of the instruments, as well as the energy which is put into their production. This physicality and materiality are in turn manifested perceptibly when the sounds are projected in space, specifically on multiple loudspeakers, as if the sounds are being produced by a (transfigured) ensemble or an orchestra.

Lachenmann observes that the merit of new music lies not necessarily in making new sounds, but rather in providing them with new contexts:

---

[32] According to Smalley, '[s]pectromorphology is concerned with perceiving and thinking in terms of spectral energies and shapes in space, their behaviour, their motion and growth processes, and their relative functions in a musical context' (1997, 124).

> It is about breaking the old context, by whatever means, to break the sounds, looking into their anatomy. […] Every tremolo or interval or tam-tam noise is as intensive and new as the context you stimulate for it. (Steenhuisen 2003, 10)

As such, electroacoustic techniques applied to instrumental sounds – besides extending their timbres – give those sounds a new dimension, or decontextualise them in Lachenmann's sense, and thus bring about a further renewal of their musical potential, for instance through spatial polyphonic thinking. We could call these electroacoustic pieces 'extended instrumental music' for loudspeakers. For instance, the timbre of instrumental sounds is extended by processing and manipulating them through electroacoustic means. The performative techniques applied to the recorded instruments are extended by making certain passages much faster or slower than they could be played in reality, or by creating complex polyphonic textures which are only possible via montage and editing techniques. Other examples of extension are the magnification of extremely soft and subtle sounds, or the multiplication of instruments into 'ensembles' or even 'orchestras'. The original spatial locations of the instruments when they were recorded are sometimes extended too, by projecting them from various points in the space over a multichannel sound system. Therefore, instead of being situated in one specific location (whether on stage or not), their presence in the space becomes extended to envelop the audience. In all these examples, the role of the original 'performer' of the sounds is hidden by the composition process, so that the instruments and their extensions seem to take on an independent existence.

In what follows, I will explain how my preoccupation with instruments and instrumental sounds on the one hand, and electroacoustic music with loudspeakers as the endpoint, on the other, resulted in the *Broken Ensemble* project in which the physical presence of the instruments provides the sound sources in space.

3.2.1. The *Broken Ensemble* project

Broken Ensemble is a series of pieces or sound installations, which might in principle be regarded as a self-playing ensemble, consisting of a number of broken instruments which can no longer be played in the normal way.[33] A transducer is attached to each instrument, in order to cause its body to resonate and produce sound.[34] In the sound-installation versions (2017 and 2022), an algorithm running on a computer in real time is responsible for reproducing the music in a certain order and sending it to the instruments through the transducers. The sound material used in these works is based on recordings of the same instruments. Like an ensemble, these broken instruments interact with each other, play together and give space to one another while structuring new musical relationships, all of this generated by the algorithm which also ensures that no exact repetition takes place. In the case of the fixed media versions, such as *Reflection*

[33] So far I have collected a broken santur, two broken setars, a broken daf, a broken tombak and a broken violin. 'The santur is a Persian hammered dulcimer, the form of which is very similar to forms found in North India and Greece […] The setar is a long-necked lute with a teardrop-shaped soundbox. Traditionally, it has three strings, usually strummed with the fingernail, spanning in range across two octaves and a fifth […] The tombak (sometimes called tonbak or dombak) is perhaps the most prevalent form: a goblet drum held horizontally or at an angle and played with the fingers and palms of the hands. The tombak adds the rhythmic element to ensemble playing, but can also be used in solo, virtuosic performance' (Martin 2020, 377-8).

[34] The word transducer 'is commonly used to refer to the device which conveys sonic vibrations to a resonant object' (Rogalsky 2006, 23).

(2016) for three broken instruments and four loudspeakers, one channel of pre-composed music is assigned to each number of sound-producing bodies, in this case seven.

The story of Broken Ensemble began with me receiving a damaged *santur* from a friend who did not know what to do with it. Drastic humidity changes had severely deformed the body of the instrument with large cracks, and it was no longer playable.[35] I took the opportunity to carry out experiments with it. During these explorations, I began to use a transducer in order to cause its body to resonate, so that the instrument itself became a unique 'loudspeaker', retaining its own original characteristics. Later on, I collected some more broken instruments to form an ensemble.

A conventional loudspeaker consists of vibrating paper or plastic cones (dome-shaped in the case of most tweeters) contained in a box which is intended to resonate with the cone(s) as little as possible, so as to be acoustically transparent and not 'colour' the sounds it reproduces. In contrast, with my broken instruments (in combination with transducers), the body of the instruments (including all the strings, the sound board, skin and so on) becomes resonating material, emphasising colouration rather than transparency. The characteristics of the instrument's body, such as its shape, size and material, determine the sonic idiosyncrasy of these 'loudspeakers'. Furthermore, the manner in which these instrument/loudspeakers propagate sound in space also differs from that of a conventional loudspeaker. While the latter is described in terms of vertical and horizontal dispersion angles, the former projects sound in a more omni-directional fashion, just as an instrument does.[36] A similar example of such instrument-like loudspeakers can be found in the 'diffusers' designed for projecting the sound of the Ondes Martenot. First demonstrated in 1928, this was one of the first electronic instruments, and was designed to be played with an expressivity comparable to that of a violin or flute - the keys of its keyboard are able to move laterally to produce vibrato, and alongside the keyboard is a long ribbon bearing a ring, which can be moved horizontally to produce more or less wide glissandi. From the outset, its loudspeakers or 'diffusers' were intended to be part of the instrument rather than something external to it; various 'diffusers' have been produced for it, each with a different sound production technique and with different sonic characteristics, showing an early approach to employing instrument-like loudspeakers to project electronic sounds.[37]

However, as mentioned above, loudspeakers are usually desired and designed to be a transparent medium, which means that they reproduce the sound sent to them in the form of electrical signals as faithfully as possible; they should not impose their own presence and physicality on what is heard. In his series of compositions entitled *Rainforest* (1968-1973), the American pianist and composer David Tudor seeks the opposite effect, which comes closer to

---

[35] This was the result of bringing the instrument from Iran with its relatively dry climate to the Netherlands.

[36] Certain instruments do have a clear directionality in their sound projection: for instance a trumpet (and other brass instruments) mainly project the sound through their bell.

[37] The *Metallique* diffuser is essentially a gong with a transducer attached to resonate it. As a result it produces a metallic sound. Another one, named *Résonance*, 'uses a set of seven brass springs stretched in front of a speaker to create resonance and reverberation. Unlike a spring reverb, in which the instrument's signal is electrically passed through the springs, the springs of the *Résonance* are excited mechanically' (www.thekingofgear.com). A third diffuser, *Palme,* has a construction similar to a guitar; twelve strings which can be tuned in various ways, rest on a bridge containing a transducer through which sound is transmitted to the 'instrument', and resonates in the strings.

my conception of broken instruments as loudspeakers.[38] He attached transducers to various objects, and aimed at refracting sonic material through the physicality of these objects, as 'natural filters' (Rogalsky 2006, 56), which changes the input sound based on the characteristics of that object. He also compares his loudspeaker-objects with musical instruments, or, in his words, 'generating instruments':

> One of the ideas in my Rainforest series is that loudspeakers should be individuals, they should be instruments. So if you need a hundred of them to fill a hall, each one should have its own individual voice ... After all what is a loudspeaker? At present it's a reproducing instrument, but my feeling all along has been that you should regard it as a generating instrument ... Why shouldn't there be a thousand or more ways of building loudspeakers? ... Suppose you build one which only responds to the frequencies between 100 and 200 [Hz]? ... If you put sine waves through it, then you get quite a different sound emerging ... The loudspeaker is transforming what goes into it, instead of reproducing it. (Tudor 1972, 26)

Similarly, in Broken Ensemble, any kind of sonic material could be fed to the instruments. However, my interest lay not so much in utilising these instruments as a 'general' loudspeaker (or as a 'natural filter' as in the *Rainforest* series), but in projecting the specific type of sonic vocabulary which originally belonged to that specific instrument/loudspeaker. As such, when the transducers are fed by sounds recorded from that very same broken instrument, a particular acoustic effect emerges, as if the instrument is actually being played, as a result of the accentuation of the resonant frequencies of the instrument. The instrument echoes its own sounds, so to speak. I expanded this idea further by processing and manipulating the recorded sounds from the instruments. A new layer was thus introduced into the sonic vocabulary of the instruments, which could be regarded as 'impossible sounds'. For instance, the pitch range of the instrument might be (electroacoustically) expanded, or it might seem to play extremely fast tempi or multiple simultaneous sounds, physically impossible when played by a human being. Nevertheless, the resulting 'hyperinstruments' still have their physical limitations in terms of intensity, volume and frequency response. It is not possible, for instance, to achieve sound levels beyond the capacity and the physicality of an instrument, or frequencies lower than those that can be produced by a sounding body of a certain size.

Broken Ensemble presents a paradox. Unlike traditional acousmatic music for loudspeakers which is concerned with pure listening without the visual presence of the sound sources, here the sounding objects have a strong visual presence although instrumentalists are absent. Usually loudspeakers are designed to be as unobtrusive as possible: black in colour and neutral in appearance. Even in the case of the Acousmonium with illuminated and colourful loudspeakers (see Chapter 2), there is no connection between their physical appearance and the sounds emitted from them. In *Broken Ensemble*, though, this connection is clearly present, and affects the listener's perception of the music. In other words, the sounds heard are perceived to correspond to the visual appearance of the sound-producing objects. For me this phenomenon has a poetic significance, and both negates and challenges the acousmatic conception, in which

---

[38] According to Tudor, *Rainforest* 'in its original version (1968), is a collection of small speakers, sculpturally constructed from physical materials having different resonant characteristics. These instruments, each having a different "voice", establish a means of sound transformation without electronics: the source sounds, when transmitted thru the physical materials, are modified by their resonant nodes. The source sounds used are performed live, with sound generators specially made to produce unpredictable oscillations' (Tudor 1988).

the causes of sounds are hidden. *Broken Ensemble,* and similar approaches to employing non-standard loudspeakers or loudspeaker-objects, can offer new modes of projecting and materialising sound in space, opening up new possibilities for both composing and performing electroacoustic music, also bringing the worlds of (acoustic) instrumental and electroacoustic music closer together and blurring their boundaries, so that we might imagine *instrumental music for loudspeakers* or *electroacoustic music for instruments*.

3.3. Spatial polyphony

> When new instruments will allow me to write music as I conceive it, the movement of sound-masses, of shifting planes will be clearly perceived in my work, taking the place of linear counterpoint. (Varèse 1936, in Cox and Warner 2017, 41)

According to the Oxford English Dictionary, polyphony is 'the style of simultaneously combining a number of parts, each forming an individual melody and harmonising with each other'. The composer Simon Emmerson describes polyphony in contemporary terms as 'more than one simultaneous coherent "line" of musical thought' (2007, 113), while for John Cage it is a matter of the 'copresence of dissimilarities' (Harley 1999, 150). According to the composer Paulo Chagas , two important aspects of polyphony are *multiplicity* and *individuality*. He explains that '[t]he notion of polyphony implies the perception of multiple and simultaneous sound events organized in a system of relationships producing a temporal processing of meaning' (2006, 47). 'Spatial polyphony' is a term that I employ to describe my approach (and that of some other composers such as Xenakis, Stockhausen and Horacio Vaggione, as will be discussed below) to multichannel/spatial composition, in which space, location and movement of sounds is a fundamental aspect of the way sounds are interrelated and form a polyphonic texture, since separation and distance between sounds and/or sound sources in itself has the effect of mobilising polyphonic qualities. Traditionally, individual lines or voices in polyphonic music are distinguished by divergences in pitch and rhythm, while divergences in timbre can also play an important role in enabling listeners to discern various 'melodies' or musical events, and give each its own individuality. Polyphonic qualities can of course encompass many other parameters beyond pitch, rhythm and timbre, including contrasts between pitched and noisy sounds, between sustained and short sounds, between reverberant and dry sounds, soft and loud sounds, synthetic and concrete sounds, or foreground and background sounds. All of these variable features may participate in the contrapuntal characteristics of the music, and enhance its polyphonic texture. By introducing space into this equation, the polyphonic texture acquires a further dimension: the locational counterpoint between voices or musical events. Earlier composers such as Charles Ives and Henry Brant in their instrumental music 'explored the simultaneity of various musical processes that take place at different points of space', according to the musicologist Maria Anna Harley, who infers that '[t]heir ideas of the coexistence of several distinct strands within a composition are rooted in polyphony' (1997, 88). The philosopher and musicologist John Dyck asserts that spatiality in music can play an important role in polyphony by 'unifying or distinguishing multiple musical parts' (2021, 280). He suggests a concept of 'spatial clarity' where '[s]pace "separates" or "unifies" musical parts in a way distinct from pitch, timbre, and volume' (2021, 282). This helps to foreground the contrapuntal qualities in music, where '[t]he degree of stream segregation covaries with the spatial distance between sound sources' (2021, 282). A multichannel configuration, for instance, is an effective way to implement such stream segregation.

Polyphonic thinking has been central to my compositions even before I began to concentrate on electroacoustic music, specifically in relation to my research into the characteristics of carpet designs and their potential connection to music.[39] Similar qualities in carpet design manifest themselves in the co-presence of diverse motifs and patterns at multiple scales, that eventually establish a complex and 'polyphonic' visual effect. This phenomenon gave me a new understanding of polyphony in music, which was one of the main inspirations behind the electroacoustic compositions I subsequently began to produce.

3.3.1. Spatial music

Music by nature is always a spatial phenomenon, and the integration of spatiality into musical composition has been present throughout music history, for example in the *cori spezzati* practice in Venetian music around 1600. Around the middle of the nineteenth century, and more intensively in the twentieth century, composers began to consider the spatial aspect of music more purposefully. For example, Hector Berlioz (1803-1869), Gustav Mahler (1860-1911) and Charles Ives (1874-1954) wrote compositions which use 'offstage' instrumental groups separating musical lines in space. However, Harley notes that, even in a traditional setting where musicians are situated on stage, an immanent and underlying spatial quality is present:

> Chamber and orchestral music has a latent quasi-spatial structure when the ensemble placement is standard, well-known and does not have to be specified. Most of the music composed for specific instrumental groups takes for granted certain types of spatial relationships inherent in the kind and size of the ensemble. (1993, 126)

One of the reasons for such arrangement is to achieve a particular blending of the various timbres and intensities of an orchestra. John Cage underlines the fact that the proximity to each other of the musicians on stage is desirable in traditional musical thinking, since it gives rise to a more coherent mixture of their sounds:

> In the case of the harmonious ensembles of European musical history, a fusion of sound was of the essence, and therefore players in an ensemble were brought as close together as possible, so that their actions, productive of an object in time, might be effective. (1961, 39)

For instance, the louder groups of instruments, such as percussion and brass, are traditionally situated further back, while the softer sounding strings are placed in the front. Composers in the twentieth century became increasingly aware of the possible effects of reversing or changing this arrangement. As Harley explains:

> In Xenakis' *Pithoprakta* (1955/1956), the instruments systematically rise and fall in tone and volume, from one side of the stage to the other. As a result, there is "a shift of the sound mass" across the stage. (1994, 295)

It is important to note that perceiving such an effect depends on the position and distance of the listener relative to the stage. Xenakis even suggested that the conductor should be situated within the audience and not on stage (like the sound projectionist in electroacoustic music!), in

[39] 'Composing Music Based on Carpet' (2014), Master Thesis, Institute of Sonology, Royal Conservatoire The Hague.

order to better hear how the blending of different groups of instruments sound and 'mix' in the concert hall:

> The conductor hears the orchestra in a certain way during the performance, he has certain instruments to the right or to the left, he has the string orchestra around him, then the woodwinds and brass farther away, followed by the percussion. The listener in the auditorium does not have the same sound image as the conductor, and the conductor has to conduct for the listener, not for himself. How can he do that when he is not there? He should conduct from the auditorium and listen to the orchestra from that place. (1992, 11)

In presenting fixed media music, the performer – considered, as discussed in Chapter 1, to have a role similar to that of a conductor – is often situated within the audience, as suggested by Xenakis for orchestral conductors, in order to have a good understanding of how the music is perceived in the auditorium.

The roots of such spatial considerations can perhaps be traced back to certain developments of instrumental music from the last century. For instance, the idea of *Klangfarbenmelodie* foregrounds timbre by splitting a musical line or melody between various instruments.[40] Inevitably, this approach splits the melody spatially at the same time, since each instrument is located in a specific point in space, so that the melodic line traverses the orchestra. Building on such latent spatial qualities in instrumental music, even the ones not composed with such intentions, the composer and researcher Jason W. Solomon proposes a concept of *spatial gesture,* described (in the context of string quartet no.14 by Beethoven) as 'a composite, dynamic pattern of motion that emerges in the physical space of musical performance, often resulting from staggered activity of multiple performers' (2019, 120). Such spatial 'patterns' are less perceivable in a traditional frontal setting where musicians are located on stage next to each other. However, when the musicians are spatially distributed in the concert space, as in Karlheinz Stockhausen's *Gruppen* (1957) for three orchestras, or in *Lichter-Wasser* (1999) for soprano, tenor, and orchestra with synthesizer, the spatial and timbral distribution of melodic lines in the space becomes much clearer.[41] According to Harley, '[w]hen the role of spatial projection, sound location and direction become important elements of musical structure, we speak of the music's "spatialisation"' (1999, 148). The American composer Henry Brant (1913-2008), who was intensely occupied with the integration of space in his music, considers spatiality on a par with other fundamental aspects of music such as pitch and duration. He explains that for him 'space is part of the composing plan. If you change the space in a piece of mine, it's no different than changing the notes or the rhythms in someone else's piece' (quoted in Dyck 2021, 283). Similarly, Stockhausen in 'Music in Space' (1959) considered space, more specifically the direction from which sound is projected, as a musical parameter which can (like any other

---

[40] *Klangfarbenmelodie* or 'tone-colour melody' was first introduced by Arnold Schoenberg in his book *Harmonielehre* (1911). According to Alfred Cramer, '[t]he term has become accepted as a name for a common twentieth-century practice in which the timbres of successive tones gain melodic importance comparable to that of pitch' (2002,1).

[41] Stockhausen describes the perceived movement of sounds and its connection to timbre in *Gruppen*: 'I also thought in terms of moving timbres: there's one spot that led to something I hadn't expected myself—a chord is moving from orchestra to orchestra with almost exactly the same instruments (horns and trombones) and what changes isn't the pitches but rather the sound in space' (Cott 1973, 200-1). In his article Paul Miller analyses *Lichter—Wasser*'s spatial composition ('shapes') and the movement of the 'melodic' lines in space. He explains that 'the apparent movement of melodic ideas in a stationary ensemble (as opposed to the *actual* movement of sounds through space through real physical movement) is the focus of a great deal of compositional design' (2012, 344).

parameter) be readily serialised.[42] Harley summarises the ideas expressed by Brant in his writings on the spatial organisation of musical material:

> (1) Spatial separation clarifies the texture; this is particularly important if the music consists of several different layers located in the same pitch register.
> (2) Spatial separation is equivalent to the separation of textures in pitch space; one can hear separately layers of music that are located in different registers, and layers that originate from distant points in the performance space.
> (3) Spatial separation permits a greater complexity in the music; which may, therefore, include more unrelated elements perceived simultaneously.
> (4) Spatial separation makes exact rhythmic coordination impossible; distant groups should avoid simultaneous, identical rhythmic patterns.
> (5) There are no optimum positions of the listeners or the performers in the hall; each situation is different. (1999, 150)

These points are also valid for multi-loudspeaker music. The first three describe issues mainly related to spatial polyphony, as discussed earlier. In the case of rhythmic coordination, this can be easily achieved in electroacoustic music. Nevertheless, the size of the venue, the distance between the loudspeakers and the audience, and their arrangement, can have an effect on the perception of rhythmic synchronicity. And, as discussed in Chapter 1, each listener in a multichannel setup hears a unique mix of all the various sound sources.

3.3.2. Multichannel composition

> It is my conviction that our epoch's contribution to the ongoing sea changes in Western music is an evolution of electronic music (in all its forms) that opens up a dimension that has always been a part of music performance but now, with the development of highly sophisticated software and the ever more common use of multi-channel amplifications systems in concert halls, is available to the composer as a structural and expressive resource. This dimension is, of course, space and the spatialization of musical sound. (Dashow 2013, 4)

The growing number of multichannel sound systems around the world, which is the result of technological advances in digital audio, lends an urgency to the exploration and formulation of approaches to composing and performing for multichannel systems, in order to gain a deeper understanding of the affordances of spatial sound and thus to realise the full musical potential of these systems.[43] The composer Eric Lyon argues that one of the reasons that spatial aspects of electroacoustic music have not been fully developed is the dominance of timbre composition which was initially the main concern in the developments of electroacoustic music, an area which has now nearly come to a saturation. Lyon asserts that '[b]y contrast, computer music

---

[42] Nevertheless, as Kees Tazelaar (personal conversation) underlines, Stockhausen was willing to compromise on this parameter by mixing down his spatial composition to stereo for release on records and CDs. But he would not do such a thing with the other parameters such as pitch and duration.

[43] To mention a few: The Sonic Lab at the Sonic Arts Research Centre (SARC), Queen's University, Belfast. The IEM-Cube, at the Institute of Electronic Music and Acoustics (IEM), Graz. The Motion Lab at the Department for Musicology, Oslo University. SPACE (Soundscape Projection Ambisonic Control Engine) at the Electronic Laboratory for Experimental Music of the Conservatorio G. Rossini in Pesaro, Italy.

composition for large numbers of speakers is an area ripe for experimentation and discovery' (2014, 4).

When I started studying electroacoustic music, I found spatiality a particularly fascinating aspect, and I soon began experimenting with multichannel compositions, strongly attracted by the potential of the medium itself to generate polyphonic textures. The way that simultaneous musical events could be situated in various points in space opened up a new world of ideas for me. As discussed earlier, electroacoustic music offers a wealth of possibilities in terms of spatialisation of sounds. As Harley puts it, '[f]or electroacoustic music spatiality is a condition *sine qua non*' (1993, 130), and for Denis Smalley, '[t]he spatial experience of electroacoustic music is one of the particular aspects it has to offer that no other musical art has to offer in such variety or with such vividness' (2000, 20). Therefore, spatial polyphony can be best implemented in electroacoustic music where each 'voice', or, in Edgard Varèse's terminology, each 'plane' can be projected anywhere in space, either from a loudspeaker, or from a virtual point in between loudspeakers.[44] In this regard, the difference between spatial instrumental music, such as Xenakis' *Terretektorh* for orchestra, and spatial electroacoustic music is that, in the former, a given sound location is limited to the sounds of that specific instrument. For instance, if a violin player is situated in the concert venue at a specific point, the only sound projected from that point is the violin sound. However, in electroacoustic music, the sound source (the loudspeaker) can produce an almost infinite variety and combination of sounds . The sound source is not bound to its own physicality (as in the violin example), but is a blank carrier which can project a plethora of sonic identities, and can be situated almost anywhere in a space.[45] An instrumentalist's positioning is often limited for practical reasons: situating a piano above the audience would not be an easy task! In *Prometeo* (1985), Luigi Nono aimed at expanding the spatial placement of musicians, by utilising a bespoke construction (designed by the renowned Italian architect Renzo Piano) to locate musicians at various heights within an architectural space. In contrast, rigging loudspeakers in various heights and positioning is considerably more conveniently realised.

According to the electroacoustic composer Robert Normandeau, multichannel composing has two principle motivations. The first is that less complex sounds are presented by loudspeakers 'with better accuracy and clarity', while the second concerns the localisation of the sounds in space: 'music spatialized over a group of speakers placed throughout a hall allows the listener to better hear the polyphony of the music' because each layer or voice in the polyphony arrives at the ears of the listener from a different location in space (2009, 278). In my opinion, these two aspects are closely entangled and also relate closely to Brant's criteria for spatial instrumental music described above. When musical material is divided over multiple sources (loudspeakers) for reasons of increased clarity, spatial polyphonic qualities automatically come into being since those loudspeakers are situated in various locations. The composer Ludger Brümmer explains the advantage of multichannel composition in reducing and nuancing the masking effect that occurs when signals are combined together in a mix and 'quiet sounds are drowned out by loud sounds' (2017, 46). When those sounds are projected from different locations, their spatial

---

[44] According to John D. Anderson, for linear melodic lines, Varèse borrowed the geometric term *plane*. (1991, 35)

[45] Obviously, loudspeakers vary in terms of their sonic characteristics, and their physicality (size, shape, type of internal components) plays an important role in their character and sound reproduction capabilities. Nevertheless, to a great extent, they all can reproduce almost any sound, some better than others. As the composer John Croft puts it, '[a] loudspeaker can, in principle, produce any sound; on an instrument, almost all sounds are impossible, and of those that are possible, some are more difficult to produce than others' (2007, 62).

separation allows for more varied mixes in terms of contrasts of loudness between different sounds or layers. Kees Tazelaar (personal conversation) explains that composing for a multichannel sound system allows for articulating complex musical structures, resulting in what he calls 'transparency'. For instance, in *Source Signals 2* (2021) Tazelaar constructs dense arpeggio-like structures over an eight-channel configuration; the resultant sonic quality (of the individual elements each with a specific location) therefore emerges in space. In other words, the material and its spatial organisation become one. The composer Barry Truax compares stereo with the eight-channel format, and underlines the higher degree of dynamic control in the latter, as well as the possibility of integrating spatiality into the composition process:

> Having eight discrete sources available, all independently controllable, is not only acoustically richer for tape music (since detail is not lost through stereo mixing) but also challenging compositionally in order to integrate a spatial conception into the work. (1999, 143)

Such a spatial conception may be clearly perceived in the work of the Argentinian composer Horacio Vaggione, who considers 'the spatial dimension of sound as something to be composed', in terms of 'size, situation, extension, speed, phase correlation, and so on', resulting in a polyphonic texture:

> I try to give each sound-object a particular, unique spatial feature. The textures created this way are spatially polyphonic or "polyspatial." This is why you can perceive a dynamic spatial depth. (Vaggione quoted in Budón 2000, 18)

While Vaggione actually creates his spatial polyphony in stereo format, his intention is generally to diffuse the music over a larger number of speakers so that the latent spatial characteristics of the music become apparent, causing it to sound almost indistinguishable from music composed in more than two channels.

Chagas underscores the importance of spatiality to the possibility of distinguishing timbral qualities within a polyphonic texture in Stockhausen's *Gesang der Jünglinge* (1956):

> The revolutionary accomplishment of *Gesang der Jünglinge* is to provide the first example of the integration of the composition of timbres with spatial articulation. Spatialization here is not treated as an ornament of the electroacoustic composition for enhancing the listening experience, but as a structural principle of the composition that "intervenes to clarify the composition of timbres" (Decroupet and Ungeheuer 1998, 128). In this sense, this approach to spatialization can be considered an extension of polyphonic thinking, as it applies the principles of independence and control of musical elements to the spatial domain of the composition. (2014, 111)

The musicologists and researchers Pascal Decroupet and Elena Ungeheuer further explain how the distribution of musical material over the multichannel setup affects its perception:

> The electronic and vocal parts . . . have a common denominator: each layer being heard in one loudspeaker, the distinction of the components of the polyphony is, if not easy, at least possible. […] it is the spatialisation which intervenes to clarify the composition of

> timbres by allotting to certain loudspeakers all the variants of one category of timbre and by concentrating the irregular changes in only one loudspeaker. (1998, 128)

Broadly speaking, two main approaches to multichannel composition can be distinguished. The first of these, the *source-point* approach, regards loudspeakers as points (sound sources) in space, comparable to musical instruments. According to the composer Christopher Burns, a characteristic of this approach 'is the tendency to activate and embody the loudspeakers as physical presences in the performance of the work' (Burns 2006, n.p.). The second approach is concerned more with a phantom image that emerges from the synergy of the multi-loudspeaker setup, so that the presence of the loudspeakers at particular points in space is of less importance: in fact this method aims rather at 'dematerialization of the loudspeakers' (Burns 2006, n.p.). The stereo format is a simple example of such an approach, where a sound field is established *in between* two loudspeakers. The Wave Field Synthesis (WFS) system is an advanced example of creating such a sound field, where virtual sound sources and trajectories in space can be established fairly accurately (and with a greater stability than that of a stereo image) by integrating numerous loudspeakers, equally distanced from one another and surrounding the audience.[46] Here the composer is not concerned with the number of channels, but with the location and the trajectory of sounds. Such an 'object-based' approach can also be found in Ambisonic technology (Zotter and Frank 2019),[47] which, similar to WFS, employs a high-density loudspeaker array (HDLA) in order to establish a sound field where virtual points can be created within a 3D space.[48] Natasha Barrett (2021) discusses composing in ambisonic formats (encoding) and the challenges of presenting (decoding) ambisonic pieces, pointing out the problem that there is still no standard HDLA setup in concert venues. Ambisonic pieces, like those composed for WFS, are highly dependent on specific software/hardware configurations in order to be fully materialised. Since the sounds and spatialisation data are stored separately, the WFS and Ambisonic systems may be scaled up and down based on the size of the space, and, as a result, the number of loudspeakers changes while the sound field's proportions stay the same.[49] Of course, the aforementioned two approaches (source point and HDLAs) can be combined in a composition. Moreover, source point techniques can be implemented within any HDLA system, for instance by placing a 8-channel piece in a WFS system in the form of eight discrete points in space, a technique I have employed multiple times. Whether the sonic result is convincing depends on the type and accuracy of the HDLA system in use and the characteristics of the musical material. Barrett's *Virtualmonium* project (2016) simulates a 'loudspeaker orchestra', such as the Acousmonium, with Ambisonic technology, by creating virtual loudspeakers (with various positions, directions and frequency responses) in space. In other words, *Virtualmonium* uses loudspeakers to emulate loudspeakers! According to Barrett, this 'allows composers to custom-design loudspeaker orchestra emulations for the performance of their works, rehearse and refine performances off-site, and perform classical repertoire alongside native 3-D formats in the same concert' (2016, 55). *Virtualmonium* thus demonstrates the potential of implementing any sort of virtual sound sources within a 3D sound field.

---

[46] For instance, the WFS system developed by the Game of Life organisation, which is approximately ten by ten meters in size, consisting of 192 loudspeakers and 24 subwoofers.

[47] According to Natasha Barrett, '[i]n the object-based method, audio objects or audio stems are coupled to spatial audio description metadata' (2021, 178).

[48] Ambisonic setups often include heigh by using loudspeakers also above the audience.

[49] In this case, the composed sound trajectories and virtual sources will be recalculated based on the current setup and number of loudspeakers.

Although an HDLA-based approach can theoretically reproduce any phantom sound source in space, in practice the actual control over the location, direction, proximity, and even the type and character of the loudspeaker, is best achieved with physical loudspeakers rather than virtual ones. While future developments in spatial sound would perhaps deliver better sonic results and bring higher degrees of accuracy and control, a critical question remains as to the compositional and musical relevance and merit of such advanced possibilities in spatialising sounds, to which spatial polyphonic thinking offers one possible answer.

Generally speaking, compositions based on the source-point approach are less adversely affected by changes and variations in the loudspeaker arrangement originally intended by the composer. As Burns highlights, '[o]ne advantage of the source-point spatialization techniques described above is that they are highly adaptable to different configurations of loudspeakers' (2006, n.p.). On the other hand, compositions based on the virtual image approach are highly dependent on an accurate reproduction of the sound system configuration envisaged by the composer, in order to retain the 'correct' image, which might otherwise be deformed or destroyed. For instance, in my composition *Tom+Bak* (2020) for eight channels – composed with the source-point approach – the exact placement of the loudspeakers is not crucial, and the configuration of the eight channels can be altered. In this music, spatial polyphonic qualities emerge from a simultaneity of various rhythmical gestures or patterns on the Persian percussion instrument called *tombak* (see above). The sound material has undergone almost no processing, so that the result is as if eight percussionists are situated in the space. Such a polyphonic quality is perhaps closer to spatial polyphony in instrumental music, especially works like Xenakis' *Persephassa* (1969) where six percussionists surround the audience and their sounds are made to circle around the audience by means of overlapping crescendos and diminuendi in the different instrumental parts. At times, the patterns in *Tom+Bak* create a canon-like effect, or, to use Brant's term, 'spill', where one instrument begins and others join in one by one until the space is filled (Brant 1967, 232). Presenting a piece like this in various loudspeaker configurations establishes new relationships between its rhythmic patterns. The spatial polyphonic effect is brought more clearly to the foreground when the loudspeakers surround the audience.

During my studies at the institute of Sonology, I spent extensive hours in the studios experimenting with multichannel sound, both eight-channel and WFS. Fascinated by my discovery of spatiality in music, I tried to develop compositional methods in which these multichannel configurations played an integral role. These experiments were crucial for me in terms of developing an understanding of spatialisation. In the following part, I will discuss in more detail some of the spatialisation techniques I have utilised in my compositions, specifically in relation to polyphony, with explanations of how these techniques translate to performance practice.

3.3.3. Symmetrical spatialisation

As the term suggests, this is an approach for distributing the musical material in space in a symmetrical manner, an approach I developed from considering the concept of symmetry in carpet designs, where multiple networks of patterns together create a complex whole. I implemented this idea in my music for the first time in *Toranj* (2012) for eight channels, and since then it has been part of my toolbox. Symmetrical spatialisation was my first systematic approach towards incorporating spatiality in the composition process, leading directly to my explorations

of the polyphonic potential of spatial composition. Related musical materials are distributed over the multichannel system in a symmetrical manner. As in traditional polyphony, each layer occupies a certain frequency range, so that a 'vertical' dimension is generated by the distribution of sounds through a more or less wide range of frequencies. A carpet gives the viewer an immediate impression of symmetry as the whole can be perceived at once, and I intended to invoke this visual quality by creating music which is spatially symmetrical, as opposed to the kinds of symmetries where music unfolds over the course of time (such as, for example, an ABA form). I was also concerned with the idea of experiencing symmetry and asymmetry simultaneously: the symmetrical relationship between corresponding loudspeakers is created not with precise duplications but with subtle variations. Other composers have also explored (a)symmetrical distributions of instruments in space. Pierre Boulez talks about symmetrical and asymmetrical arrangements of timbre in the arrangement of instrumental groups on stage:

> [T]wo groups will be symmetrical if they are situated at an equal distance from an axis of some kind; if they possess homogeneous or non-homogeneous timbres, identical in quality and density, they can be considered as regularly symmetrical; they are irregularly symmetrical if their homogeneity is not of the same nature (a group of brass against a group of strings, for example) or if their non-homogeneity differs in quality and density; they will otherwise be asymmetrical. (Boulez 1971, 70)

A symmetrical arrangement of instruments in itself is not sufficient to create the perception of symmetrical qualities in music, unless it is combined with other compositional strategies. For instance, in Bela Bartok's *Music for Strings, Percussion and Celesta* (1936) the instruments are arranged on stage in a symmetrical manner and the disposition of the piece's musical materials often follows that symmetry, for example at the opening where a motif gradually spreads across the string ensemble as it is repeated and developed. As Harley notes, Bartok 'connects symmetries in pitch space and in timbral domain with symmetries in performance space' (1999, 150). According to the score, the instruments are arranged on stage in a symmetrical manner: percussion and keyboards in the middle are surrounded by two identical string groups, one on the left side of the stage and the other on the right. In the first movement, the opening fugue subject is presented symmetrically by the left and right viola groups playing in unison. Musical materials (repetitions and sequences) consistently alternate between the two string groups, establishing various symmetrical relationships, and enhanced by the position of the other timbrally contrasted instruments. The music's pitch organisation and temporal structure also involve symmetrical relationships (Gillies 2000, 291). In electroacoustic music, a multichannel setup spread around the entire space allows for even more complex symmetrical relationships between sound sources, which are not only limited to the stage.

3.3.4. Spectral spatialisation

Another approach to multichannel composition is to implement spatial separation between frequency bands, which may be done in several different ways, resulting in different qualities. The general idea is to split the frequency spectrum of a given sound and distribute the resulting components over a multichannel setup. As such, these components (projected from various locations) converge and recreate the full spectrum *in space*, so that spectral spatialisation may be defined as a process of decomposing sound and recomposing it in space.

In a study on the effectiveness of various spatialisation techniques in creating a sense of envelopment, Hugh Lynch and Robert Sazdov (2017) concluded that such strategies of splitting a sound spectrum over a multichannel sound system in space are perceived by the listeners to be the most enveloping and engulfing, specifically when the frequency bands are changing over time.[50]

I employ this approach in my own compositions extensively, and I am continually exploring its affordances during the composition process. For instance, by splitting the spectrum of a short sound object into eight frequency bands, and assigning each to a separate channel (of an eight-channel sound system), the resultant sound appears to take on an extended shape in the space, instead of coming from a single point. The way in which frequency bands are distributed through the multichannel setup directly affects the perceived shape, and can be used as a compositional parameter. Going one step further and applying delays to these components – in other words, manipulating the temporal aspect of the material – causes a different quality to emerge as a function of the change in alignment of the frequency components, which can in turn transform the timbre of the original sound. The amount of delay greatly affects the sonic result: whereas short time delays create an arpeggio-like effect, longer delay times create isolated sound events. Of course, further processing can be applied to each of these frequency bands individually; additionally, the division of the spectrum can be increased to a much higher number of narrower frequency bands. Variations like these provide extensive possibilities for the integration of spatiality into the process of composing the sound material.

I applied this technique for the first time in 2012 in my composition *Dohasht* for 16 channels. In *Dohasht*, a recording of percussive tapping on piano strings is used as a building block. The dense frequency spectrum of such a sound lends itself well to spectral division, so that, when it is split into several frequency bands, each of these still contains an abundance of frequencies. While the idea of *Klangfarbenmelodie* is concerned with splitting a melody horizontally, in spectral spatialisation sounds are divided vertically. Normandeau discusses a comparable approach to *timbre spatialization* where space plays an important role in the reconstruction of the timbre. As he explains:

> What is unique in electroacoustic music is the possibility to fragment sound spectra amongst a network of speakers. When a violin is played, the entire spectrum of the instrument sounds, whereas with multichannel electroacoustic music timbre can be distributed over all virtual points available in the defined space. (2009, 278)

In fact, such strategies in spatial polyphony are comparable to the pointillistic technique in painting, in which colours, in the form of small dots, are painted next to each other directly on the canvas instead of being mixed on the palette beforehand. Subsequently, the resultant 'mixed' colours emerge in the eyes of the observer, being mixed in their mind. According to Gernot Böhme, in pointillism '[t]he colours the painter wishes the onlooker to see are not located on the painted surface but "in space", or in the imagination of the onlooker' (2013, 4). Observing such paintings from close up does not reveal the image. Similarly, spatial polyphonic techniques require space and distance in order to be perceived by the listener. As a result, each listening position in a concert hall has its own unique 'mix' of these multiple points or sound

[50] According to Lynch and Sazdov, envelopment 'is defined as a sense of being surrounded by sound' and engulfment 'as a sense of being "covered" by sound' (2017, 17).

sources. In contrast to the idea of a 'sweet spot' where an 'ideal image' is recreated at a specific point, spatial polyphony gives rise to multiple sweet spots, each giving a different perspective on the music. This can motivate revisiting a performance and listening to the same piece multiple times, from different locations. Obviously, such qualities will not emerge in a stereo mix-down of a multichannel piece; they remain an exclusive feature of spatial music, fully experienced only when the music is presented in a spatial configuration.

As discussed earlier, multichannel pieces composed with the source-point approach are more flexible in the sense that they allow for some variations to the initially intended multichannel arrangement, which in turn gives rise to different actualisations of the piece. In my experience of performing my pieces composed with the spectral spatialisation technique, I could change and bend the multichannel configurations without destroying the material, but instead creating a new variation of the sonic material and the way it forms extended shapes in space.

3.3.5. The *Pejvak* method

Pejvak, which means 'echo' in Persian, is the term I use for a spatialisation method that I have developed based on and inspired by the phenomenon of echo or reverberation, which exemplifies another strategy for achieving spatial polyphony within a multichannel configuration. Sounds reflect from hard surfaces, and on each reflection or iteration they lose part of their energy until they fade out into silence. Echoing is a natural behaviour of sound in a space. The Pejvak method takes this paradigm and schematically expands and transfigures the delayed repetition and decaying which is characteristic of echoing. Each sound source (loudspeaker) represents a reflecting surface on which the sounds are made to 'bounce' by means of electroacoustic processing rather than physical reflection. Three parameters are involved in this process: the degree of reduction of intensity for each iteration, the delay time between each iteration, and the spatial location of each iteration, together establishing a network of diminishing or decaying repetitions in a space. An extra compositional layer can be added here by modifying and processing the sounds on each iteration. By varying the aforementioned three parameters (with or without extra processing), highly diverse results can emerge, from a realistic echo effect to an abstract one in which the delay times are exaggerated so that the sounds are no longer perceived as echoes. This technique works best with short sound objects, so that the relationships between the iterations in the space are better delineated. Applying multiple layers of such a process gives rise to a complex and dense spatial polyphonic texture.

I applied this method for the first time in *Hafthasht* (2019), composed for 24 channels. The piece begins with rather clearly perceivable iterations of short sound objects framed by silence. This might be called 'sonic *chiaroscuro*' in which relatively short sound events emerge from and recede into a background of silence.[51] Close to the end of the piece, these iterations shift towards a more realistic echo effect. In other words, the piece begins with 'abstract' echoes and ends with 'real' ones. Pejvak is therefore another compositional method directed towards the integration of space as a musical parameter. Again, music produced with this method can be actualised in a variety of manners with different loudspeaker configurations.

---

[51] Chiaroscuro is an Italian term which translates as light-dark, and refers to the balance and pattern of light and shade in a painting or drawing Chiaroscuro is generally only remarked upon when it is a particularly prominent feature of the work, usually when the artist is using extreme contrasts of light and shade. (https://www.tate.org.uk/art/art-terms/c/chiaroscuro)

3.3.6. Spatial micropolyphony

The affordances of electroacoustic music, such as the possibility of layering and controlling numerous 'voices' can turn spatial polyphony into a kind of micropolyphony as described by György Ligeti (Clendinning 1989, 3), or 'sound masses' as described by Edgard Varése (Anderson 1991, 35) where individual voices or layers are concealed in highly dense textures. The term micropolyphony, first introduced by Ligeti, denotes a dense polyphonic texture in which the individual lines (voices) are not discernible as such. According to contemporary music scholar Eric Drott, 'in micropolyphonic pieces, the circulation of independent voices within a narrow ambitus produces a masking effect, the overlapping of parts interfering with their segregation into distinct streams. Individual threads become difficult to discern and, as a result, merge into a fused fabric' (2011,7). This is the threshold where perceiving (spatial) polyphony blurs into a monolithic texture. A *granular synthesis* technique, employing numerous 'sound grains' as building blocks, can benefit greatly from multichannel configurations.[52] Each grain (or each group of grains) may be assigned to different points in space (different channels), and thus projected from a different spatial direction. In his book *Microsound* (2001), the composer Curtis Roads discusses the possibilities of distributing sound particles spatially via a multi-loudspeaker setup, which can result in a 'cloud' of sound:

> Through new particle scattering algorithms, micromodulation, per-grain reverberation, and convolution, we have now extended spatialization down to the level of microsound. When we project these microspatial effects in a physical space over widely separated loudspeakers, these tiny virtual displacements appear far larger, and the sounds dance. (2001, 233)

Some of the aforementioned techniques, such as spectral spatialisation and Pejvak, might produce such a spatial micropolyphony by increasing the number of layers and musical events, although the sonic outcome tends, as Drott points out, to become a dense immersive monolithic texture, blurring the spectral shapes or the relationships between initial sounds and their echoes.

3.3.7. Sound movements

Spatial polyphony can also be achieved through coordinated movements of multiple sounds, or a combination of moving and static sounds. As the composer James Dashow explains:

> Several events in motion simultaneously along different trajectories add a physical (directly experienced) sense of counterpoint to the ensemble of events that is occurring. Following the trajectories of two or more sound sequences that move through perceptual space produces a fresh kind of contrapuntal awareness: you have the sense of musical linear interactions, but now physically transcribed in such a way that the musical lines moving around you define space – or, better, make you aware of space (and the effect of counterpoint) in an entirely new sense. (2013, 5)

[52] According to Curtis Roads, '[a] grain of sound is a brief microacoustic event, with a duration near the threshold of human auditory perception, typically between one thousandth of a second and one tenth of a second (from 1 to 100 ms)' (2001, 86).

In theory, all the aforementioned point-source approaches can also be implemented using moving (virtual) sound sources. However, achieving convincing sound movements requires a precise arrangement of the multichannel sound system, which might not always be possible for technical and architectural reasons. This reduces the range of possible actualisations of a piece. Among the available technologies for moving sounds in space, Wave Field Synthesis (WFS) is one of the more successful approaches to create convincing sound trajectories. When I have an idea for a composition which involves moving sounds, I prefer to implement it on the WFS system, since this provides a higher degree of accuracy and stability in reproducing sound movement, in comparison with more conventional sound reproduction methods. I have composed three pieces for WFS: *Dor* (2012), *Sefrhasht* (2016) and *Yekhaft* (2021), each of which focuses on musical interrelationships between sound materials and the inherent potential for movement in space.

In Persian, the word Dor has different meanings such as 'cycle', 'turning' and 'whirling'. Being inspired by the whirling ceremony of Sufis, circular movement is the key gesture throughout the piece. All the sound materials are recorded from an ancient (circular shaped) frame drum known as daf, whose poetic and ritualistic function plays an important role in forming the narrative structure of the piece. The sound movements relate closely to those executed in recording the drum, with a microphone moving in a circular pattern to follow the movement of rubbing and scratching the drumskin. The same kind of circular trajectory was then implemented on the WFS system. In *Sefrhasht*, I combined moving virtual sound sources with spectral spatialisation (using static and moving virtual sound sources) in WFS. The music consists of four layers: static polyphonic sources, extremely slow movements, short gestures and extremely fast movements which function as sound oscillators. All these layers coexist and overlap, or appear in isolation. In *Yekhaft* I also explored the connection between sound production movements and their representation on the WFS system. Here all the sound materials were produced by bowing strings, and the bowing movements form the core idea of the composition's spatialisation, so that the sounds describe arc-shaped trajectories.[53] The length and speed of these trajectories in space are proportionate to the speed and intensity of the bowing itself.

In terms of their presentation, WFS pieces use one of the least flexible formats, since their composed virtual sound sources and trajectories can only emerge using a highly specific and uncommon combination of hardware and software. In other words, any variation to the precise arrangement of the loudspeakers in a WFS system results in deformation and disturbance of the intended trajectories. While this system provides a unique listening experience, it is at present an non-standardised technology so that presenting a WFS piece on a system other than that for which it was composed might require implementing all the movements once again on the new platform. Presenting a WFS piece is often considered to be no more than 'playback' (due to the rigidity of the format), although, in my own experience, controlling and balancing the mix of the various elements in the music, in relation to the venue and the atmosphere of the concert, is often required before (in the soundcheck) and during the performance. In presenting my WFS pieces, I often actively change the loudness and EQ of individual tracks (musical events), and of the overall mix, as the music unfolds.

[53] All the bowing was done on the strings of a santur, which, originally, is not a bowed instrument.

3.3.8. Critical reflections on spatialisation

In my experience, there will always be surprises, both positive and negative, in how ideas for spatialisation turn out in practice, since, in comparison to orchestral compositions, there is less tradition or body of theoretical work to draw upon. Some recent studies attempt to fill in this gap by providing some theoretical and practical insights into how space as a musical parameter can have an influence on our musical understanding. For instance, Luca Danieli et al. (2021) conducted a study on 'sonic trajectories and the perception of cadence in electroacoustic music'. A sense of closure in a musical cadence is traditionally achieved by harmonic progression. Their experiment provides some useful information on how various sound trajectories in space can evoke the perception of a sense of cadence or closure or 'completeness'. While the results show that certain spatial patterns evoke such musical phenomena, it appears that the results also depend on the group of listeners and their acquaintance with spatial music. Their research is certainly a step in the right direction, but clearly much more investigation is needed in order to establish a solid conceptual framework.

Gary S. Kendall and Andrés Cabrera (2011) discuss some examples of misconceptions in spatial audio, resulting in aspects which do not work as expected: '[m]aybe more than any other facet of technological music, mastering spatial audio seems to involve a learning process in which one slowly discovers the things that work and those that don't' (2011, n.p.). Similarly, Ludger Brümmer confirms that '[t]he desired spatial impression defined by parameters can differ from the perceived impression, sometimes in significant ways' (2017, 55). Such considerations lead directly to the performative concepts discussed in the present thesis. Apart from the limitations imposed by technology and/or acoustics, a common issue arises from thinking of sound and spatial sonic relationships in visual and geometrical terms. Visually conceived patterns, shapes and trajectories will not necessarily be perceived as such in the sonic domain. As Kendall and Cabrera put it, '[s]onic artists need to be alert to the nuances and idiosyncratic relationship of spatial hearing to spatial thinking' (2011, n.p.). Spatialisation, therefore, is better informed not by abstract geometrical designs but by sonic realities described by psychoacoustics, which is concerned with how we actually perceive sounds and their spatial qualities, rather than how we imagine they might be perceived.

In the article 'Octophony: Electronic Music from Tuesday from Light', Stockhausen delineates the interconnection between the musical material and its spatial movement in his piece *Oktophonie* (1991). Sophisticated 3D sound trajectories are designed to be projected on an eight-channel configuration in the form of a cube, which also allows for vertical sound movements. Stockhausen underlines his compositional strategy in foregrounding the (polyphonic) simultaneous sound movements, and by reducing activity in other musical parameters such as pitch and rhythm thereby allowing for a better perception of the spatial movement:

> In order to be able to hear such motions – above all, simultaneous ones – the musical rhythms must be drastically slowed down; the pitches must change only very occasionally, and only in small steps or with glissandos. (1993, 163)

Indeed, an important part of composing multichannel music involves being conscious of the interconnection between the musical material and its spatial attributes, not imposing spatiality on the material but causing it to emerge from the inherent characteristics of a given sound object. Spatialisation is thus not something to be done once a composition is 'finished', but

something embedded in the composition process at every stage. Moreover, as Gottfried Michael Koenig already wrote in 1961, we need to be cautious 'so as not to fall unresistingly into gimmicks or into a fetishisation of the medium' (1961, 47). Put differently, spatial arrangements or moving sounds in space ought to be musically and compositionally motivated, rather than acting merely as effects or ornaments, or simply because the requisite technological means are at hand. As Dashow aptly underlines:

> Spatialization is already changing the way music is conceived. One could say that up to now, musical composition has been largely a question of "what happens when." With spatialization, composition now becomes "what happens when and where." As more work is done to refine spatialization concepts and discover new modes of musical thinking in terms of space, it becomes clear that spatialization is our genuinely new contribution to musical art. (2013, 6)

As Koenig remarks, it might, be considered inappropriate to ascribe the same musical importance to the 'where' of a sound that we accord to its 'what' and 'when'. Nevertheless, I argue that the crucial point in composing spatial music is to establish a meaningful and musical relationship between 'what', 'when' and 'where', so that each contributes to a composition in its own way and to its fullest extent.

3.4. Post-mix

Post-mixing, being an adaptive, creative and practical approach to the presentation of fixed media music in public spaces, brings an element of the composition process onto the performance stage. This idea stems from my involvement in presenting fixed media music in concert venues in recent years, and from dealing with the challenges inherent in such a process. Unlike the well-known approach of 'sound diffusion' (see Chapter 1) in which a smaller number of channels (usually two) is actively projected or diffused through many more sound sources (loudspeakers) during the performance,[54] post-mix is defined as composing for a larger number of channels and mixing them down to fewer (or the same number of) sound sources, depending on how many loudspeakers are available at the venue.

Something similar is described by Jonty Harrison and Scott Wilson as *stem* composition (2010, 245), referring to the common practice of sound engineers in mastering where '[s]tems constitute the submixes or – more generally speaking – discretely controllable elements which mastering engineers use to create their final mixes'. Harrison and Wilson continue that '[i]n a similar fashion, one can compose in stems, separating out elements that need to be treated discretely in a final spatialisation, which in itself may vary to a small or great extent from one performance to another' (2010, 245). Such separation of the constituent musical elements further increases the scope for actualisation (Chapter 1) as it expands the range of choices a performer can make. Harrison and Wilson state that 'composing in stems does not in itself imply any particular final distribution or technique'. Post-mix, on the other hand, is not concerned with an arbitrary relationship between 'stems' and their eventual spatial distribution, but with a spatial compositional concept which may be varied from one situation to another while retaining its integrity, and whose internal relationships thus vary in some aspects while remaining true to the original concept in others. For instance, a piece can be composed in a higher number of

[54] Curtis Roads in his book *Composing Electronic Music* refers to such practice as *upmixing*. (2015, 385)

channels for a specific arrangement at its first performance – as in *Sehasht* (see below) – and then be rearranged for another presentation. The main objective here is to increase the adaptability of the composition in relation to various presentation circumstances, which vary, often dramatically, from concert to concert. The goal of post-mixing is not to recreate in the concert an 'ideal' piece as heard in the studio, or to bring 'discretely controllable elements' (cf. Harrison and Wilson's stems) to be assembled into a spatial composition *in situ*, but for a specific musical conception to be *completed* within the context of a performance situation. The 'imagined' composition is actualised only in the moment of its concert presentation.

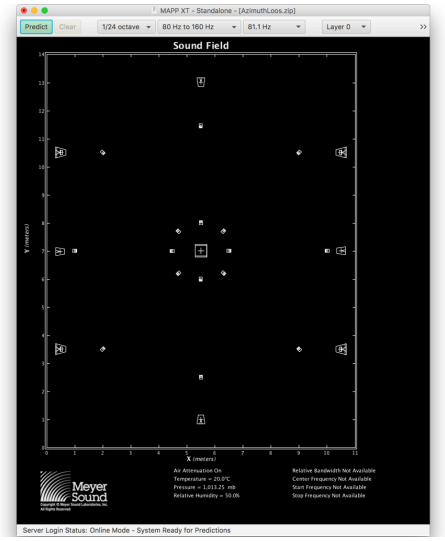
This may be seen as opening up fixed media music to a further dimension of interpretation, where the performer is able to highlight (or diminish) certain elements in the music, at the same time making it easier to adjust the composition to the acoustics of various venues. For instance, in a particular concert hall, certain sound materials might sound too faint or too harsh because of the acoustics, and in particular the frequency response of the space. Having precise control over the interactions between the constituent layers of the music makes it possible to accurately rebalance those relationships. In the following case study, I will demonstrate how post-mix can be conceived in practice.

3.4.1. Presenting *Sehasht* in three different spaces

Sehasht (2016) is a fixed media piece composed in 24 channels. Presenting this piece in various situations and circumstances gave rise to the idea of post-mix, by making clear the potential advantages and importance of such an approach to composing and performing fixed media music. *Sehasht* was composed for the first concert given by Azimuth (see below) in Studio Loos in The Hague.[55] Since one of the central objectives of the Azimuth organisation has been to promote multichannel spatial music, we designed a 24-channel sound system, which, at that time, was not a common occurrence. Knowing the venue and having participated in determining the exact arrangement of the loudspeakers in the space, I composed a piece specifically for this elaborate setup. A crucial element of this process was a 'mini-residency', a week prior to the concert, to work with the system and to finish and fine-tune my piece in the same space and with the same sound system as would be used for the premiere. Such a possibility is generally speaking quite luxurious. In most concerts of electroacoustic music, there is only enough time for a quick sound check and a rehearsal of about one hour per piece, which is often insufficient especially for longer pieces. This is usually also the first time that the piece can be heard in the form the audience will hear it, as opposed to the studio(s) where it was produced. In the case of *Sehasht*, thanks to the mini-residency, there was sufficient time for me to listen and make adjustments in the actual situation. Having a variety of loudspeaker groups in diverse positions and facing in various directions (see image below) created extensive possibilities for 'orchestrating' the music in the space. In typical multichannel setups, the audience is surrounded by loudspeakers, but here sounds could also be projected outwards from a central eight-channel ring, giving rise to the possibility of a more complex spatial polyphony.

After the premiere, I was invited to present *Sehasht* at other locations. Initially, I was sceptical about presenting the piece in any arrangement other than the 'original' one. However, given that recreating the original setup would always be difficult to achieve in another space, I decided to take on this challenge and see to what extent I could adjust and bend the original compositional

[55] www.loosdenhaag.com/what-is-loos



Azimuth #0 loudspeaker setup

intentions to fit a new situation. My first opportunity, in 2017, was in a Sonology Discussion Concert in the Arnold Schönberg Hall in the old building of the Royal Conservatoire in The Hague. A 16-channel sound system was set up, consisting of an eight-channel ring surrounding the audience (the default setup for most Sonology concerts), and another eight-channel system situated on the stage forming an arc. This onstage system was not intended for my piece, but for another live performance in the same concert, but I decided to find a way to use it creatively. This arrangement was vastly different from the setup in Studio Loos, as were the size and shape of the space itself, which, as a traditional concert hall, was much larger and much more reverberant. Having 24 discrete tracks in the composition enabled me to experiment with various configurations on this 16-channel setup. This involved mixing down two groups of eight tracks onto the surrounding ring – the material that was originally meant to envelop the audience. The other eight-track group was assigned to the arc of loudspeakers on stage, which formed a choir-like entity so that the sound material projected through them took on a kind of 'soloistic' character, giving a new meaning to the musical relationships composed into the piece. This 'soloistic' effect was not originally intended, but made musical sense in the context of a typical concert arrangement where the audience faces in a single direction towards the stage.

In October 2022 I had the chance to present *Sehasht* once more, this time in the Conservatoriumzaal of the Royal Conservatoire's new building in The Hague. Here, the spatial circumstances were not dissimilar from those of the previous performance – a large concert hall with a forward-facing seating arrangement. This time, a 24-channel sound system was available, however with a different layout: one eight-channel ring surrounded the audience at ear-level, and a second ring was situated on a balcony facing upwards. The considerable distance between the two rings created a sense of vertical depth, generating a new and interesting musical effect by adding height to the spatial polyphony of the piece, another new dimension not originally anticipated. Here again, I used an arc-shaped eight-channel array on the stage to complete my 24-channel setup. I preferred this actualisation of *Sehasht* to the first one, although the future may hold yet more possibilities for bringing out different aspects of the music which might have been relatively latent at the time of composition.

Reflecting on my experience of presenting *Sehasht* at various locations and in different circumstances, it became clear to me that this piece, despite consisting of 'fixed media', was in fact quite *flexible* in being able to take on new sonic shapes with each performance. This led me to rethink the ontological status of fixed media compositions, to formulate it in terms of the concept of the virtual and the actual, as discussed in Chapter 1, and to realise the potential of

composing in a *higher* number of channels than might be used in a concert, which in turn prompted the idea of post-mix. In my experience, each concert is substantially different from every other, not just in atmosphere, but as a result of how the various locations impose on the music their own physical conditions and characteristics, such as their scale, shape, acoustics and possibilities in terms of the positioning of loudspeakers and audience. Moreover, the type of equipment often varies from venue to venue, necessitating the 're-orchestration' of the piece for each event. Post-mix, therefore, is not only a practical solution to the variability of concert circumstances, but has an important artistic dimension in embodying a motivation to realise a given piece anew each time it is performed, so that 'fixed media' compositions become open and alive, and are 'completed' differently at each concert in response to circumstances and contingencies.

After the experience of *Sehasht*, I expanded the idea of post-mix in *Charhasht* (2017) for 32 channels, composed for another Azimuth concert, this time with a 32-channel sound system designed for the Nutshuis in The Hague. Subsequently, in 2018, I presented the piece during the TodaysArt festival in the Satosphère (a temporary inflatable dome-shaped venue) on an 8-channel sound system.[56] An unwanted comb-filtering effect, resulting from reflections within the dome, required extensive EQ, which I was able to apply separately to each track thanks to the separation of the materials. The number of tracks used in a composition will depend on the compositional ideas and their spatial implications. Moreover, mixing and controlling the higher number of channels is often a demanding task which at times might become overwhelming for the performer. (For related reasons I reduced the number of tracks in *Hafthasht* (2019) from 32 to 24 after its premiere.) But the main point of the post-mix principle is not the number of channels in itself, but the possibilities it opens up: to shape and actualise the piece in response to the context of each presentation.

3.5. Dynamics in fixed media music presentation

> The ears should go to the music, not the music to the ears.
>
> (Beatriz Ferreyra)

A seemingly simple but crucially fundamental aspect of the performance practice of electroacoustic music is the controlling of loudness as the music unfolds. According to the acoustician and researcher Reinier Plomp, '[l]oudness generally refers to auditory intensity', and, in comparison to other attributes of sound, such as pitch and timbre, is 'strongly dependent on environmental conditions (such as distance and reflections)' (2002 ,29). Unlike (acoustic) music where loudness is the direct result of the physical effort of the performer, there is no direct correlation in electroacoustic music between loudness and effort: producing loud sounds is in fact quite effortless. A *fortissimo* on a piano requires a physical effort from the performer, and cannot exceed a certain loudness level owing to the physical limitations of the instrument and the playing technique. In electroacoustic music, any sound material may be projected more softly or loudly just by a simple movement of the faders on the mixing desk at any given moment, regardless of the dynamics already incorporated into the piece at the composition stage. Loudness is thus a crucial parameter of the performance of fixed media music, but in quite a different way compared to its role in instrumental music. While loudness can be precisely and objectively measured, it is one of the most subjective aspects of music perception. Not only

[56] www.sat.qc.ca/en/satosphere/

do people have different aural organs and therefore different hearing capacities; cultural and aesthetic factors also play an important role. Something that might be considered annoyingly loud for one person could be a comfortable volume for another. Furthermore, the type of sound material and its spectral composition affects the perception of loudness:

> Two tones of the same physical intensity can still differ considerably in their perceived loudness, depending on their spectral structure. The more the intensity is spread over a wider frequency range, the louder the tone seems to be. The most extreme difference in perceived loudness is between a sinusoidal tone without harmonics and a tone consisting of a large range of strong harmonics – the sound level of the sinusoidal tone may need to be as much as 12 dB higher in order to be heard as equally loud as the complex tone. (Plomp 2002, 29)

These considerations should be taken into account both at the composition stage and in the presentation of music to be heard exclusively through loudspeakers. My own experience is that finding a proper volume is crucial for a successful performance of fixed media music: playing the music too loud (which is actually a common occurrence) tends to destroy the subtleties and nuances of a piece. According to the music researcher Arnie Cox '[l]oud sounds "come at us" and in some cases "push us away"; they require no effort on our part to hear them, but they can motivate protective or otherwise aversive responses' (2016, 207). It is often observable that if loudness reaches an extreme, people in the audience begin to cover their ears. This is the moment that the trust and bond between audience and performer is breached; one can no longer focus properly on the music, knowing that such extremes might happen again. Nevertheless, for some composers, loudness and the high intensity of sounds is an aesthetic aspect of their music, such as the performances of Thomas Ankersmit, where the extreme volume can make the human body vibrate. Everyone who has attended a concert of Xenakis performing his own electroacoustic pieces confirms that it was always uncomfortably loud. According to Agostino Di Scipio, '[t]he deafening première of *Bohor*, in 1962, caused Pierre Schaeffer's bitter disappointment, although that piece was dedicated to him!' (2010, 180). He underlines that:

> Xenakis acknowledges that the idea of immersion is an important feature in *Bohor*, and that *Bohor* needs volume for the ear to penetrate into the sound and hear the minute details of the sonorities. (2013, 2)

Similarly, the composer James Brody talks about a performance of *Bohor* in 1968:

> A tremendous furor was aroused in Paris in October 1968 at a performance of *Bohor* during the Xenakis Day at the city's International Contemporary Music Week. By the end of the piece, some were affected by the high sound level to the point of screaming; others were standing and cheering. "Seventy percent of the people loved it and thirty percent hated it" estimated the composer from his own private survey following the performance. (1971 n.p. in Roads 2015)

The composer and author James Harley believes that the reason for Xenakis' loud performances was actually the fact that he had problems hearing high frequencies 'owing to his wartime experiences' (1998 ,75). But it may be that playing such music too softly indeed fails to convey its intended impact and power, because certain frequencies might lack presence and because

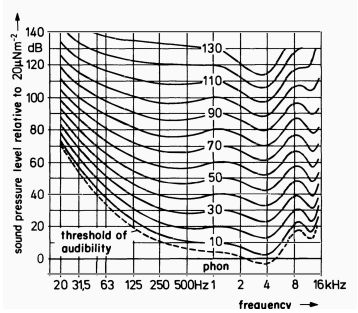
Xenakis intended the audience to hear the music with the overwhelming power he imagined it to have.

Quietness, on the other hand, can also be a powerful compositional tool, for example to promote a heightened sense of awareness and attention. As Arnie Cox explains,

> quietness has another effect. The acoustic impact here is more of a non-impact, making listeners come to the sounds. This unusual effort (effort is too strong a word) is, I find, integral to devoted engagement with this music, as it is in attending to significant portions of, say, Feldman's *Rothko Chapel*, or listening to quiet musical moments and silences generally. Of course, some listeners might be frustrated by the effort in such cases (here, I think effort is not too strong a word). The quietness makes a demand, and engaged listeners will feel something about this demand. (2016, 207)

I argue that this 'demand' can sometimes have a much stronger musical impact than high sound level, as I explored in my composition *Toranj* (2012), which begins at the threshold of hearing – the audience is not sure whether the music has started or not – and continues slowly to reach an extreme loudness towards the end. Establishing the 'right' loudness is crucial in performing *Toranj*. The threshold of hearing is not only subjective, but also depends on the space and the acoustical circumstances, so that it is a delicate task for the performer to maintain this 'demand' and control a crescendo curve over almost 22 minutes, like a conductor performing Maurice Ravel's *Bolero*. I often employ such a large dynamic range as a compositional element, which in turn requires great attention to detail in a performance to ensure that quietness and loudness are both appropriately represented.

Besides influencing the mode of perception, the intensity of sounds also affects their perceived quality. A given sound object has different characteristics at different sound levels. According to the figure below, our perception of the frequency spectrum in relation to loudness is not linear: a given sound object at a lower intensity is perceived as missing a significant proportion of its lower frequencies, affecting the composition of the frequency spectrum and hence the perceived quality of that sound (Blauert 1997,120). To understand those various characteristics and behaviours, I always listen to my sound material at different volumes while composing. This correlation between sound level and timbral qualities underlines the importance of loudness on the sonic outcome. Finding the proper volume – and actively adjusting it as the piece unfolds – is a complex issue, depending on various elements such as musical structure, material of the piece, the space and its acoustical characteristics, the aesthetic choice of the performer as well as the atmosphere of the concert. It is therefore the task of a performer to find a balance among all these elements.



Curves of equal loudness level for sinusoids (Blauert 1997,120)

3.6. Azimuth

In the light of the various challenges I experienced in performing my multichannel music, I realised how difficult it is to present this music in the 'real world'; it is often frustrating to convince concert programmers why it is important to have a multichannel setup in their venues, and why the high costs of doing so is justified, given that most venues work with stereo sound and that sound engineers are not accustomed to thinking in more complex spatial terms. I often had to convince them why eight or more loudspeakers had to be arranged in some specific way when, according to them, a fine stereo PA system was already installed in the hall! This problem stems, of course, from the dominance and omnipresence of the stereo format, as well as a lack of awareness of the concept of spatial music. Apart from the loudspeakers, a suitable mixing desk in a suitable location (not, for example, at the side of the space) is needed in order to route the signals and to be able to control them independently and accurately. The main problem, in my opinion, is the lack of organisations specialised in this field, with both the necessary technical knowledge and artistic insights. This is how and why Azimuth was born in 2016, after some discussions and brainstorming with two colleagues-friends. Azimuth is dedicated to promoting and developing the composition and performance of multichannel music by organising concerts in various locations in order to introduce this music to a more general public, and to give the composers the possibility to develop new spatial compositions. Azimuth is not bound to any specific system, setup or equipment, but takes a flexible approach to the circumstances of each performance as well as the needs of the music being presented, with an emphasis on exploring the architectural features of various venues, including spaces not originally intended for concerts. From the outset it was clear that Azimuth should not be a sound reproduction system or another 'loudspeaker orchestra' along the lines of BEAST or the GRM Acousmonium, or a permanent setup such as Klangdome; rather, it should be a platform which connects composers and audience, while exploring the architectural sites as the locus to establish unique spatial sonic experiences.

Azimuth provided an opportunity to observe other composers' approaches to presenting their fixed media music in public. Some composers created new pieces in the knowledge that a sophisticated multichannel system was available to them, bringing up the question of how such pieces might then be performed on other occasions. Here, the post-mixing might offer a convenient and compositionally fruitful solution, as discussed above. Other composers reworked and adapted their existing compositions for Azimuth concerts, either by 're-orchestrating' the composition for the available multichannel setup or diffusing their multichannel composition live over the Azimuth system. Horacio Vaggione's approach in the Azimuth #3 concert (2017) was quite idiosyncratic. After spending some time with the system and trying out his composition *24 Variations* (2001) in the venue (Studio Loos), he decided to split the whole sound system into two halves (skipping the centre loudspeakers), and statically assign the two-channel (stereo) music to each half, in distinction to the common practice of sound diffusion in which the performer moves the stereo image through the multi-loudspeaker setup during the concert. He mentioned that the reason behind his decision was the symmetry and balance of the sound system. Nevertheless, he controlled the levels during the concert.[57] The sonic result was quite surprising and spatially rich, due to the specific technique he utilises

[57] In contrast, Trevor Wishart sometimes prefers to sit among the audience during the concert, eradicating his agency as a performer completely.

in creating a stereo image through very slight time delays between the channels (Strassmüller 2008, 6).

Francisco López, on the other hand, constructed a performance rather than presenting a piece. He combines various musical elements flexibly, based on the circumstances of each performance, rather than performing a single piece, to create an experience built and constructed during the performance. According to López, presenting a 'fixed piece' in various situations is bound to create problems since each space requires a different approach. This is similar to what was discussed earlier as 'completing' the composition during its performance. For his performance Azimuth (together with Lopez) designed a sound system where he could diffuse his stereo source over eight clusters of four different loudspeakers and one subwoofer. In this way he could vary the colour of the material for each channel by diverse mixtures of those four loudspeakers. He also specifically wanted to use an analogue mixer in order to be able to have a constant and simultaneous control over all the parameters (EQ, sends, etc.).

Taking the performative aspect still further, Ji Youn Kang composed a live piece inspired by and based on the specific setup of the Azimuth #8 (2019) concert. She used the room resonances of the space as the main material, by picking them up with two microphones attached to her wrists and two other microphones in the hall. The result consisted of continuously stabilised audio feedback coming out of 16 loudspeakers and 8 wooden panels with transducers.

In addition to the wealth of possibilities in materialising fixed media pieces in space, length and temporal aspects can also be modified for each presentation by adding or removing various parts to or from the composition. For instance, in presenting my piece *Charhasht* (2017) at Azimuth #7 (2018) in the Satosphère, I decided to extend the length of the piece, given the circumstances of the concert. This decision was based on the unique dome-shaped concert venue where, in the absence of any chairs, the audience could lay down or sit on the soft floor. I believed that a longer duration better matched the relaxed bodily condition of the audience. I added an extra (penultimate) section of around three minutes before the ending of the piece, which at the same time better completed the dramatic structure of the music. At another concert, I removed a middle section from *Tom+Bak* (2020), making the overall length more suitable for the opening of the programme. Those experiments led me to the idea of constructing a seamless performance, together with the singer and composer Marie Guilleray, in a concert during the Peel Slowly and See festival (2022) in Leiden. When we were asked to give a concert together, we decided to combine various parts of our pieces to form a single whole instead of each performing a separate piece. Similarly, Richard Barrett, in his contribution to Azimuth #3, extracted a number of 8-channel fixed media sections from his composition *life-form* (2012) for cello and electronics, and combined them into a new sequence. Such examples demonstrate that the temporality and the structure of fixed media pieces can also be open to modification from one performance to another.

From the very first Azimuth concert on, we decided to break with the conventional arrangement in which audience seats are organised in rows facing the stage. This is a functional arrangement when attention is centred on music-making actions taking place on that stage, with the seating area designed to provide an optimum perspective on the performance for the majority of audience members. However, such an arrangement is less compatible with fixed media music pieces, and specifically those in which space plays an important role, for example when the music is projected from various locations, thus destabilising a frontal point of attention. The

presence of the 'performer' in fixed media music is, therefore, of a different nature than that in most other music (see Chapter 1). Having the audience sit in a circular arrangement - with no raised stage and no frontal directionality - might correspond more closely to the spatial and immersive nature of multichannel music, and also provides a situation where audience members can easily see each other and be aware of each other's presence, giving rise to a social bond, and enhancing the atmospheric qualities of the event (see Chapter 2). In practice, realising such an arrangement is sometimes limited by the architecture and the shape of the space, so that a creative solution or compromise has to be found.

Working in this way with Azimuth has certainly deepened my understanding of the interrelationships between composition and performance practice in fixed media music, both through presenting my own compositions and in observing the different approaches taken by other composers. This experience continues to have a profound influence on my present and future compositional work.

Azimuth #5, Nutshuis, The Hague, photography Anna Glinka

Conclusion

> The experience of the 8 loudspeakers is extraordinary. There is no room for anything but immediate listening. The air was so alive one was simply part of it. (Cage 1953 [1993], 143)

In this letter to Pierre Boulez, John Cage reflects enthusiastically on the experience and the atmosphere of the first concert at the University of Illinois (1953) with eight tape recorders and eight loudspeakers surrounding the audience, where his piece *Williams Mix* was premiered. 70 years later, the extraordinariness of listening to multichannel music still strikes me every time I attend a concert of electroacoustic music.

The main objective of this research has been to understand and articulate the importance, indispensability and artistic possibilities of the public presentation of fixed media electroacoustic music, regarding such presentation as the only way to fully materialise and experience this music. I have shifted the focus from the fixity of the medium towards the diversity and wealth of the listening experiences that it can engender, and I celebrated the creativity and imagination that multiple actualisations of a piece of fixed media music can afford. I have explored this topic through a close observation of my own practice as a composer, performer and listener of fixed media music, as well as through documenting and observing other composers' approaches, conducting interviews with some prominent practitioners in the field, and drawing on various sources of literature such as music history, electroacoustic and computer music, sound studies, conducting, architecture, and philosophy. Throughout this process, I have experimented and enacted the ideas generated through my research by composing new works of fixed media music for various configurations, sound systems and technologies, as well as presenting them in diverse circumstances. By considering the composing and performing processes as components of a single continuum, I have delineated the reciprocal relationship between these processes to shed light on the question of what it means to *perform* fixed media music. I have done so by providing an insight into the practice from within, reflecting on my own activities and concerns in the form of (audiovisual) autoethnographic work.

The electroacoustic technology of sound recording has transformed our conception of music: from documenting and 'storing' a musical performance (as in recording a concert) to *constructing* a performance through editing, to composing the music *with* and *onto* the medium. While this notionally fixed medium seemed to suggest and promote the emancipation of the music from live performance, in practice the collective listening situation and the bodily presence of the audience gave rise to a performative situation and a quality of liveness. The responsibility for shaping the audience's experience, by controlling the parameters involved in materialising the 'fixed' sound files, requires an agent that we may call a performer. My research has demonstrated that fixed media music should not be regarded as an abstract entity, but rather as something that needs to be materialised and formed as a sonic substance in space, so that it can come to life and become music. In other words, the sounds heard by the audience are inseparable from the space of their performance; the circumstances under which such a performance takes place play an important role in the sonic result. It follows that there is no perfect and ideal *realisation* of a piece of fixed media music, but rather different *actualisations* related to the circumstances and contingencies of the situation in which they are presented. Just as with orchestral performance, CDs or online platforms for private listening give only a limited impression of the richness and spatiality of the music.

While giving a comprehensive account of spatialisation techniques and their history was beyond the scope of my research, I have nevertheless tried to formulate an understanding of the role and importance of space as a musical parameter in composing and performing fixed media music by proposing the concepts of *spatial polyphony* and *post-mix*. Spatial polyphony is concerned with thinking compositionally in terms of multiple sound sources at every stage in the process of music making, rather than considering this as an 'ornament' added at the end of the process. At the same time it grounds the work within its performance context, so that the work comes to full existence only in the performance space. Listeners to such spatially conceived compositions find themselves so to speak *inside* the music, becoming more active participants rather than distant 'observers'. Composing in a higher number of channels than those to be used in a performance – which I have termed *post-mix* – proved to offer more flexibility in adapting fixed media pieces to various circumstances. This in turn prompts a more creative and artistic approach to performance, which, as demonstrated in my case studies, may generate quite new musical experiences from a single piece.

Anyone who has attempted to make an audiovisual documentation of a concert of fixed media music knows that this is most likely doomed to fail. Apart from the technical difficulties of recording in low light conditions, the concert situation of fixed media music somehow resists being documented, and the recorded material fails to communicate the essential qualities of the live experience, seemingly to a greater extent than with other musics. I argue that a principal reason for this lies in the *atmospheric* aspects of the concert situation, which are not reproducible in a recording but can only be sensed physically in the performance space: the absence of a stage with performers causes listeners to be more aware of their own bodily presence and that of their fellow audience members. An audio recording of fixed media concert presentations is also reduced relative to its source, the original sound file. Depending on the recording technique, it carries with it the acoustical footprint of that concert hall, which has no relevance when the music is heard in another space. Even using spatial recording techniques such as Ambisonics does not remove the problem of listening to one space inside another. Nevertheless, I have always tried to make ambisonic recordings of my concerts, resulting in an archive of ambisonic B format files. However, I find myself less and less frequently going back to listen to those recordings. If I need an 'impression' of one of my pieces outside the studio or concert hall – in other words a stereo reduction – I prefer to recreate that version from the 'original' multichannel sound files, removing any expectation that the ineffable atmosphere of the concert event might be sensed through the recording. Rethinking the fixed media music concert situation in terms of atmosphere, as discussed by Gernot Böhme and others, provides a deeper understanding of the ineffable feelings which occur only at the here and now of the concert moment. This involves a synergy of various elements ('atmosphere generators' according to Böhme) which together constitute the atmosphere of the concert. When I compose now, I tend to think more broadly than just in terms of the composition itself; I have become more conscious of the circumstances of its presentation in a more holistic manner. Imagining the atmosphere of the concert, in turn, inspires me and guides me through the composing journey. While fixed media music can and often does take place in an acousmatic situation, where the music is 'invisible', lighting can still play an important role as an atmosphere generator. Through this research project I realised the importance of lighting and peripheral vision in shaping the experience of listening to fixed media music, an area which requires further investigation.

Having a background in instrumental music composition, I found that the affordances of electroacoustic music opened up a new *modus operandi* in working with instruments. I have continued to explore the question of what it might mean to make instrumental music for loudspeakers, expanding on the possibilities of shaping and forming instrumental sounds, not only by exploring new timbres but, more importantly, by re-contextualising them, specifically in the context of using traditional Iranian instruments. Although this research has concentrated on electroacoustic music as something distinct from instrumental composition, my work on the Broken Ensemble project should serve to underscore that I regard my work with fixed media as a continuation and extension of composition for more traditional resources, rather than as something alien to it. Broken Ensemble explored the potential and affordances of alternative (or nonstandard) loudspeakers for presenting fixed media music, and the way these might affect and shape the sonic material, while also shaping the performance situation through their visual presence and materiality.

Future perspectives

I plan to develop the spatial polyphonic dimension further by composing for a 'broken string orchestra', increasing the number of sound sources beyond the four instruments that I have utilised so far. This could also include capturing the 'noise' of the audience as input data to control certain variables in the music, introducing an interactive layer to it. Another aspect that I plan to explore includes the use of design and lighting to shape and define the visual presence of this string orchestra in space. Also emerging from this PhD project is a plan for a new research project on discovering the most suitable type of transducers and the manner of their attachment to the instruments, with the goal of achieving a richer sound and having more control over the sonic result, for instance by attaching multiple transducers of various types and sizes to a single instrument.

On a practical level, this research prompted the idea of founding an organisation, Azimuth, involved in presenting and promoting fixed media electroacoustic music, a laboratory to experiment and put into practice my (and the co-founders') ideas in composing and performing this music. Playing to audiences from diverse socio-cultural backgrounds, many of whom would be experiencing such music for the first time, Azimuth proved that fixed media electroacoustic music can reach audiences beyond academic and research contexts; our concerts established a loyal community of composers and listeners. The experience of Azimuth in return enriched this research by setting creative challenges to working with limited resources and non-concert hall venues. For example, Azimuth wishes to continue its activities by exploring new modes of presenting fixed media music, like organising open air concerts which grounds the musical experience in a background of ambient sounds, thus giving rise to new kinds of atmospheres. Another area of investigation would be designing the concert situation in interior spaces more consciously, through collaboration with artists from disciplines such as set designing and lighting.

Hence, this research project has raised questions that open up perspectives for future research, also regarding the communication of ideas and performance suggestions from composers of fixed music to possible performers of their work, in the absence of a traditional score. To explore this area, I will embark on a project of 'publishing' my fixed media music, not as reduced (stereo) versions, but as 'raw' material: a package including the original sound files accompanied by suggestions on how to actualise the pieces. The intention is to investigate how best to

communicate the musical ideas of the composition and the intended quality of its constituent sounds, as a guide to other performers as they adapt it to whatever performance circumstances. The intention here is not to specify an 'ideal' performance but to suggest how performers might think about this adaptation. In addition to technical information and suggestions for post-mixing, such a 'score' may involve an analysis of the work and its structure to give an insight into the dynamic interrelationships between its sections. These instructions could take the form of an explanatory, anecdotal, poetic or abstract text, and can even include pictures, illustrations, videos or anything that can communicate the *atmosphere* which surrounds the work.

On the audiovisual part

The idea of integrating video into my project gave it an equally important dimension. The resulting double research trajectory involved, alongside its focus on sound, space and atmosphere, an exploration of the affordances of the audiovisual medium in artistic research. I carried out extensive experimentation in combining video, sound, image and text in order to find my way through the infinite possibilities that such combinations would offer. The audiovisual medium enabled me to articulate issues and aspects of my research that were difficult to convey through text or sound alone, especially in working with concepts such as atmosphere. In fact, what I was doing the whole time was composing, sometimes with sounds, sometimes with images and sometimes with words. The audiovisual part of my dissertation is itself a fixed media piece, which requires performance, just like its subject matter. In other words, the multichannel pieces integrated into this part of the dissertation are post-mixed when they are presented in public, together with the multichannel soundtrack and the spoken text and interviews. The presentation of the documented experiences thus becomes a new experience – reality doubling back on itself.

The integration of the audiovisual medium introduced a new observational angle into the practice through the lens of the camera: it allowed me to observe certain things that otherwise might have gone unnoticed, and this helped me to elaborate and reflect on those issues in the textual part of this thesis. Moreover, through interviews with composers and practitioners in the field, and by documenting their practice, I was able to gather some firsthand and up-to-date information and gain insight into the current state of affairs in the field. The audiovisual medium also helped me in the process of self-reflection through documenting my own performances.

One of the challenges here was the combination of video and spatial audio. While the image has a frame, and thus occupies a fixed point in space, the multichannel sound track surrounds the audience. This might create a conflict, formulated by Michel Chion (1994) as *spatial magnetisation*: a psychological phenomenon where the image 'magnetises' the sound events as if they emanate from the image, negating their original location. This phenomenon, in fact, undermines spatialisation. Therefore, I had to be conscious as how to combine the visuals with the spatial sounds. By reducing the level of activity in the image during the denser spatial polyphonic moments, for instance by employing static shots, or abstract and out of focus (blurry) images, or even eliminating visuals altogether the 'magnetisation' effect could be mitigated and the focus could turn to listening.

The experience of making this audiovisual part of my dissertation inspired me to design a course to help and motivate other students to integrate various media in their artistic research. I have now been teaching this course as a Master elective at the Royal Conservatoire in The

Hague since 2023, and I find it extremely illuminating to observe how each student adapts these techniques and approaches in relation to their own capacity and interests. 'Non-traditional research outputs' (NTRO) are still in its infancy and given the countless possibilities and the potential that the audiovisual medium offers, specifically in relation to artistic research, it is yet to be fully explored. I hope that the audiovisual component of this thesis can serve as a point of departure for others, as well as myself, to develop further this fusion of (spatial) sound and visual communication in the presentation of research outputs in the field of music, as well as other disciplines such as, dance, theatre and visual arts.