Erik Christensen

THE MUSICAL TIMESPACE

A Theory of Music Listening

Aalborg University Press

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To Poul Borum

Contents

Preface

1. The Basic Listening Dimensions

2. States, Events and Transformations

3. Space, Time, Flow and Memory

4. Time, Space and the Environment

5. Microtemporal listening dimensions: Timbre, Harmony and Pitch height

6. Macrotemporal listening dimensions: Movement, Pulse, Rhythm and Melody

7. Density, Extension and Color of the Soundspace

8. Micromodulation

9. A Model of the Musical Timespace 152

Preface

The first impulse for this book came from Ingmar Bengtsson, Swedish professor of musicology. In a Nordic seminar on music theory in 1971, Bengtsson played a recording of contemporary music for us and asked, "What kind of theory will you apply to this music?". This book is an attempt to answer that question.

The theory presented in this book is derived from the listening of contemporary music. There is a gap between classical music theory and the theories of contemporary music, and it is my intention to contribute to the closing of that gap. Another intention is to illuminate connections between music theory and the findings of research in music psychology.

Everything in this book is based on listening. Repeated listening is the basis of musical insight, and I recommend to the reader to listen at least seven times to any piece of music discussed in this text.

For each work, reference to the timing of a particular CD recording is given, except for three works which are not yet issued on CD. The description of music with reference to minutes and seconds does not imply that clock time is considered particularly relevant for music listening. On the contrary, the nature of musical time is basically different from measured time. The indication of timing is simply a means of precise reference to a particular passage of the musical flow. Descriptions of the flow and form of the music based on listening are supplemented by score analyses wherever necessary for clarification and verification.

For copyright reasons, it has not been possible to enclose a CD of musical examples with the present book. All CD's referred to are, however, commercially available.

I wish to express my gratitude to Kjeld Fredens, Danish neurobiologist, for his explanation of relationships between music and neurobiology in lectures and articles and personal communication, to Julio Estrada, Mexican composer, for convincing me that a theory of listening is not identical with a theory of composition, to Carl Bergstrøm-Nielsen, Danish composer, for valuable criticism and discussion, to Mette Stig Nielsen, Lecturer at the Carl Nielsen Music Academy, Odense, for many years of cooperation and intense discussions of music listening, and to Nikolaj and Mathias for opening my ears to the qualities of rock music.

My work has been supported by grant no. 15-9126-1 from the Danish Research Council for the Humanities. I am grateful for kind assistance from the Library and Music library of the Danish Broadcasting Corporation and from the Music department of the Odense University Library.

The publication of the present book would not have been possible without the linguistic advice of Stanley T. Bento, M.A. I have benefited not only from his linguistic revision of my manuscript, but also from his precise criticism of substance and argumentation. Special thanks to Jens Brejnrod, who provided the layout and the setting of notation examples, and to Jytte Fassov, manager of Aalborg University Press, for her kind and open-minded cooperation.

The Musical Timespace is dedicated to Poul Borum, an insightful poet, a sensitive music listener and a generous mind.

Copenhagen, spring 1996
Erik Christensen

1

The Basic Listening Dimensions

Listening is essential for survival

Hearing is not designed for music listening. Hearing is designed for survival in a natural environment. Hearing arouses attention of events and dangers, and it is a vital means of spatial orientation. Hearing permits the localization and distinction of sounding objects, and it evokes and maintains awareness of the movement of sound sources.

Attention

When the auditory system is activated by sound hitting the two eardrums, it is aroused to a state of attention. The listening mind becomes aware that something is happening, auditory awareness is oriented towards the occurring event, and the awareness is enhanced and maintained by emotional response.

The sense of hearing is active even when we are asleep, and when we are awake, it warns us against dangers we cannot see. The emotion of surprise evoked by a powerful sound can immediately be followed by an emotion of fear, inducing the listening person to flee for his life, or an emotion of aggression preparing him to fight against a potential danger. So a primary survival value of hearing is the arousal of attention.

Localization and estimation

Instantly, when auditory perception is activated by a sound event, two questions are asked subconsciously; what is the source of this sound, and where is that source? Both questions are important for survival. It is wise to ascertain immediately if the sound source is potentially dangerous like a hissing snake or buzzing insect, howling wind, sneaking footsteps, crackling fire or rolling thunder. And it is equally wise to gain an idea of the direction and distance of the sound source.

The sense of hearing is well equipped for both tasks. It has a great potential for detecting the quality of sound as a basis for estimation and identification of sound sources. And hearing yields immediate information about the possible location of the sound source, as the minute differences between the sound that hits the two eardrums are sufficient cues for the auditory perceptual processes to provide awareness of the directions and distances of sound. All this happens within a fraction of a second. Within a moment, the sense of hearing shows its value for survival, the potential of attention and the ability of estimating and localizing the sources of sound. These perceptual potentials constitute the underlying basis of three dimensions of listening; intensity, timbre and space.

Intensity, the arousal of attention

Physical intensity is the prerequisite of sound. Above a certain threshold of physical intensity, auditory perception is activated, and the listening mind experiences sound of a certain loudness. Below that threshold, the mind experiences silence. The alternation of sound and silence is the fundament of music.

As a listening dimension, intensity is a subjective quality, largely dependent on the loudness of sound. But other factors contribute to the experience of intensity, such as distinctness, sharpness, duration and temporal density of events. Intensity perception is delicate. We can detect infinitesimal variations of intensity in a continuum from tender whispering to violent explosions. Intensity is a characteristic quality of sound, permitting us to distinguish between a storm and a breeze, a waterfall and a brook. Thus intensity is a contributing factor in the identification of sound sources. It also contributes to the estimation of the distance of a sound source.

Space, the ability of localization and orientation

The experience of space is multidimensional in nature. Visual space is experienced in the dimensions of height, length and width. Visual spatial orientation is limited by the borders of the visual field, but the auditory space is not limited in the same way. With the head as center, the listening mind experiences a surrounding space of sounding events variable in character, quality, distance and direction.

The impression of distance is produced by the composite sensation of loudness and distinctness, resulting in an approximate estimation of distance. The experience of direction is somewhat more precise. With normal hearing in both ears, we can localize sounds at reasonably precise angles between left and right, and we localize sounds in front of us or behind, high up in the air or near the ground. Sounds of high frequency and clearly defined attack are more easily localized, while low-frequency sounds appear to fill the space without well-defined direction.

Spatial hearing is the result of accurate perceptual processing arising from the comparison of the sound signals arriving at each ear. The spatial omnipresence of sound gives rise to infinitely variable and multifaceted experience. Listening draws the world into the mind, contrary to vision, which has a tendency to draw the mind out in the world. Vision often dominates hearing, reducing sound events to concomitant phenomena in a visual space (Fredens & Fredens, 1991). As such, the full and intense presence of auditory space is experienced with eyes closed.

Timbre, the ability of estimation and identification

Simultaneously with the localization of sound, we gain an idea of the nature of the sound source. Some sounds are sharply attacked, like the breaking of a dry twig, the cracking of ice or the sound of a falling waterdrop. Other sounds have no distinct beginning like blowing wind or splashing waves.

Sound conveys information of events and objects. When an object is struck, it emits a sound that reveals its material, size and character. The sound of a hollow tree is different from the sound of a massive trunk and the sound of an oil barrel. Stone, wood and metal reveal the nature of their material when struck, and the sounds of large and small objects are significantly different. Voices of living beings like cats, lions, sheep, mice, birds and children each have their peculiar characteristics, and in the case of birds and human beings, different species and individuals possess their own unmistakable quality of voice.

The ears constantly receive large amounts of detailed information about events, objects and beings in the surrounding world. The characteristic and distinctive qualities of sound conveying this information are timbres. By comparison of perceived timbre with earlier experience, the listening mind can estimate the nature of sound sources and, if necessary or relevant, identify them. Differences in timbre permit the experience of many simultaneous events or the focusing on one kind of event, eliminating others. Hearing has a great capacity for the immediate and differentiated processing of timbre, providing precise auditory images of an infinitely variable multitude of sounds.

The potential of hearing essential for survival is the arousal of attention and the orientation in the surrounding space by localization, estimation and identification of sound sources. The basis of this potential is the auditory perceptual processing of intensity, timbre and spatial cues.

Intensity, timbre and space are three basic listening dimensions, experienced instantly and simultaneously; they are *microtemporal* listening dimensions, within a fraction of a second providing information about the relation between the listening body and mind and the surrounding world. Their correspondence with perceptual potentials are shown in *Fig. 1.1*

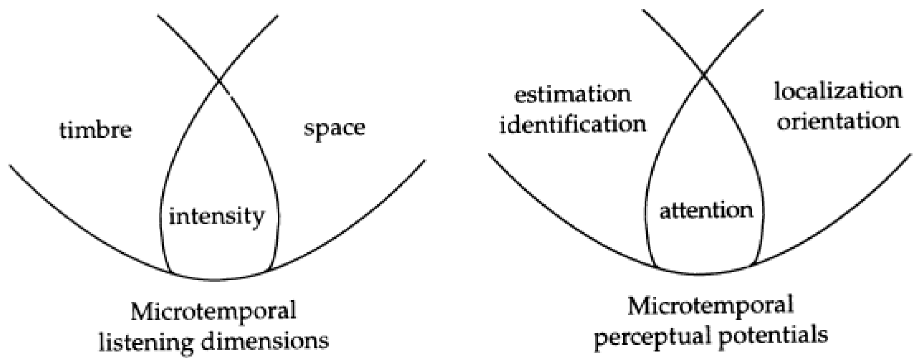


Fig. 1.1. Microtemporal listening dimensions

Movement, the stimulation of awareness and the emergence of time

Immediately after the arousal of attention by the microtemporal listening dimensions, successive information is provided by the experience of macrotemporal movement of sound; while the subconscious question evoked by sound arriving at the two ears, "What is it?" is being answered by the processing of timbre, and the simultaneous question "Where is it" is treated by the processing of spatial cues, a third question arises; "Is it moving?". If a sound remains constant for a while, arousal of auditory perception diminishes, and attention is weakened. The listening mind loses interest. But if the sound moves or changes, auditory attention is restimulated, and the sound event and its source is followed with renewed awareness. The listening mind is informed whether the sound source is approaching, passing by or receding, and has the chance to decide if it is necessary to run away or whether it might be a better idea to find and follow the moving sound source in order to fight, scare or eat it.

Hearing detects movement by changes in intensity, timbre and spatial localization. Increasing intensity is interpreted as approaching, decreasing intensity as moving away, and coherent continuous change in localization cues is experienced as movement in a certain direction.

To enable the listening mind to follow a directed movement, the instant processing of timbral and spatial information has to be supplemented by another perceptual potential, the processing of successive cues in short-term memory. In short-term memory, incoming information can be stored and kept in an active state for at least 5 or 6 seconds (McAdams, 1987). This means that the movement of sound can be perceived as a coherent process and estimated in terms of beginning and end, direction, course and goal.

Estimations of sound movement in memory evoke the concepts "before", "during", and "after", which are integrated in the idea of duration. This implies that movement is one of the essential factors underlying the sensation of time. The other essential factor is pulse.

Pulse, the awareness of regularity

Recurrent repetition of sound is heard in ocean waves, dripping water, specific kinds of birdsongs, heartbeats and the sounds of animals and human beings running or walking. If a sound event is repeated regularly, the listening mind estimates the regularity in short-term memory and experiences a pulse. Pulse and goal-directed movement evoke two kinds of temporal experience which are qualitatively different. The experience of regulated continuity and the experience of beginning, duration and end.

Movement and pulse are *macrotemporal* listening dimensions, creating the experience of time in the listening process. They represent two kinds of auditory awareness. Movement evokes the awareness of change, pulse the awareness of regularity.

Intensity is a microtemporal as well as a macrotemporal listening dimension. Intensity provides instant information about sound sources as well as information about the successive changes of states and events in the world. The correspondences with perceptual potentials are illustrated *in Fig. 1.2.*

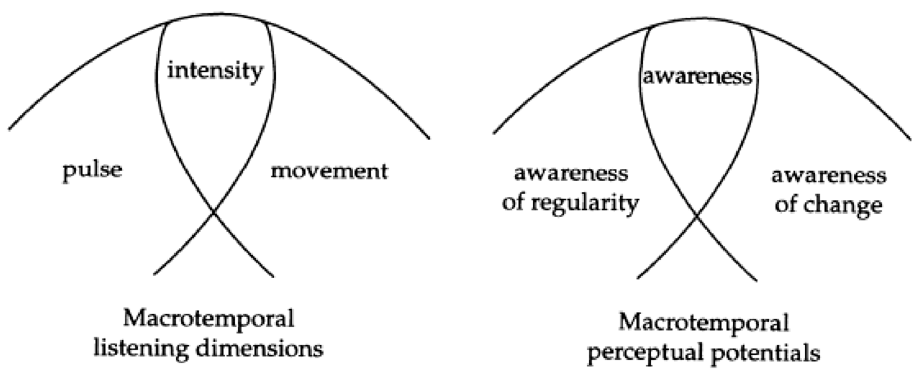


Fig. 1.2. Macrotemporal listening dimensions

Microtemporal and macrotemporal dimensions

The two models above are combined in one model in *Fig. 1.3,* showing the five basic listening dimensions. The upper half of the model represents the microtemporal dimensions, the lower half the macrotemporal dimensions.

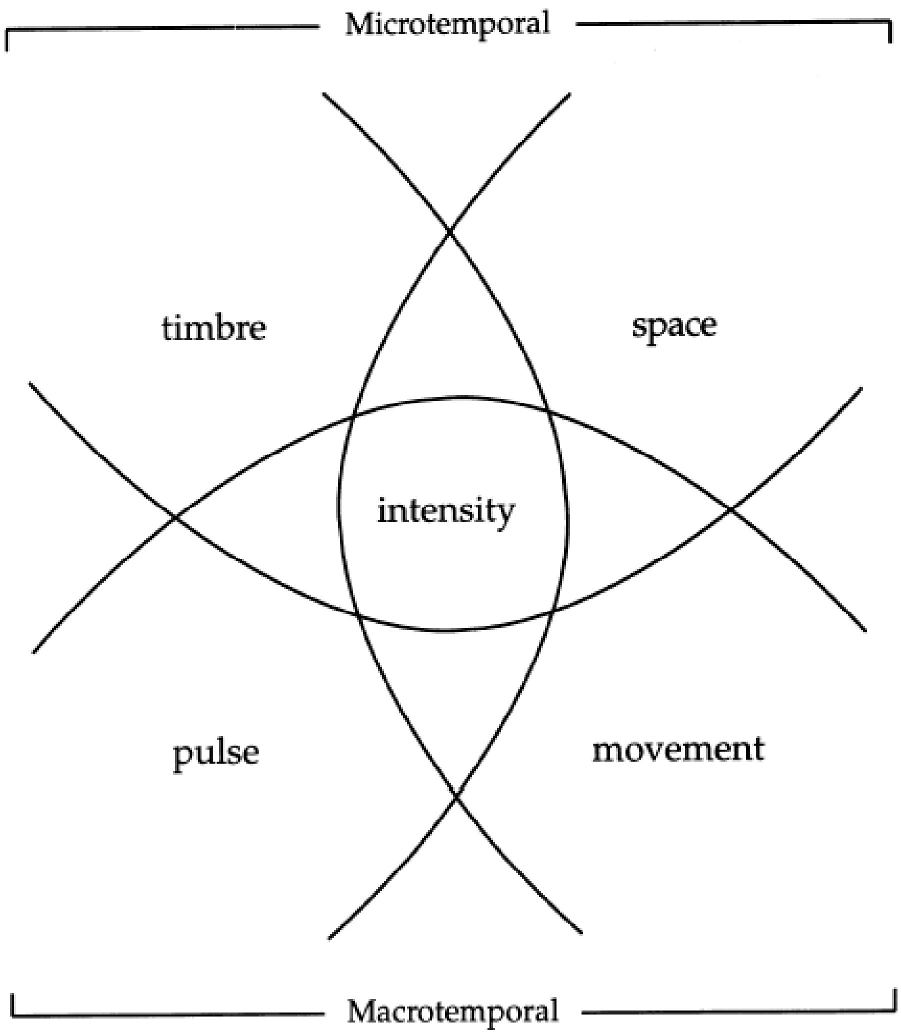


Fig. 1.3. The five basic listening dimensions

The five listening dimensions space, timbre, intensity, movement and pulse provide a basis for orientation in the environment surrounding the listening body and mind. The underlying processes of auditory perception are essential for survival and therefore highly developed, fast-working, precise and capable of simultaneous multitasking.

These natural perceptual resources are employed in the listening of music. Through the development of musical cultures and musical instruments, the addition of the culturally evolved notion of pitch height has gained prominence as a distinct feature.

Pitch height is an aspect of timbre

Music is flux, movement, it is not an abstract form, it exists only in its incarnation in time and in sound; timbre is its very substance. (Jean-Claude Risset, 1986)

Distinct pitch height is a predominant feature in the art music of Europe and the Western World. Consequently, pitch height is often considered the basic element in music and music perception, but as a matter of fact, it is not. Timbre is the substance of music, and pitch height is an aspect of timbre.

All kinds of sound are characterized by their timbre, and many kinds of sound can be characterized by their quality of brightness or darkness, which can be heard as differences of height. But only certain kinds of sound are characterized by clearly defined pitch height.

According to the traditional view of music perception, pitch is perceived on the basis of resonance in the ear cochlea, so that there is a direct correspondence between physical frequency and perceived pitch. This is a too simplified understanding of the function of the ear.

Investigations of the neural activity in the ear cochlea shed light on this question. Approximately 30.000 nerve fibres connect the cochlea with the brain. These nerve fibres exert the function of acoustic-electrical filters, responding to sound stimuli within a particular frequency area by sending impulses into the neural pathways. Each nerve fibre has a particular, most sensitive frequency, and responds to neighboring frequencies as well. Some nerve fibres respond to a narrow band of frequencies, others to a broader frequency band, and there is overlapping between the response areas of nerve fibres. (Evans, 1989).

This implies that the neural information leading to the sensation of pitch height does not stem from a resonance with one precisely defined frequency in the ear cochlea. It is the result of a more complex interaction and integration of impulses from a number of responding nerve fibres.

The refined biological system of interacting acoustic-electrical filters of the ear cochlea is designed for the purpose of survival, providing neural input to the brain for the estimation and localization of natural sound sources. The primary functions of auditory perception essential for survival are timbre perception and spatial perception. Timbre perception permits the estimation and identification of sound sources and sounding objects. Spatial perception permits orientation in the surrounding world and estimation of the distance and direction of sound sources.

On the basis of these natural perceptual potentials, pitch perception can be developed through a learning process. This process is dependent upon the exposure to music of a given culture, characterized by a selection of preferred pitch intervals and interval combinations established as a common convention by tradition.

The auditory perception of timbre is the general basis for the perception of musical tones, and pitch perception has to be understood as an aspect of timbre perception.

In the beginning of this century, Arnold Schoenberg emphasized the priority of timbre. Schoenberg writes on the last pages of his "Harmonielehre";

> I cannot unreservedly agree with the distinction between timbre and height of sound. The tone becomes perceptible by virtue of timbre, of which the height of sound is one dimension. Timbre is consequently the large domain, an area thereof is the height of sound. (Schoenberg, 1911)

Pitch height is an emergent quality of timbre arising from a perceptual focusing at a comparatively well-defined frequency area. When clearly defined pitches emerge by perceptual focusing in a timbral spectrum, pitch heights can be compared and estimated as higher or lower.

Pitch is experienced as a certain height in a sound height continuum. This is a crucial phenomenon, evoking a vertical dimension of musical space. Pitch height adopts the nature of a spatial dimension in the perceptual processing.

This experience is reflected in many European languages, including Italian, German, French, English, and Danish, ascribing the notion of "high" and "low" or "deep" to tones.

The inclusion of pitch height as an aspect of the spatial dimension leads to the modification of the model of dimensions shown in *Pig. 1.4.*

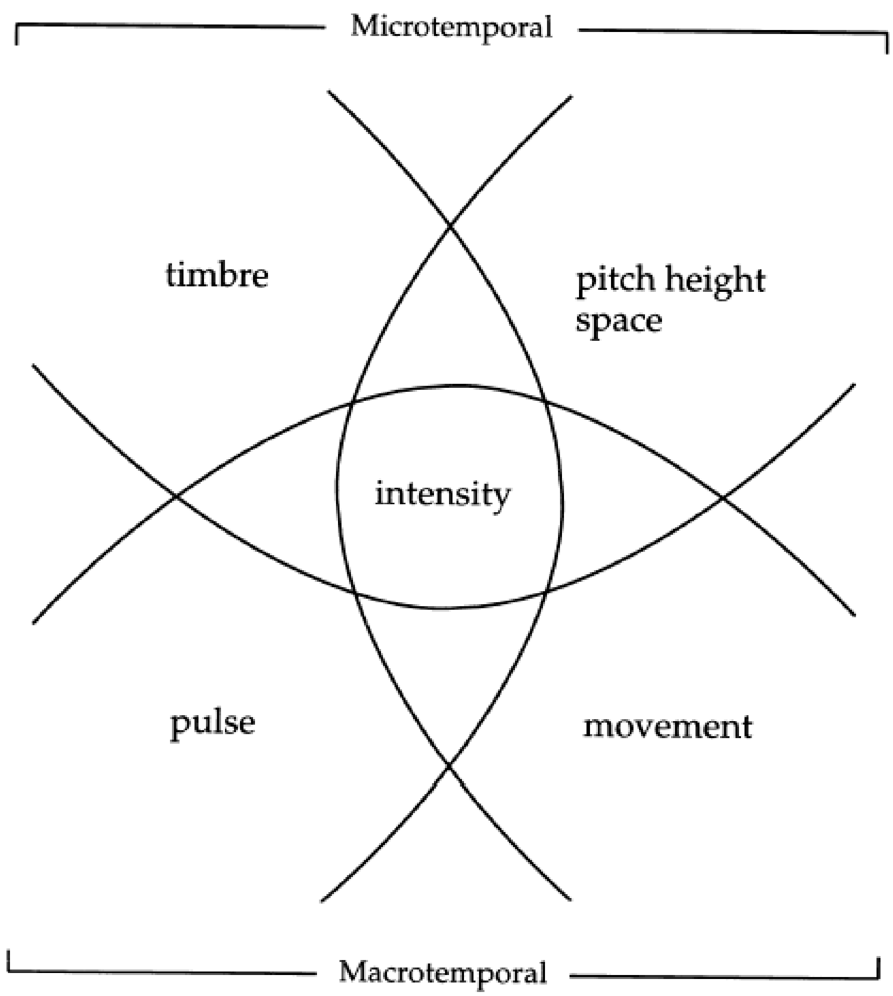


Fig. 1.4. The five basic listening dimensions, including pitch height as a spatial dimension

The temporal continuum

The inclusion of pitch height as a spatial dimension in the model permits considerations of the connections and polarities of the dimensions.

In the graphic model, *pitch height* is now placed opposite pulse, reflecting the fact that pitch height and pulse are related to the fast and the slow ends of the physical frequency continuum. This continuum is divided into two parts by the processes of auditory perception. Below approximately 16 Hz (16 impulses per second), frequency is heard as pulse or separate beats. Above approximately 16 Hz, it is heard as continuous sound, varying in height with varying frequency. If the height of the sound is relatively clearly defined, it is heard as a pitch height, otherwise as a comparatively bright or dark unpitched sound.

In a similar way, *movement* and *timbre* are placed opposite each other as the slow and the fast end of a motion continuum. In this continuum, movement is a perceptual phenomenon arising from the processing of comparatively slow changes of sound in short-term memory, while timbre is the quality rapidly evoked by the fast motion of sound. Toru Takemitsu provides a precise characterization;

> The sensing of timbre is none other than the perception of the succession of movement within sound. As well as being spatial in nature, this perception is of course also temporal in nature. To put it another way, timbre arises during the time in which one is listening to the shifting of sound. It is, as symbolized by the word sawari (which also has the meaning of touching some object lightly) something indicative of a dynamic state. (Takemitsu, 1987)

There is no distinct border between the microtemporal experience of a characteristic timbre and the macrotemporal experience of sound movement. When a large metal instrument like a Chinese tam-tam is struck, the instant identification of metallic timbre is immediately followed by the experience of movement, growth and dynamic change of timbral color.

A theoretical article by Karlheinz Stockhausen, "The Unity of Musical Time" (1961) sheds light on the relations of microtemporal and macrotemporal dimensions. Stockhausen takes as his point of departure that all differences in auditory perception can be traced back to differences in the temporal structure of oscillations. He introduces the concept of a continuum of unified time, which is divided into temporal sub-areas corresponding to different categories of perception, and characterizes four areas, emphasizing that transitions and overlappings of areas are fluid;

(1) 1/16.000 - 1/32 sec. (2) 1/6000 - 1/16 sec. (3) 1/8 sec. - 8 sec.
(4) "a few seconds" to 30 minutes.

Stockhausen relates sound color to the first area (16.000 - 32 Hz), harmony and melody to the second area (6000 - 16 Hz), which corresponds to the range of tones produced by familiar musical instruments. He relates meter and rhythm to the third area (8 Hz - 8 seconds), that is, from eight beats per second to one beat every eighth second. The fourth, roughly delineated area is ascribed to musical "form".

Stockhausen's areas (1) and (2) are microtemporal. Area (1), encompassing the highest end of the audible frequency continuum, corresponds to the listening dimensión *timbre.* Area (2), which comprises the range of clearly defined instrumental tones, corresponds to the listening dimension *pitch height.*

The areas (3) and (4) are macrotemporal. Area (3), 1/8 sec to 8 sec, encompasses the time of *pulse* as well as the time of sound *movement.* It is appropriate to divide it into two sub-areas.

The temporal area of *pulse* has been subject to investigation in tests of the perception of regular tapping. Music psychologist Paul Fraisse (1982) has summed up the findings of research in this field. He concludes that tapping is perceived as a continuous regular succession of events when the intervals between the single taps are between 120 msec and 1800 msec, that is, between the rapid tapping of 8 beats per second and the slow tapping of approximately 1 beat per 2 seconds. If tapping is slowed down beyond this limit, the taps are no longer linked perceptually, but appear as independent events. According to these findings, the temporal area corresponding to the listening dimension *pulse* is approximately 1/8-2 sec.

The temporal area corresponding to the listening dimension movement is not precisely delimited. Its upper limit is the duration limit of short-term memory storage, which is considered to be approximately 5 seconds (Fraisse, 1982. McAdams, 1987). The lower limit of the perception of sound movement is a matter of conjecture. It can be estimated to 1/4 sec.

Stockhausen's area (4), corresponding to musical form, encompasses a large span, "from a few seconds to 30 minutes". At one end, it overlaps the temporal area of movement; at the other end, it enters the temporal area of long-term memory. The temporal area of musical form exceeds the field of the basic listening dimensions. For a discussion of the relations between musical form and temporal flow, see chapter three.

Summing up, the correspondences between listening dimensions and temporal sub-areas can be estimated:

Timbre:	1/16.000 - 1/32 sec.
Pitch height:	1 /6.000 -1/16 sec.
Pulse:	1/8-2 sec.
Movement:	1/4-5 sec.

The *intensity* dimension does not correspond with one particular sub-area of the temporal continuum. It is related to microtemporal as well as macrotemporal areas, and consequently placed in the center of the model of dimensions.

Intensity is the prerequisite of sound and the core of all listening dimensions. Understood as a physical phenomenon, the natural continuum of sound is nothing but a continuum of energy spectra of variable intensity distribution, which can be measured as air pressure varying in time.

Physical intensity is the fundamental dimension of sound; the listening dimensions timbre, pitch height, pulse and movement are different temporal sub-areas, segregated from the total energy spectrum of the physical intensity continuum by the processes of auditory perception.

Three secondary listening dimensions can be derived from the basic listening dimensions. The musical dimensions melody, harmony and rhythm can be understood as secondary listening dimensions which arise from the interactions of basic dimensions. Harmony is a microtemporal dimension arising between timbre and pitch height. Rhythm is a macrotemporal dimension arising between pulse and movement. Melody is a dimension which integrates the microtemporal quality of pitch height and the macrotemporal quality of movement.

Timbre, harmony and pitch height are discussed in chapter five, movement, rhythm and melody in chapter six.

2

States, Events and Transformations

Explorations of the sound continuum

The world of natural sound is a multivariable continuum of noises, timbres and tones, states and events, transitions and transformations, change and regularity.

In the 1950's and early 60's, the composers Iannis Xenakis and György Ligeti began to explore the vast and many-faceted continuum of sound by composing sonorous states, events and transformations in musical spaces of timbre, intensity and movement. They changed the direction and scope of contemporary art music in a crucial way by introducing fundamental innovations in the technique of composition which permit music to approach the continuum of natural sound, thus bridging a gap between listening to music and listening to the world.

Their pioneer works are *Metastasis* (1953-54) and *Pithoprakta* (1955-56) by Xenakis, *Apparitions* (1958-59) and *Atmospheres* (1961) by Ligeti. In these works, they dissociated themselves from the European art music tradition by avoiding melody and harmony, and by giving low priority to well-defined pitch or altogether avoiding tones of clearly discernible pitch.

The two composers conceived their musical innovations independently of each others, but it seems significant that their individual fates were marked by particular common features. Both were born in Eastern Europe in Romanian territory, but in families speaking a different language. Ligeti was born in 1923 of Hungarian parents of Jewish origin in central Transsylvania, Xenakis in 1922 of Greek parents in Braila near the mouth of the Danube.

During World War II, both composers escaped death several times. Ligeti could easily have been killed in 1944, when he was conscripted to unload munition trains at a railroad junction which was regularly attacked from the air. Moreover, it was most likely that he, like his father and brother and most Hungarian jews, would have been exterminated by the German occupying forces. Xenakis was extremely close to death in 1945 when, while fighting in the Greek resistance, his face was hit by an exploding shell, tearing out his left eye.

After the war, both were forced to flee to live in exile. Xenakis chose to desert from the Greek army in 1947, when he was pressed to sign a document abjuring his political conviction. Condemned to death, he escaped illegally through Italy to France. Ligeti chose to flee from Hungary when Soviet troops invaded the country in 1956 and found refuge in Austria and Germany. Catastrophes, threatening death, violence, noise and lack of security are formative experiences underlying the music of Ligeti and Xenakis. They have gained first-hand knowledge of the fragile border between death and existence, an experience of the zero point where everything or nothing is possible. This may well be the motivating force behind their persistent investigations of unexplored realms of sound and sonorous experience.

Metastasis - A soundspace in continuous transformation

The premiere of *Metastasis,* Iannis Xenakis' first orchestral work, was a challenge to the audience. *Metastasis* was premiered in the Donaueschingen Festival by the SWF Radio Symphony Orchestra Baden-Baden, conducted by Hans Rosbaud, on 16th October, 1955. The event was tumultuous, and Xenakis recalls the audience being divided into two opposing parties; "As to the scandal, half of the audience, the young people, were for me, their elders against."

It is the nature of this work to provoke the listener to revise his listening habits, open his ears to noisy and unexpected events and retrace the pathways of his musical perception, adjusting his auditive expectations in the direction of a musical continuum.

Metastasis was composed in 1953-54. The instrumentation of the work is piccolo, flute, 2 oboes, bass clarinet, 3 horns, 2 trumpets, 2 tenor trombones, timpani, percussion and strings (12, 12, 8, 8, 6).

The 1955 Donaueschingen live performance of *Metastasis* is available on CD, but for clarity of sound and detail, a technically better studio recording is preferred. Here I employ the LP recording by the French ORTF Orchestra conducted by Maurice le Roux as reference.

The total duration of this recording of *Metastasis* is 8'55. The music takes shape in three sections:

Metastasis

> ***0'00-2'54 Beginning:***
> A single sound emerges, growing in gliding motion, first upwards, then downwards, dividing itself into a high and a low stream, and expanding to a vibrating space filled with sound.
>
> ***2'55-8'03 Middle Section:***
> A polyphony of melodic fragments unfolds *(2'55-4'02),* changing to a polyphony of points, sound masses and lines of different timbres and intensities *(4'03-7'55),* endmg in a brief gliding movement *(7'55-8'03).*
>
> ***8'06-8'55 Final section:***
> Gliding sound emerges in the high and low registers, moving towards the middle register, and finally meeting in one sound.

In the middle section, Xenakis employs a fragmentary serial technique, from which he shortly thereafter dissociated himself. The most important musical innovations of this work are found in the first and last sections. This is an outline of the musical events and processes in the beginning of Metastasis:

Metastasis, beginning

> ***0'00-l'32:***
> An initial tone appears; continuous gliding movement in strings, interspersed with attacks of wooden percussion, spreads out fan-like upwards and downwards, reaching a climax in a mass of sound, consisting of a high and a low part *(1'00-1'19),* during which percussion and plucked string attacks are heard. At *1'20* the sound masses are set in intensified vibration by tremolo; sudden breakoff at *1'32.*
>
> ***1'32-2'26:***
> Tinkling metal percussion breaks the brief silence, *1'37* followed by sheets of string tremolo, changing suddenly in loudness several times.
> *1'42* Deep trombones emerge, salient when the strings are soft, gradually intensifying their sound in sliding movement. *2'02* Loud trumpets enter, playing noisy flutter-tongue tones, *2'09* followed by penetrating sounds of horns. After a climax of noise *2'10-2'18,* the brass instruments disappear, leaving the strings.
>
> ***2'26-T54:***
> Transparent string sound glides up to a high flageolet register and down to a low register; in the middle register a tone is sustained.

During this first part of Metastasis, an extensive soundspace is expanded, approaching the high and low limits of perceptible pitch. The attention of the listener is stimulated by percussive attacks and sudden changes in loudness. Contrasts between attacked and sustained sound yield impressions of musical foreground and background. Variation of timbres and sound movement activates and maintains the listener's awareness. The use of tremolo enhances perceptual intensity.

In Metastasis, the listening mind is opened to the experience of a continuous, multidimensional soundspace. Hearing and following sound appearing, changing and disappearing, the listener perceives a space of musical states, events and transformations.

The first page of Metastasis is reproduced as *Ex. II-I.* In the preface of the score, Xenakis explains the title Metastasis as "dialectic transformation", and states some new ideas introduced by this work:

> (1) The normal orchestra is totally divisi: 61 instrumentalists play 61 different parts, thus introducing the mass conception in music (music built with a large number of sound events).
>
> (2) Systematic use of individual glissandi throughout the whole mass of orchestral strings; glissandi whose gradients are calculated individually. These glissandi create sound spaces in continuous evolution, comparable to ruled surfaces and volumes. It was precisely these glissandi which led the composer several years later to the architectural conception of the Philips pavilion at the 1958 Brussels Exposition, on behalf of Le Corbusier. (Xenakis, score note)

The composition of *Metastasis* is closely related to Xenakis' work as an engineer and architect. After arriving as a fugitive in Paris in 1947, Xenakis, who had achieved his diploma in engineering in Greece, had the opportunity of being employed by the renowned architect Le Corbusier, a relationship that lasted from 1947 to 1960.

In the beginning of the 1950's, the work of Xenakis had changed from engineering calculations to architectural design, and owing to his exchange of ideas with Le Corbusier, he discovered that the problems of contemporary architecture were akin to the problems he was trying to solve in music. The professional occupation with forms, volumes, surfaces and proportions in architecture led to the idea of creating a space of sound in motion by designing surfaces of glissando movements in graphic form. This graph was subsequently transcribed in ordinary score notation.

Fig 2.1 shows the graphic design of measures 309-314, which constitute the brief gliding sound movement at the end of the middle section, *7'55-8'03* in the recording. The score notation of these measures is reproduced as *Ex. II-II.*

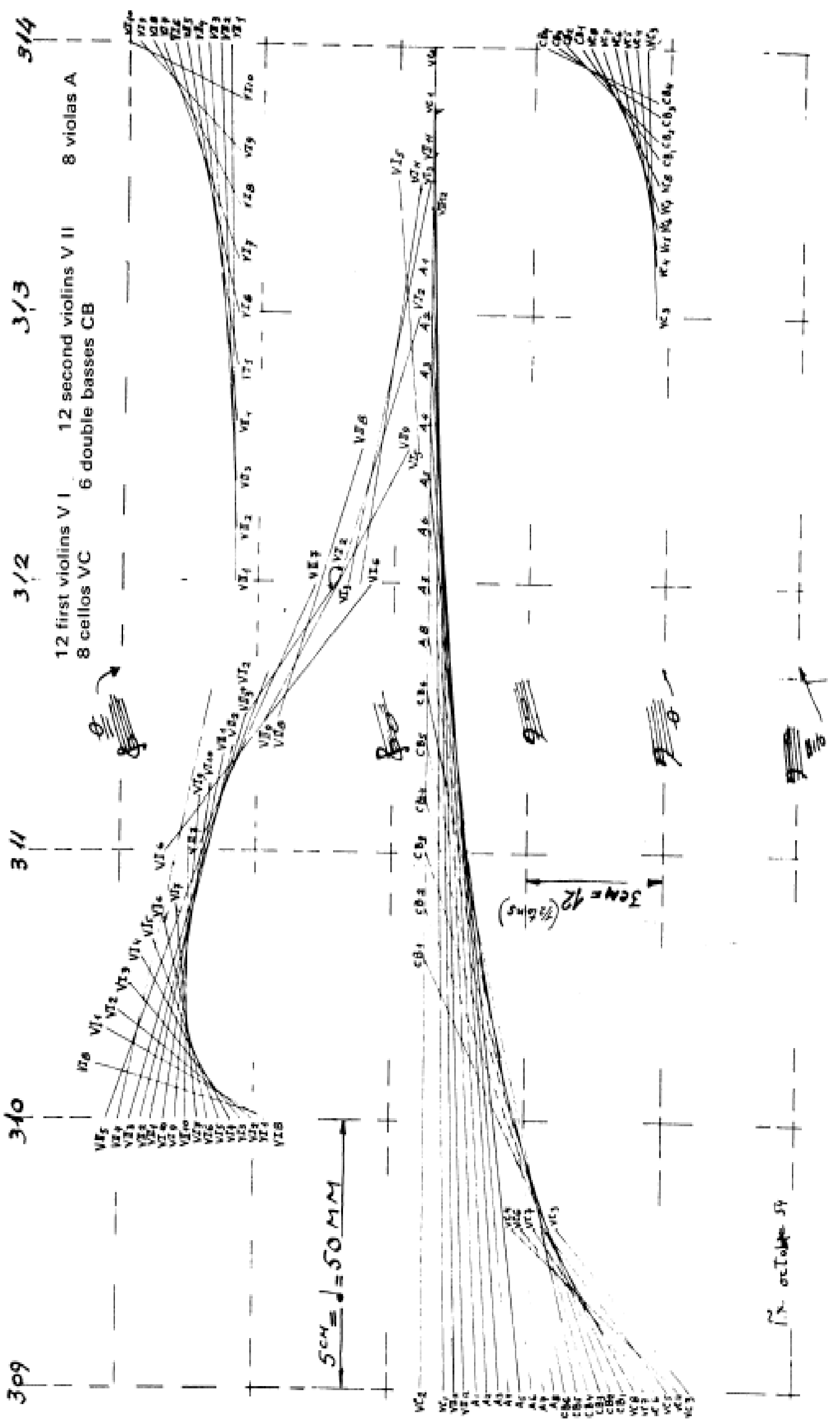

12 first violins V I
8 cellos VC
12 second violins V II
6 double basses CB
8 violas A
309
310
311
312
313
314

Fig. 2.1 String glissandi of Metastasis (opposite page)

In the two-dimensional graph, the horizontal dimension represents time, divided in measures marked 309-314. The vertical dimension represents pitch height; octave division is indicated by the pitch height levels E1, E2, E3, E4, E5 and E6, marked by inserted notes in the middle of the graph.

The gliding movement of each single instrument is drawn as a straight line. At the beginning of measure 309, a 24-tone cluster ranging from C#2 to C#4 is played by Cellos 3-4-5-6-7-8, Double Basses 1-2-3-4-5-6, Violas 8-7-6-5-4-3-2-1, Second violins 12-11 and Cellos 1-2. The cluster is chromatic except for the top interval B3-C#4. Departing from this cluster, the lowest group of cellos perform a short glissando movement in measure 309, reaching a chromatic cluster C#3-D3-D#3-E3-F3. The other instruments glide slowly towards a target tone which is the C#4 sustained by Cello 2. This tone is reached by the instruments one by one, first by Double Bass 1 in measure 310.

The exactly opposite process takes place in measure 313, where Cellos 3-4-5-6-7-8 and Double Basses 1-2-3-4 begin, one by one, at the same tone F2 and spread to a chromatic cluster ranging from F#2 to D#3.

In the higher register, sixteen violins playing a chromatic cluster D5-F6 at the beginning of measure 310 divide in two groups, eight gliding upwards, eight downwards.

In measures 312-314, a spreading from one tone to a high-register cluster is performed by 10 violins.

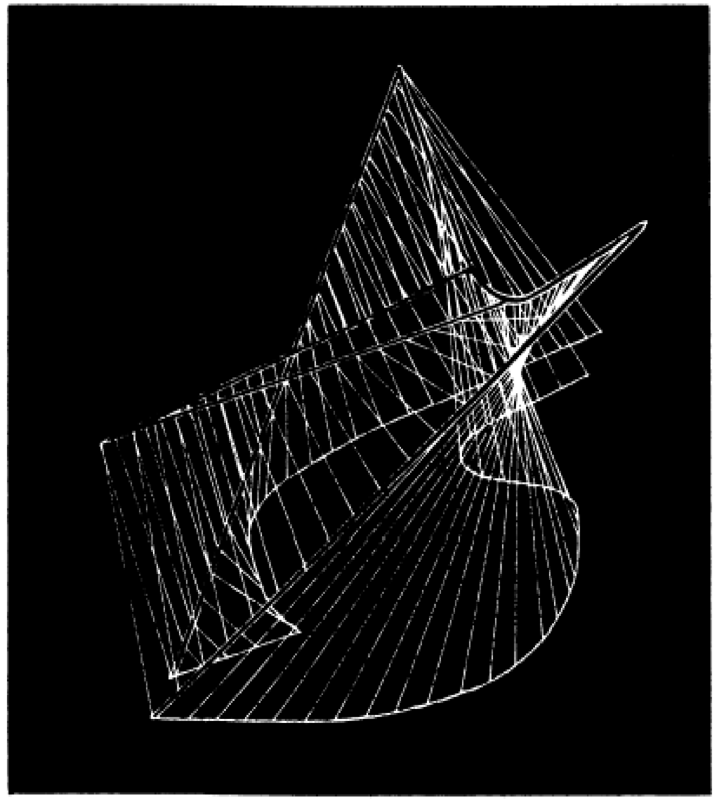


Fig. 2.2. First model of Philips Pavilion

A few years after composing *Metastasis,* Xenakis was asked by Le Corbusier to suggest a design for the architecture of the Philips Pavilion for the World Exhibition in Brussels. Xenakis took up the Metastasis idea of ruled surfaces and transferred it back to architecture, designing and calculating the walls of the Pavilion as ruled surfaces. *Fig. 2.2.* shows a first model of the Philips Pavilion, which was built in reinforced concrete in 1958.

In this building, the sounds of Edgar Varèse's *Poème electronique* were heard from 350 loudspeakers in the curved walls. After the exhibition, the Pavilion was demolished.

Apparitions **- States and events in continuous interaction**

Ligeti's orchestral work *Apparitions* (1958-59) is another imaginary space created by sound. The work is scored for 3 flutes, 3 clarinets, 3 bassoons and contrabassoon, 6 horns, 3 trumpets, 3 trombones, tuba, percussion, celesta, harp, harpsichord, piano and strings (12,12, 8, 8, 6), plus 3 violins and a trumpet placed behind the audience, providing echo effects.

The premiere of *Apparitions* on 19th June, 1960 at the ISCM festival in Cologne, by the NDR Hamburg Symphony Orchestra conducted by Ernest Bour was Ligeti's breakthrough in European music life, calling forth immediate international attention and recognition.

No CD or LP recording is presently available. My reference is a tape recording of a live radio broadcast on 28th April, 1966 by the Danish Radio Symphony Orchestra, conducted by Janos Ferencsik, total duration *7'30.*

Apparitions has two movements, *Lento (0'00*-4'57) and *Agitato (5'02-*7'*30).* This is a description of the musical events;

Apparitions, First movement: Lento

0'00-2'24: Appearances

0'00 Sound emerges out of nothing. Soft sounds of a variety of distinct string, brass, woodwind and percussion timbres appear and disappear. *1'13* A celesta cluster is followed by increasing density and presence of events.

1'40 Silence.

1'43 String tremolos initiate increasing coherence and activity; *2'16* salient trombone glissando ... string pizzicato clusters.

2'24 Silence.

2'26-4'57: Explosions with consequences

2'26 A sudden bass drum stroke releases a loud string tremolo, followed by deep, dark sustained sounds and a succession of faint, clearly

attacked events of great timbral variety. 3'*09 A* falling string glissando continued by hectic brass activity leads to a second explosion at *3'15,* accentuated by a metallic percussion stroke. Deep sounds remain.
3'36 A third explosion occurs as a shrill clash of noise, continued in sustained high-register strings; *3'44* other string instruments move tumultuously upwards, contributing to the intensity of the high sound-layer, *3'50* winds added, *4'00* celesta and glockenspiel. High strings remain until the end of the movement, gradually fading away... *4'57.*

Apparitions, Second movement: Agitato

5'02-7'30
This movement has a scherzo character. A transparent flow of different kinds of agile, fluent, restless or weightless motion, *6'17* slowed down for a while by massive strings, *6'40* accentuated by knocking sounds and a few explosions, ending in airy, toneless blowing sound.

"States, events, transformations" is the headline of Ligeti's "Remarks on my orchestral work Apparitions". In this article, Ligeti recalls the origin of Apparitions in a surrealistic childhood dream of a room filled with a finely threaded, complicated web, moving and trembling, twisted here and there, torn and entangled. He gives a verbal description of the music as transformations of energy, concluding that;

> The musical form has its origin in a continuous interaction between states and events. The states are interrupted by suddenly appearing events and are changed under their influence; and vice versa: The altered states also have a certain influence on the nature of the events; for the latter must always be new in character in order to continue to change the altered state. In this way, an unceasing transformation is created. (Ligeti, 1960)

Atmospheres **- A vibrating space of timbre and movement**

The composition of events, states and transformations of sound energy is further developed and refined in Ligeti's orchestral work *Atmospheres* (1961). This is music without melodic or rhythmic gestalts, and without clearly discernible pitches and durations. *Atmospheres* is a flow of sound. Subtle changes in timbre, intensity and movement create auditory impressions of variable sound masses appearing and disappearing, approaching, passing and withdrawing. Sheets and layers of sound are revealed or superimposed, illuminated and darkened, changing in color and density.

Atmospheres is scored for 4 flutes, 4 oboes, 4 clarinets, 3 bassoons and contrabasson, 6 horns, 4 trumpets, 4 trombones, tuba, piano and strings (14,14,10,10,8). An excellent recording of the work is the one by the SWF Radio Symphony Orchestra Baden-Baden conducted by Ernest Bour, issued on CD by Wergo and CBS, duration *8'33*. Some characteristic musical occurrences are the following:

Atmospheres

0'00 Sound emanates "out of nowhere", gradually changing in color, nearly disappearing... *0'53*

0'53 ... emerging, vibrating and growing, *1'18* being illuminated, *1'26* approaching, *1'45* brightening ... shimmering, 2'*00* dissolving ...

2'15 ... gently oscillating, 2*'30* darkening ... *2'50* thinning out

2'56 ... trembling, *3'16* rising towards a high extreme ... *3'50*

3'50 Sudden fall into darkness; *4'06* waves of transparent sound gliding upwards and downwards, *4'40* growing and rotating, *4'46* slowing down

4'50 Subtle separate movements, *5'00* condensing in a few substantial tones in rising motion, 5'11 penetrating, sharp intrusions, 5'43 receding in static sound, disappearing ... 6'35

6'35 Blowing; faint trembling, *6'53* strands of light, 7'06 waves of glittering sound spectra, *7'34* darkening, disappearing ... *8'33.*

This music creates impressions of height and depth, distance and proximity, transparence and density, brightness and darkness, stasis and motion. Sensations of rise and fall are created by the massed pitches of clusters moving high up and deep down, even if no single pitch height stands out separately. Subtle oscillations, vibratos and tremolos add a living quality to static or slow-moving sound. Impressions of varying distances of sound events and of sound approaching and receding are created by differences in attack and intensity. Sharply attacked tones seem to protrude, softly initiated sounds seem to emerge far away or at an indefinite distance. Crescendos create the impression of sound coming nearer, diminuendo sounds seem to move away.

These virtual auditory images can be heard as sounding analogies of states, events and transformations perceptible in the outer world, changes in movement, distance, light, color and texture. Ligeti's *Atmospheres* evoke the illusion of a virtual space in the listening mind.

***Pithoprakta* - Actions by probabilities**

Iannis Xenakis' *Pithoprakta* (1955-56) is another soundspace of states, events and transformations. The work is scored for an unusual combination of instruments, 46 strings, 2 trombones, 1 xylophone, 1 wood-block. It is recorded on the same LP as *Metastasis,* Maurice le Roux conducting the ORTF Symphony Orchestra. Pithoprakta is composed in sections of varying kinds of activity.

Pithoprakta

0'00-2'03:
Soft, knocking sounds, *0'13* one sharp percussion attack; slowly increasing density of events, 0*'35* deep pizzicati and melodic fragments added, increasing activity of knocking sounds,
0'55 gradually increasing density of all kinds of events ....
1'55 percussion attacks...

2'03 Silence

2'05-4'21:
Swarms of gliding pizzicati, 2'22 Percussion and pizzicato pulses in different tempi on a background of wide-range sustained sound, *3'06* pizzicato polyphony, 3'*32* pizzicato lines gliding fan-like upwards and downwards. 3'*48* webs of glissandi, 3'*56* solo glissandi accompanied by pizzicati.

4'23 Silence

4'27-7'14:
Simultaneous activities of glissando, pizzicato, col legno and arco strings, *5'10* emerging pulses, *6'04* swarms of high pizzicati with deep slow trombone glissandi, *6'20* change to middle-register pizzicati gathering in a pulse, followed by a slower pulse.

6'35 Silence

6'40 Pizzicato pulse repeated; sharp attack, silence, slow pulse.

6'53 Long Silence

7'05 Gliding lines of pizzicato.

7'14 Silence

772-930:
Gentle glissandi and pizzicati appear in high and low registers, *8'05* intensified, gathering into a stream, spreading out, *8'15* filling the total space with sustained sound, *8'28* dissolving.... high violin flageolets disappearing "into thin air"... *9'30*

Pithoprakta is a space of sound masses, expanding and contracting, rising and falling, changing in speed, intensity and density. The listener experiences a density continuum from single events to masses consisting of multitudes of events, a great variety of attacks, timbres and movements of stringed instruments. Silences sharpen the listener's attention and expectations of coming events. In contrast to the soundspace of Ligeti's *Atmospheres,* regular pulses in different tempi appear and disappear, creating a continuum between regular and irregular temporal distribution.

Composing *Pithoprakta,* Xenakis had images of the universe and the starry sky in mind. In the score, several sections are described as "nebulae of sound" with "galactic configurations" of sounding events. A score page of the first nebula, heard *at 4'27-6'02* in the recording, is reproduced as *Ex. II-III.*

The title *Pithoprakta* means "Actions by probabilities". In this work, the distribution of musical elements is calculated by the mathematical laws of probability. Xenakis names this kind of music "Stochastic music", after a Greek word signifying "to concentrate one's thoughts on a point of aim, to select something as a target." The aim of stochastic music is to merge a multitude of sonic details in a particular massed quality, characterized by its timbre and intensity and the density, speed, attack and direction of sound events. Such a particular quality can be gradually transformed from one characteristic state of mass events towards another characteristic state of events.

In his book "Formalized Music", Xenakis describes the experiences of natural phenomena and sonic mass events that led him to the invention of stochastic music. Xenakis refers to his own criticism of the serial composition technique, see this chapter, p 36.

> As a result of the impasse in serial music, as well as other causes, I originated in 1954 a music constructed from the priciple of indeterminism; two years later I named it "Stochastic Music". The laws of

> the calculus of probabilities entered composition through musical necessity.
>
> But other paths also led to the same stochastic crossroads - first of all, natural events such as the collision of hail or rain with hard surfaces, or the song of cicadas in a summer field. These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen as a totality, is a new sonic event. This mass event is articulated and forms a plastic mold of time, which itself follows aleatory and stochastic laws. If one then wishes to form a large mass of point-notes, such as string pizzicati, one must know these mathematical laws, which, in any case, are no more than a tight and concise expression of a chain of logical reasoning. Everyone has observed the sonic phenomena of a political crowd of dozens or hundreds of thousands of people. The human river shouts a slogan in a uniform rhythm. Then another slogan springs from the head of the demonstration; it spreads towards the tail, replacing the first. A wave of transition thus passes from the head to the tail. The clamor fills the city, and the inhibiting force of voice and rhythm reaches a climax. It is an event of great power and beauty in its ferocity. Then the impact between the demonstrators and the enemy occurs. The perfect rhythm of the last slogan breaks up in a huge cluster of chaotic shouts, which also spreads to the tail. Imagine, in addition, the reports of dozens of machine guns and the whistle of bullets adding their punctuations to this total disorder. The crowd is then rapidly dispersed, and after sonic and visual hell follows a detonating calm, full of despair, dust, and death. The statistical laws of these events, separated from their political or moral context, are the same as those of the cicadas or the rain. They are the laws of the passage from complete order to total disorder in a continuous or explosive manner. They are stochastic laws. (Xenakis, 1971)

In *Pithoprakta,* consciousness of mass events in the natural and social environment and the universe is reflected in music, linking sensations of natural phenomena with the formalized description of the physical laws of nature.

Livre pour Orchestre **- A space of motion and emotion**

In *Livre pour Orchestre (1968),* scored for 3 flutes, 3 oboes, 3 clarinets, 3 bassoons, 3 trumpets, 4 horns, 3 trombones, tuba, percussion, celesta, harp, piano and strings, Witold Lutoslawski creates a musical continuum different from the continua of *Metastasis, Apparitions, Atmospheres* and *Pithoprakta.* This is a music of strong gestures, expressive in character and closer to the musical forms of the classical tradition.

The title reflects Lutoslawski's idea of writing a "book for orchestra" as a collection of orchestral pieces of various lengths and forms, like Couperin's "Livre pour clavecin" or J.S.Bach's "Orgelbüchlein". He abandoned this idea, however, because the movements grew so long and became so linked together that there was no room for any other pieces.

Livre pour Orchestre is recorded on an EMI Classics CD with the composer conducting The Polish Radio National Symphony Orchestra. It is divided in chapters, separated by short interludes:

Livre pour Orchestre

Chapters and Interludes	*Timing*	*Duration*
First Chapter:	*0'00-4'06*	*4'06*
First Interlude:	*4'07-4'21*	*0'14*
Second Chapter:	*4'23-7'20*	*2'57*
Second Interlude:	*7'24 - 7'41*	*0'15*
Third Chapter:	*7'41 -9'35*	*1'54*
Third Interlude and Final Chapter:	*9'37-21'10*	*11'33*

The First Chapter of *Livre pour Orchestre* is music rich in color and movement, of great emotional power for an ear sensible to the nuances of saturated Polish string sound, music that fills the space around you, and grabs your heart.

Livre pour Orchestre, First Chapter

0'00-2'32 Prevailing falling motion in a flow of large and small waves of sound:

0'00-l'15:

Gently gliding stream falling and rising wave-like, appearing three times; *0'22* continued in a rising melodic line, flowing onward, turning, growing and spreading, *0'47* expanding in space; 1*'02* interrupted; deep fall and violent gestures; *1'11* gently rising...

1'15-2'32:

Re-emergence of the initial gliding stream, this time continuing in one long, descending wave, slowing down, flattening out; *1'47* regaining energy, *1'50* reactivated by a polyphony of violent, downward-directed gestures; 2*'00* the polyphonic mass gradually rises in register, increasing in speed and density; 2*'20* outburst of brass and percussion... dispersing in deep, scattered sounds *...2'32*

2'32-4'06 **Predominating rising motion, flowing into a transparent chord of soft, sustained sound:**

232-*3'00:*
Building up to a climax: massive strings followed by rising
waves of brass instruments, growing and culminating in an eruption of percussion *(2'56-3'00)*

3'00-4'06:
Revelation of a transparent sustained string chord set in gentle motion internally by slowly falling, sliding voices;
3'45 piano figures appear, strings gradually disappear; piano finally slows down to a standstil.. *4'06*

The music is a rich polyphony of internal streams, in which each voice is not clearly separated from the other voices. This creates an over-all impression of a living stream of sound moving flexibly and multi-directionally in space.

Lutoslawski achieves this impressive effect through a refined use of quarter-tones. It is his intention to overcome and transgress the musical limitations of the chromatic scale, which restrict the choice of pitch to the twelve fixed pitch height steps obtained by the division of the octave in equal parts. Lutoslawski explains his technique in a conversation with Tadeusz Kaczynski;

> The use of quarter-tones seems quite natural today, when there is a general tendency to go beyond the traditional twelve-note scale. In my case it came about not just because of my interest in any new non-twelve-note scale: It reflects my interest in something quite different, namely in notes whose pitch changes continually. The choice of the quarter-tone scale was dictated here by the need to adapt my original idea to the existing set of instruments. The idea was to achieve a continuous change of pitch in the most precise way possible. It is better therefore to use definite pitch, even if that can only be approximate. One can't expect a perfect rendering of notes on the quarter-tone scale, especially from instruments like the violin. The majority of these quarter-tone sequences (incidentally, you must have noticed in the score that there are no sequences which employ notes other than adjacent ones in the quarter-tone scale) are in fact heard as notes which change their pitch in a continuous way. They aren't the same as glissando, especially as one can sometimes hear the individual steps of the quarter-tone scale. But not always. Sometimes I deliberately employ bundles of voices from a number of strings which move along the quarter-tone scale in such a way as to give the impression of the quarter-tone cluster moving in space. (Lutoslawski/Kaczinsky, 1972)

The gliding bundles of quarter-tones opening *Livre pour Orchestre* are heard at *0'00-0'32* in the recording. In this microtonal polyphony, the instruments merge in a flow of sound, but the flow is not without direction. The sound-stream takes the shape of lines, curves and gestures evoking fleeting harmonious colors in continuous transition.

The shapes of musical movement and the accumulations of gestures leading to climactic eruptions are akin to the expressions of emotion through melody and harmony in the European symphonic tradition; the gliding, falling streams gain a lamento character comparable to the expression of sorrow in the last movement of Tjajkovskijs Sixth Symphony, *Adagio lamentoso.*

Lutoslawski's invention of quarter-tone polyphony does not constitute a break with European tradition, but a continuation of tradition by new means. Conversely, the early works of Xenakis and Ligeti described in this chapter constitute a break with tradition. Furthermore, both composers dissociate themselves from a predominant line of thought in the musical avantgarde of the 1950's.

Xenakis' and Ligeti's dissociation from early serialism

Ligeti and Xenakis take the concept of the total, continuous soundspace as their point of departure in *Metastasis, Pithoprakta, Apparitions* and *Atmospheres.* This is a top-down approach to music, proceeding from the investigation of a multidimensional continuum to the composition of smaller parts and elements of music. Consequently, both composers adopted a critical attitude towards the bottom-up approach to musical creation based on the definition of discrete musical units in terms of pitch, duration, intensity and timbre, which was the basis of serialism in its initial phase. The first book of Structures for two pianos (1951-52) by Pierre Boulez is a paradigm of this technique.

Xenakis proposed his criticism in the article "The crisis of serial music" in the first pages of the first issue of Hermann Scherchen's periodical "Gravesaner Blätter", July 1955. He accused the serialist avant-garde of "frenzy of decomposition of sound, overlapping of its components, and recomposition." Xenakis found no cogent reason for the choice of a series of 12 discrete steps face to face with the musical possibilities inherent in the continua of frequencies and timbres, intensities and durations. And he questioned the idea of superimposing a number of series to constitute a polyphonic structure;

> The linear polyphony destroys itself by its very complexity; what one hears is in reality nothing but a mass of notes in various registers. The enormous complexity prevents the audience from following the inter-twining of the lines and has as its macroscopic effect an irrational and fortuitous dispersion of the sounds over the whole extent of the sonic spectrum. There is consequently a contradiction between the linear

> polyphonic system and the heard result, which is surface or mass. This contradiction inherent in the polyphony will disappear when the independence of sounds is total. (Xenakis, 1955).

When Xenakis published this article, it was a bit outdated, because serial techniques had by then progressed from the early experimental beginnings and reached a high degree of flexibility, differentiation, inventiveness and freedom in the hands of composers like Stockhausen and Boulez.

The article is a manifesto introducing Xenakis' own original intentions; to compose in the continuous spectra of sound, and to generate sound masses of differentiated and specific qualities by means of stochastic procedures. He elaborated his point of view in an interview with Mario Bois;

> With the serial system one cannot, for example, encompass systems with glissandi, or continuous evolutions, or complexes more or less dense. In fact, it constitutes a particular case of the overall "massing" conception which I introduced in Metastasis. (Xenakis/Bois, 1967)

Gyorgy Ligeti expressed his criticism in a 25-page detailed analysis of Pierre Boulez' *Structures la* (1951-52) in the serialist magazine "Die Reihe" 4, describing, dissecting and commenting Boulez' serial structures and procedures with persevering accuracy and a bit of irony. Ligeti criticizes the limitations and inconsistencies of Boulez' early serial explorations with insight and sympathy. But he also points out that "in the latest developments of serialism, compositional dimensions until now completely undreamt of are opened", and concludes that Boulez had to break out of his ascetic self-imposed restraint "in order to throw himself into something quite contrary (although closely related). And so he created the multi-colored-sensuous cat-world of 'Marteau' " (Ligeti, 1958).

Ligeti here refers to *Le Marteau sans maître* (1954) for contralto voice and instruments, rich in sonority, agility and invention. The innovations achieved by serial techniques were acknowledged by Ligeti in his article on "The Metamorphosis of Musical Form" (1960) in "Die Reihe" 7, describing the multifaceted differentiation and transformation of serial textures.

In his article "Questions and Answers by Myself", Ligeti explains his personal dissociation from serialism in the late 1950's. He found it problematic to organize all areas of musical elements according to one unitary scheme, because the human nervous system reacts in basically different ways to relations between pitches and relations between durations. He also found that the musical potential of the intervallic relations provided by the 12-step chromatic scale was exhausted. So he preferred to eliminate the intervals as structure-forming elements;

> I composed interlacing patterns of voices, so dense that the separate intervals disappeared, no more functioning as independent intervals,

> but merely collectively, as multitudes of intervals. But in this way, the pitch function was also eliminated. Pitch series lost their meaning. In their place the internal relations of movements and the texture patterns of the webs of voices gained relevance for the formation of structure and form. Pitch heights and intervals were merely assigned a global function as relations between layers of tones (registers) and tone densities. Thus, in "Apparitions", no serial organization of pitches is found. This means that the equality of musical elements, the foundation of serial music, is cancelled. (Ligeti, 1971)

Ligeti points out here that essential musical phenomena occur when discrete musical elements lose their clear definition and contribute to a borderless flow of sound energy in transformation.

Innovations and achievements
In terms of exploration of the potentials of the musical continuum, the achievements of Ligeti and Xenakis in their pioneering works of the 1950's and early 60's can be summed up as follows;

Space: Opening and investigation of the total musical soundspace of height and depth, proximity and distance, foreground and background, masses of sound expanding and contracting, merging and dividing, states, events and transformations occurring and disappearing.

Timbre: Composition with and composition of timbre as a predominant musical dimension, determinative for musical events and processes from the articulation of brief musical moments to the unfolding of large-scale musical form. Timbre is investigated in its rich variety between harmonic color and noise, brightness and darkness, individualized attacks, contrasting instrumental groups and fused complex timbres.

Intensity: Exploitation of intensity as a constitutive factor in musical evolution and structure, varying from the barely perceptible sound to explosions and fields of maximized noise. Intensity is investigated in its vast potential for continuous transitions, for contrasts and interruptions, for oppositions of sound and silence.

Movement: Composition of movement and transformation in a variety of continuous and discontinuous shapes, patterns and processes, rise and fall, oscillations and glissandos, flow and growth, activity and stasis.

Pulse: Application of pulse as an independent musical dimension, evoking slow, fast or multilayered patterns of time, sensations of speeding up or slowing down, and transitions between regularity and irregularity.

Common for the three composers discussed in this chapter is their intention of creating virtual spaces of sound; Ligeti by the merging of pitches in vibrating masses, streams and sheets of colored sound, Xenakis by the stochastic distributions of sonic events, and Lutoslawski by the illusions of spatial movement created by gliding bundles of quarter-tones.

The virtual space evoked by music is the theme of the next chapter. Subsequent chapters focus on different aspects of the musical insights and innovations provided by Ligeti, Xenakis and Lutoslawski; chapter four deals with relations between musical space, musical time and the natural environment, chapter five with the continuum of timbre, harmonic color and pitch. Transparence and density of the soundspace is discussed in chapter seven, the nature of vibrating and fluctuating qualities of sound is in the focus of chapter eight.

3

Space, Time, Flow and Memory

Music listening evokes a virtual space

Musical sounds compete with the sounds of the surrounding world. When auditory attention and awareness are activated by musical sounds, a competition arises between the perceptual cues of the music and the perceptual cues conveying auditory information about objects and events in the world. The tendency of hearing to draw the world into the mind implies the obtrusive side effect that music may be drawn into the mind, engaging the potentials of auditory perception to such a degree that ordinary auditory spatial consciousness is disturbed and suppressed.

An everyday example of the attention-attracting power of music is the experience of unwanted music heard through a wall or an open window. If the music is intense and coherent, it is hard to avoid its mind-focusing attraction, as the ears cannot be closed by voluntary decision. The involuntary listener may then choose to surrender to the music, make a conscious effort to ignore it, try to stop it, play another kind of music, or leave the place.

When music wins the competition against rivaling perceptual cues and drowns out other kinds of sound, the auditory images of the real world are eliminated, and a virtual musical space is evoked in the listening mind. This is a fundamental reason for the fascinating and enchanting effects of music. Music has the power to conjure up a virtual world in the listening mind. That is the essence of the words set to music in Schubert's Lied "An die Musik";

> Du holde Kunst, in wieviel grauen Stunden,
> Wo mich des Lebens wilder Kreis umstrickt,
> Hast du mein Herz zu warmer Lieb' entzunden,
> Hast mich in eine bess're Welt entrückt! (Franz von Schober)

Thou lovely art, in many a dreary hour
When life in all its dreaded toils surrounds me,
Hast thou my heart enkindled to new love,
And set me forth into a fairer world !

Whether the virtual world of music is really a better or fairer world, remains an open and personal question. Music that evokes intense joy in one person appears to be worthless, annoying or rage-provoking to another person. Both kinds of reactions confirm the strong mental impact of music.

Music listening activates and engages the sensitive, fast-working and complex auditory perceptual processes essential for spatial orientation as a means of biological survival, so the sound of music hits a powerful natural potential of sensory experience.

György Ligeti has described the experience of the illusory space evoked by music in his thought-provoking essay on Form in contemporary music;

> "Form" is originally an abstraction of spatial configurations, of proportions between the extensions of objects in space. Transferred to non-spatial areas - form of poetry or music - "form" is an abstraction of an abstraction.
>
> In accordance with the origin of the concept, spatial aspects adhere to forms unfolding in time. This is supported by the fact that time and space always appear coupled with each other in our world of thoughts and imaginations; wherever one of the two categories is present, the other one immediately appears by association. By imagining or listening to music in which the progress of sounding events is primarily temporal, imaginary spatial relations emerge on several levels.
>
> In the first place on the associative level, as changes in pitch height (the word in itself already refers to spatial analogy) evoke the vertical dimension, the persistence of a particular pitch height evokes the horizontal spatial dimension, while changes in timbre and intensity, such as differences between open and muted sound, produce the impression of proximity and distance, in a general sense an impression of spatial depth. Musical gestalts and events appear to us as if they take up certain positions in the imaginary space evoked by themselves.

Ligeti further describes specific types of imaginary space evoked by harmonic relations and syntactic relations betwen separate musical features, and concludes;

> Because we spontaneously compare any new feature appearing in consciousness with the features already experienced, and from this comparison draw conclusions about coming features, we pass through the musical edifice as if its construction were present in its totality. The interaction of association, abstraction, memory and prediction is the prerequisite for the formation of the web of relations that renders the conception of musical form possible.
>
> From the point of view stated here, the difference between music as such and musical form can be pointed out. "Music" would thus be the sheer temporal process, "musical form", on the contrary, the abstraction of the same temporal process, where the internal relations in the process no more present themselves in temporal succession, but as virtual space. Musical form emerges only when the temporal course of musical events is surveyed retrospectively as "space". (Ligeti, 1966)

In this Ligeti text, three main points invite a discussion; the spatial experience of music, the concept of musical form and the role of memory in music listening.

The musical space is a continuous flow

The virtual space evoked by music is not a static edifice, characterized by unchanging relations between elements, gestalts, states, events and transformations. The musical space is evoked as a continuous flow in the listening mind. The Danish composer Jan Maegaard gives this description;

> Music is only there while being played. No matter where you listen, you must hold on to what is played right now, understand it in the light of the preceding musical events and process it in preparation of the following events. You are obliged to experience the music in its own tempo, without the possibility of lingering or hurrying. It continues relentlessly to the end, insisting on your following it in its course. (Maegaard, 1966)

The nature of music is continuous disappearance. Nevertheless, there is always something to hold on to, as the listener's short-term memory is constantly active, retaining auditory images of musical events for a short while. The retention in short-term memory permits the experience of coherent musical entities, comparison with other events in the musical flow, conscious or subconscious comparison with previous musical experience stored in long-term memory, and the continuous formation of expectations of coming musical events.

The retrospective survey of the virtual musical space is, according to Ligeti, the origin of musical form. In a comment (1966) to Ligeti's essay, the Danish composer Per Nørgård dissociates himself from this view. Nørgård considers the distinction between "music" and "musical form" impossible, arguing that the concept of form is not identical with the concept of an ideal musical totality, as the perception of form arises as a complex texture of smaller and larger musical entities during the listening. This process is experienced in the listening of Nørgård's works, see the discussion of his Second Symphony in chapter seven, pp. 133-42. Nørgård's understanding of form is, however, rather close to Ligeti's statement about "the web of relations that renders the conception of musical form possible". The reason for disagreement is a difference in evaluation of flow versus remembered form.

The musical experience is a balance between flow and retention. This balance is variable, never constant. Its extremes are on one hand the mind-absorbing experience of being completely carried away by music; on the other hand the careful elaboration of analysis and synthesis leading to the mental reconstruction of a musical form.

Music listening takes place somewhere between the extremes of immediate disappearance and complete retention in a continuous interaction between memory and flow. The transitory flow and its retention in memory are complementary sides of the musical experience.

Retention of musical form is the effect of a variable and rather unpredictable interaction between short-term memory, sensory input and processing, and long-term memory. Music psychologist Stephen McAdams explains that

> The capacity of memory structures in music listening is of paramount importance since musical structures are extended in time. The perception of movement, of transformation and of musical significance depend on the perceived element being heard in relation to remembered elements. We might say *that perception really only becomes musical when it is "in relation to" events, sequences, progressions and structuring in memory.* The form of a piece of music is what gets accumulated in memory, and thus the richness of that form depends very heavily on one's capacities and experience as a listener. (McAdams, 1987)

Memory depicts the temporal flow of sound

In short-term memory, the macrotemporal listening dimensions pulse and movement are created by perceptual processing. During this process, impressions are retained, which may subsequently be wiped out or stored in long-term memory. Pulse leaves the impression of tempo, movement an impression of shape.

The impression of *tempo* is created by the awareness of regular repetition. If the sensations of regularly repeated impulses are continuously fed into short-term memory, auditory perception adapts to the regularity, constituting the perceived tempo as a reference for further listening. If the regular impulses stop, their tempo is retained and can be continued in tapping, dancing or gestures.

The impression of *shape* in short-term memory is characterized in an elegant way by the American musicologist Jan La Rue;

> Music is essentially movement; it is never wholly static. The vibrations of a single sustained note, the shock waves of a clipped staccato induce motion even in isolation. Any sounds that follow may then confirm, reduce, or intensify the embryonic sense of movement. At the same time that a piece moves forward, it creates a shape in our memories to which its later movement inevitably relates, just as the motion of a figure skater leaves a tracing of visible arabesques on the ice when the movement has passed far away. (La Rue, 1970)

Memorized representations of listening dimensions

Tempo and *shape* are the memorized representations of the macrotemporal dimensions pulse and movement.

The microtemporal dimension timbre is precisely memorized as a particular *prominent quality* of sound. A large number of distinctive timbres are stored in long-term memory, permitting later recognition of sound sources such as guitars, church bells, empty barrels, breaking glass or familiar voices.

In the vertical spatial continuum of pitch, a focusing at a precise pitch level is memorized as pitch height. It remains in short-term memory for a while, and can be recalled and reproduced by a person of adequate musical ability.

In *Fig. 3.1,* the memorized representations *tempo, shape, prominent timbral quality* and *pitch height* are included in the model of listening dimensions.

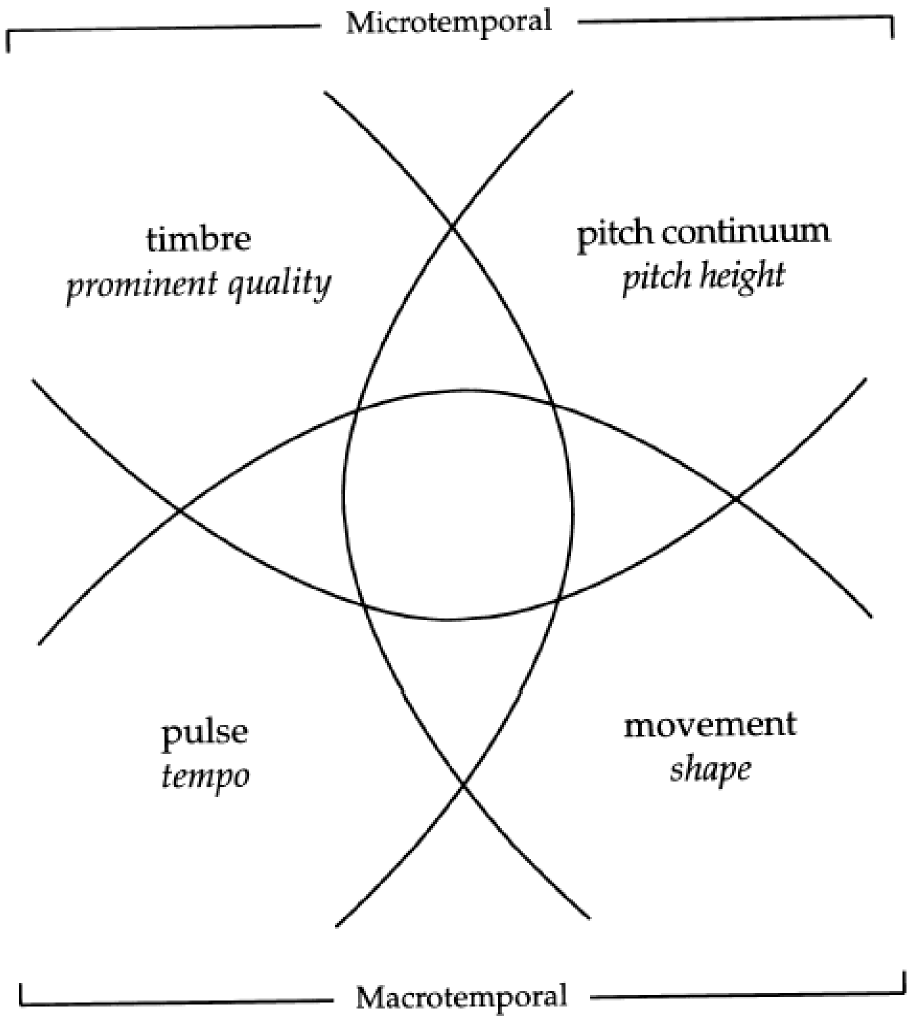


Fig. 3.1. Memorized representations of listening dimensions

Qualitative and quantitative potentials of listening dimensions

The memorized representations of listening dimensions are basically qualitative potentials of perceived sound.

Timbre as such is a qualitative dimension, memorized as the prominent quality of a particular sound source or sound event.

The memorized shape of a sound *movement* retains contour qualities specific to the perceived movement. Contour qualities permit the memorization and recollection of a large number of tunes and themes. Melodic contour qualities are discussed in chapter six, pp. 98-107.

Pitch height possesses the qualities of brightness and clarity in high registers, fullness and sonority in medium register, and dark and diffuse qualities in low registers. Even the electronic sine wave tone displays different qualities in different registers.

The qualitative aspect of *pulse* is its tempo, and acceleration and deceleration of the tempo. The particular quality of tempo stems from its similarity with the biological pulse of the heartbeat, speeding up and slowing down in relation to changes in bodily and emotional states. We gain an immediate qualitative sensation of slow, medium and fast tempo, and the slowing down or speeding up of tempo evokes emotional response. Listening to music with a pulse evokes a sensation of regulated time in the listening body. This is a powerful means of coordination, and a powerful source of fascination and emotion.

Quantitative potentials are inherent in two of the memorized representations of listening dimensions, *pitch height* and *tempo.* Both are natural continua.

The natural continuum of *pitch height* is easily demonstrated by the human voice gliding from its lowest to its highest register and back again, or by a glissando on a string. The division of the pitch height continuum in intervals of equal or unequal sizes is the basis for the formation of scales and modes developed in different cultures. The possibility of counting, grouping, adding, dividing and measuring these intervals is the quantitative potential of pitch height.

The double potential of pitch height, quantitative and qualitative, is reflected in the French language, employing two pairs of words for describing differences in pitch height, *haut - bas,* designating the quantitative potential of the high - low continuum, and *aigu - grave,* pointing out the qualitative difference between sharp and heavy pitch heights.

The natural continuum of *tempo* is experienced in the process of running, proceeding from a standstill through slow and medium tempi to the highest possible speed of one's personal capacity and subsequently slowing down to another standstill. Simultaneously, the heartbeat will speed up and gradually slow down again. This reveals the coexistence of two different tempo layers in the body, the tempo of the feet and the tempo of the heartbeat. A third tempo layer can be added by clapping or finger tapping, and a fourth by chewing.

Quantitative potentials are inherent in tempo as well as its underlying pulse. Tempo can be defined and quantified by technological means such as the metronome or electronic impulse generators. Pulse beats can be counted, added, grouped and divided in order to constitute a basis for additive rhythm or divisive rhythm and meter. Examples of additive and divisive rhythm are discussed in chapter six, pp. 91-96

Qualitative and quantitative potentials of listening dimensions are shown in *Fig. 3.2.* The quantitative potentials are properties of the dimensions *pulse* and *pitch height,* related to the low and the high end of the physical frequency continuum.

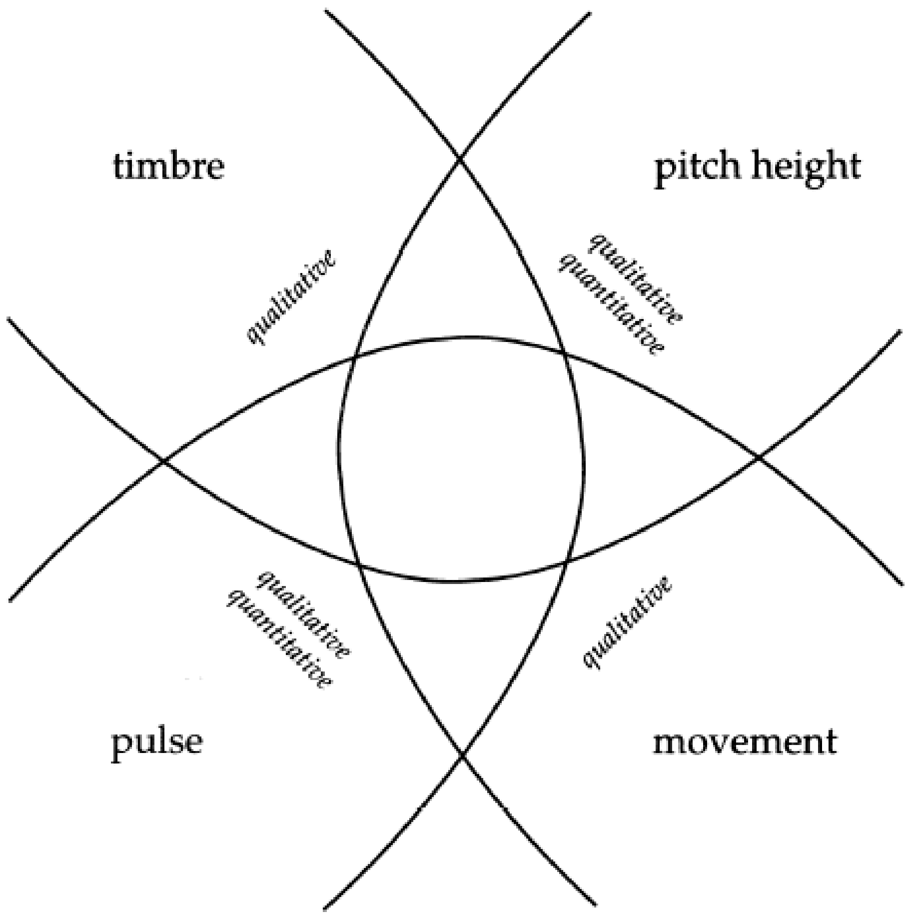


Fig 3.2. Qualitative and quantitative potentials of listening dimesions

4

Time, Space and the Environment

Music creates time

Music does not "unfold in time". Music *creates time.* A succession of musical sounds evokes sensations of time. The experience of musical time depends on the nature of the sounding phenomena, their relations and interactions. The experience of musical movement evokes sensations of change and duration; the experience of musical pulse evokes sensations of regulated continuity and tempo. These are two qualitatively different kinds of time, called forth by the awareness of change and the awareness of regularity. They interact with each other, and they may interact with a third kind of temporal experience, related to sensations of gradual transformations which are so slow or indiscernable that they are not perceived as movement. Ligeti's *Atmospheres* is a prominent example of slow, gradual transformations.

Due to the variable balance between experienced change and regularity and due to the complementarity between the transitory flow of musical sound and its retention in memory, musical time is flexible. Musical time is different from the regularity of measured clock time. The flexibility of musical time is characterized by Susanne K. Langer;

> The elements of music are moving forms of sound; but in their motion nothing is removed. The realm in which tonal entities move is a realm of pure *duration.* Like its elements, however, this duration is not an actual phenomenon. It is not a period - ten minutes or a half hour, some fraction of a day - but it is something radically different from the time in which our public and practical life proceeds. It is completely incommensurable with the progress of common affairs. Musical duration is an image of what might be termed "lived" or "experienced" time - the passage of life that we feel as expectations

> become "now," and "now" turns into unalterable fact. Such passage is measurable only in terms of sensibilities, tensions, and emotions; and it has not merely a different measure, but an altogether different structure from practical or scientific time.
>
> The semblance of this vital, experiental time is the primary illusion of music. All music creates an order of virtual time, in which its sonorous forms move in relation to each other - always and only to each other, for nothing else exists there. (Langer, 1953)

Langer's view is shared by Jonathan D. Kramer (1988) who states that "the age-old idea that time is out there, is questionable. Events, not time, are in flux. And music is a series of events, events that not only contain time, but also shape it."

Music listening gives rise to three kinds of temporal experience, the time of movement and events, the time of pulse, and the temporal experience; related to apparent musical stasis or slow, barely perceptible changes of musical states, the time of being.

The time of being

The time of being is the kind of time we experience when no other sensations of time impose themselves on our consciousness. The time of being is sometimes called timelessness, moment time or eternal time. It is the time experienced in nature when we are not near a clock or watch, and we are not expecting something to happen, and we are not impatient for a change to occur. The time of being may be experienced as "timelessness" because we lack a habitual sensation of time that runs or elapses or passes by.

In a civilization governed by timekeepers, there is a prevailing tendency to forget the time of being, consider it out of the ordinary, or ignore it completely. But the time of being is recalled in the experience of nature, the universe, and living beings. We know that a child and a plant grow and that a flower opens and turns and closes itself, but we do not perceive the minute changes constituting these processes. We see that the snow is falling, but we do not discern the movement and direction of the single snowflake. We know that the tide rises and falls, that the sun and the moon move across the sky (or so it seems from our viewpoint), but we don't sense the movement as such.

The core of this kind of temporal experience is that we realize or know that something is changing or being transformed, but the process of change is so slow or imperceptible that it escapes our immediate sensory experience.

The time of movement and events

The sime of movement and events is derived from everyday experience. A movement directed towards a goal is perceived as having a beginning, a course and an end; the experience of expectation, continuation and conclusion evokes a sensation of duration.

The time of events is ambiguous. If successive events are experienced as related, the continuity of their succession evokes a sensation of duration akin to the duration of movement. If an event is experienced as a self-contained entity without connection to previous or coming events, it may evoke a feeling of unfulfilled expectation akin to the sensation of duration, or it may, on the contrary, evoke a feeling of timelessness akin to the time of being.

Pulse time

Pulse time emerges from the sensation of a regular succession of impulses. Pulse time has qualitative properties arising from the experience of tempo, acceleration and deceleration, and quantitative properties related to the experience that impulses can be counted, grouped, added and divided. This implies a crucial difference from other kinds of temporal experience. Pulse time is quantitative as well as qualitative, contrary to the time of being and the time of movement and events, which are not quantitative, but qualitative experiences of time.

Pulse time can be related to the forward-directed time of movement, as one impulse can evoke the expectation of the next impulse, and the experience of a group of impulses can evoke an expectation of a succeeding group.

Continuous pulse time can be related to the omnidirectional time of being, as continuous pulse has no definite beginning and end. This means that pulse time can, and does, create relationships between the time of movement and events and the time of being. An example is Steve Reich's *Music for 18 musicians,* described in chapter six, pp.

For some centuries, the art music of the Western World has been closely linked with the time of pulse and the time of goal-directed movement. This relationship was reinforced by the evolution of tonality. But in the beginning of the twentieth century, musical works were composed which loosened themselves from the relation to forward-moving, goal-directed time. Works of this kind are found in the music of Charles Ives, Arnold Schoenberg and the Dane Rued Langgaard.

The Unanswered Question

In 1906, Charles Ives composed a pair of musical "contemplations"; *The Unanswered Question* and *Central Park in the Dark.* The first work was characterized by Ives as "a contemplation of a serious matter", the latter as "a contemplation of nothing serious".

The Unanswered Question, subtitled "A *cosmic landscape",* is scored for strings, solo trumpet, and 4 flutes. Two of the flutes may be substituted by oboe and clarinet.

In the extensive foreword of his score, Ives sets the scene of the music, introducing ideas and images as a guide for musicians and listeners.

> The string quartet or string orchestra (con sordini), if possible, should be "off stage", or away from the trumpet and flutes. The trumpet should use a mute unless playing in a very large room, or with a larger string orchestra. If more than four strings, a basso may play with the' cellos (8va basso). The strings play ppp throughout with no change in tempo. They are to represent "The Silences of the Druids - Who Know, See and Hear Nothing." The trumpet intones "The Perennial Question of Existence", and states it in the same tone of voice each time. But the hunt for "The Invisible Answer", undertaken by the flutes and other human beings, becomes gradually more active, faster and louder through an animando to a con fuoco. This part need not be played in the exact time position indicated. It is played in somewhat of an impromptu way; if there be no conductor, one of the flute players may direct their playing. "The Fighting Answerers", as the time goes on, and after a "secret conference", seem to realize a futility, and begin to mock "The Question" - the strife is over for the moment. After they disappear, "The Question" is asked for the last time, and "The Silences" are heard beyond in "Undisturbed Solitude." (Ives, score note)

A live performance by The New York Philharmonic and Leonard Bernstein, distinguished by its poetic serenity, is chosen as reference. In this recording, issued on CD by Deutsche Grammophon, the woodwind quartet is composed of two flutes, oboe and clarinet. The duration of the recorded work is 6'03. The first page of the printed score is reproduced as *Ex. IV-I.*

Throughout the piece, strings play slowly changing, space-filling harmonies. On this background, the trumpet states its question seven times, answered six times by the woodwinds. This is a survey of the music;

The Unanswered Question

Strings:	Trumpet Questions:	Woodwind Answers:
0'00-1'35 Strings alone		
:	*1'35* Question	
:		*2'04* placid, gentle answer
:	*2'27* Question	
:		*2'44* calm, slightly dissonant answer
:	*3'13* Question	
:		*3'30* hesitating statement
:	*3'52* Question	
:		*4'07* firm statement
:	*4'23* Question	
:		*4'33* lively polyphonic discussion
:		*4'38* soft sustained cluster.....*4'52*
:	*4'47* Question	
:		*4'53* hectic activity
:	*5'37* Question	
5'47-6'03 Strings alone, Fading		

The piece opens in a feeling of timeless harmony. The first score page displays a sustained G major chord, played ppp con sordini by the strings spread over a range of four octaves, evoking the impression of a transparent space.

The string voices continue in diatonic motion and mainly triadic harmonies, moving slowly in phrases of irregular length so that a sense of beat does not emerge, and time almost seems to stand still.

A slow forward-directed movement appears in violas and cellos in measure 11-13. The movement is absorbed in the long sustained chord in measure 14.

The atonal trumpet question stands out as a distinct gestalt in the transparent string space, salient due to its particular timbre and precise attack. Its slow-moving triplets contribute to the feeling of fluid time.

The woodwind answers represent a competing musical force, tending towards the emergence of regular pulse time. The first and second answers are vague and indistinct, but in the third answer a feeling of pulse and rhythm emerges. In the fourth answer at *4'07- 4'13,* pulse time comes clearly to the fore in distinct, disciplined, almost march-like rhythms.

But this well-disciplined agreement is not of lasting character. The next entry of the woodwinds is an exchange of uncoordinated musical arguments, and the "secret conference" in a tight, sustained cluster at *4'38* does not lead to unanimous pulse, but to an agitated dispersal of energy. The piece then comes to an end as it began, in harmony with the time of being.

Central Park in the Dark

In the companion piece, *Central Park in the Dark,* another musical space is created by the strings. Soft, rather dense and complex chords of particular, individual colors are played continuously, piano pianissimo, in slow phrases of unequal shapes by the strings. One and the same succession of chords is played over and over again as an unchanging cycle till the end of the piece. The chord succession is shown in *Ex.VII-II.*

According to remarks written in one of Ives' early sketches, it is his intention to let the strings represent "night sounds of nature, bugs, leaves on trees, sounds of silent darkness, sounds natural and unnatural."

In the recording by Bernstein and the New York Philharmonic, musical events appear as the following.

Central Park in the Dark

Strings:	Other instruments:
0'00-0'47 1st chord cycle	
0'48-1'29 2nd cycle	*0'55-1'13* soft, slow clarinet phrases
1'30-2'10 3rd cycle	*1'46-2'00* clarinet continues *2'01-2'23* flute and oboe join in a tune
2'll-2'49 4th cycle	
2'50-3'27 5th cycle	*2'52-3'17* clarinet, oboe and violin play slow melodies in polyphony *3'14-3'30* piano rhythms
3'28-4'07 6th cycle	*4'02* slow clarinet, *4'04* piano rhythm *...4'12*
4'08... Strings continue, gradually drowned out by other events	*4'18 a* fast, loud, ragged mixture of music begins; clarinet, pianos, trombone, drums, flutes, trumpets and others join in; musical density and tempo increases, growing to a chaotic, noisy climax at *5'20-5'25*
5'30-6'12 9th cycle	*6'02* soft, sweet clarinet melody
6'13-6'55 10th cycle	*6'22* flute, *6'27* two-part violin melody *...6'42*
6'56-7'09 Standstill on the first chord of the cycle	

Akin to *The Unanswered Question,* several kinds of music are heard simultaneously, creating variable relations between the background of strings and other instruments which stand out in the foreground of the music. A score page of high instrumental activity is shown in *Ex. IV-II,* corresponding to *5'11-5'14* in the recording.

In comparison with *The Unanswered Question,* the background color of *Central Park in the Dark* is less transparent. It is more complex and slightly blurred, but not disturbingly dissonant. This soundscape is earthly, not cosmic; no solemn questions are asked and discussed, but snatches of tunes and rhythms in recognizable musical styles appear and disappear. Each new event gives rise to a focusing or zooming in, and its disappearance re-opens the spatial sound perspective to the recurrent cycle of softly colored string chords. In Ives' own words;

> This piece purports to be a picture-in-sounds of the sounds of nature and of happenings that men would hear some thirty or so years ago (before the combustion engine and radio monopolized the earth and air), when sitting on a bench in Central Park on a hot summer night. The strings represent the night sounds and silent darkness - interrupted by sounds [the rest of the orchestra] from the Casino over the pond - of street singers coming up from the Circle singing, in spots, the tunes of those days - of some "night owls" from Healy's whistling the latest or the Freshman March - the "occasional elevated", a street parade, or a "break-down" in the distance - of newsboys crying "uxtries" - of pianolas having a ragtime war in the apartment house "over the garden wall", a street car and a street band join in the chorus - a fire engine, a cab horse runs away, lands "over the fence and out", the wayfarers shout - again the darkness is heard - an echo over the pond - and we walk home. (Ives, score note)

The interactions of different kinds of time in *Central Park in the Dark* can be heard as follows;

Central Park in the Dark

0'00 Slow movement time: the string chords change quietly, but no regular pulse or grouping appears.

0'55 Event and movement time: The clarinet timbre attracts attention, and awareness of its fluid melodic movement continues.

1'14 As the clarinet disappears, the slow-moving background of strings reappears. Sensation of chord movement is now weakened, the quality of background more prominent.

1'47 Events and movements; the clarinet reappears. 2'*01* New event; The timbre of flute attracts attention. 2*'10* the oboe attracts attention.
2'27 Soloists disappear, background reappears.

2'52 Movement time: Clarinet, flute, oboe and a violin are linked in a slow-moving melody.

3'14 Pulse time emerges discreetly in piano rhythms.

3'30 Background reappears.

4'02 Movement time: Slow clarinet melody and quiet piano appear, continued by clearly forward-directed movement in clarinet at 418, leading to

4'22 Salient pulse time in ragged piano rhythms, competing with several layers of movement.

4'40 Pulse time is reintroduced by high clarinet with piano pulse, on a dense background of movements. New pulses are introduced, *4'54* trombone, *4'58* drums, *5'05* flutes, *5'07* trumpet, and a chaos of competing pulses and movements increases, accelerating to a climax at *5'20.*

5'25 The strings, largely drowned out and forgotten, reappear. After the preceding chaos, they seem to adopt the quality of an ever-present natural background sound, and movement time gives way to the time of being.

6'02 and *6'22* The slow movement time of clarinet, flute and violin is now nearly absorbed in the background time of being which continues in a standstill on the first chord of the string cycle.

Summer Morning by a Lake (Colors)

The third of Arnold Schoenberg's *Five Pieces for Orchestra op. 16 (1909)* is closely related to the time of the natural environment.

Contrary to Ives, Schoenberg was reluctant to indicate any inherent meaning of his music in words. Jan Maegaard (1976) points out that when Schoenberg was urged by his publisher to add titles to the orchestral pieces, he preferably chose technical terms, giving Piece number three the title *Chord Colors,* in the printed score simplified to *Colors.* But preparing a later edition (1949), Schoenberg changed the title to *Summer Morning by a Lake (Colors).*

Maegaard relates that Schoenberg's impressions of the Austrian lake Traunsee in the summer of 1909 were formative for the piece (Wellesz, 1921), and quotes Webern;

> Through this change of chord color, which persists throughout the whole piece, a peculiar shimmering sound emerges, comparable, as Schoenberg says, with the continuously changing impression of the colors of a lake surface in quiet motion. (Webern, 1912)

Another of Schoenberg's students recalls that "the title 'colors', written nowhere, was communicated personally to us by Schoenberg, 'in the tranquil surface of the lake the sun is reflected' " (Max Deutsch, 1980)

In the score of this piece, Schoenberg indicates that the change of chords have to take place so smoothly that no accentuation of entering instruments should be perceptible, only a change of color. The beginning of the score is reproduced in *Ex. V-VI.* A recording faithful to Schoenberg's indication is the one by Simon Rattle conducting The City of Birmingham Symphony Orchestra, issued on CD by EMI. This is a description of the recorded piece, with the idea of a surface of water in mind.

Summer Morning by a Lake (Colors)

0'00-1'04:
Gently waving surface, subtly changing in light and color. *0'32* and *0'43* slight disturbances; *0'52* movement ceases. *0'56* Completely static, rather dark and dense sound, *1'01* fading.

1'04-2'46:
Renewed movement. *1'11* Surface colors in gliding wave motion, 1'*27* sense of pulse briefly evoked by a few "spots of light". *1'48-1'53* Glittering splashes break the surface twice (like the tail of a fish); 2'*06* darkening .... 2'*11* brief splashes and a bright streak of light. *2'16* Gradually increased agitation... 2'*40* calming down in static sound.

2'47-4'07:
Clear, tinkling "tic-toc" sound appears. *2'51* Waving, gliding surface colors, *3'28* and *3'34* soft, deep disturbances; *3'38* bright reflection. *4'00* calming down, fading.

This piece is static, but not completely static. The sound is in motion, but not moving in a particular direction. The change of instrumental color is a little too slow to be heard as pulse, but not slow enough to lose its momentum. The movement repeats itself cyclically, analogous to the movement of waves. This temporal structuring can be characterized as the time of undirected cyclic movement.

The wave-like cyclic time is the continous background sensation of this piece, now and then disturbed by brief events which restimulate attention not only on the occuring event itself, but also on the background when it reappears.

Brief glimpses of pulse time occur at *1'27* and 2*'47.* Within the frame of the image of nature, these glimpses could be interpreted as reflections of sunbeams in surface waves or the sound of waterdrops. But the tinkling sound at 2'*47* is so close to the ticking or striking of a clock that it is likely to hear it as a sudden intrusion of measured time disturbing the time of nature. A cue to this interpretation is the tic-toc sound appearing in another of the Pieces for Orchestra op. 16, number one, Premonitions, where ticking sound is heard at *1'54 -2'03* in the Simon Rattle recording.

Summer Morning by a Lake (Colors) evokes the time of being by its slow, undirected cyclic movement. The cyclic regularity of the changes of timbral color is so slow and gradual that it is not experienced as pulse time. The time of movement and events interacts with the time of being in the form of quiet disturbances which appear and disappear.

This piece displays similarities of temporal structure with Ives' two orchestral pieces. In all three pieces, the background time of being is temporarily disturbed by events and movements, but it reappears when the disturbances disappear.

The three pieces evoke different kinds of spatial scenery. In *The Unanswered Question,* the calm solitude of the Universe is the background for the impersonal trumpet question and the human activity of the woodwinds. In *Central Park in the Dark,* the sounds of silent darkness constitute a cityscape background for the interactions of a multitude of musical activities. In *Summer Morning by a Lake (Colors),* the tranquil water surface is the background for events and movements of the natural environment, splashes of water and flashes and reflections of light. The tinkling tic-toc sound stands out as a brief intrusion, like a memento of the contrast between the measured time of civilization and the unmeasured time of nature.

The Music of the Spheres

The orchestral work *The Music of the Spheres (1916-18)* by the Danish composer Rued Langgaard is music that evokes images of space, transparence, distance, light and weightlessness, and evokes two kinds of temporal experience which are directly opposed; the dissolution of forward-moving time, and the increasing tension of intense acceleration.

Rued Langgaard (1893-1952) was a singular figure. It was his firm intention to continue the tradition of Danish romantic music, yet his sensibility of sound, his eminent musical memory and outstanding creative imagination led him to compositional innovations unheard of at the beginning of this century, such as tissues of clusters, multilayered sound masses, noise effects, brushed piano strings and extensive use of repetitive patterns. In terms of delicate sensibility and unpredictable inventiveness, Langgaard is comparable to Charles Ives.

The innovative techniques of Langgaard were not incompatible with the melodic-harmonic idiom he valued so highly This is heard in *The Music of the Spheres* which is romantic and modern, episodic and coherent, noisy and breathtaking beautiful In his Langgaard biography, Bendt Viinholdt Nielsen characterizes the work;

> In The Music of the Spheres the composer succeeds in creating striking and suggestive impressions of space, surfaces, distances, height and depth, foreground and background. The large orchestra with chorus and organ is employed in the manner of chamber music; the full orchestra is not heard until the conclusion of the work. In addition, Langgaard uses a small "distant orchestra", contributing to the impressions of foreground and background.
>
> The organic and dynamic movements from one climax to another climax characteristic of late romantic music are found nowhere here; considerable parts of the work are static and kept within the limits of the most quiet dynamics. The composition consists of juxtaposed blocks of sound describing a succession of states, not an actual progress. The work is linked together by its strong concentration around the spatial aspect of music. (Viinholdt Nielsen, 1993)

The Music of the Spheres is a work of considerable length, more than half an hour. It is recorded by the Danish Radio Symphony Orchestra conducted by John Frandsen, issued on CD by Danacord. This is a description of the work;

The Music of the Spheres, 0'00 - 9'54

Extended tremolo space ***(A)***

0'00 Transparent high-register string tremolo cluster expands downwards,

0'27 joined by timpani, *0'37* recedes upwards... *0'55*

High line of strings remains

1'01 Three swift tremolo clusters expand and recede... *1'48*

High line and low timpani roll remain

1'54 High line, *2'03* deep horns enter, repetitive pattern of oscillating melody expands downwards and recedes upwards... *2'46*
Explosion in timpani and cymbals

2*'56* Transparent high-register string tremolo cluster expands downwards, is joined by timpani, recedes upwards... 3'40

High line of strings remains

3'56 Swift string tremolo expansion downwards, *4'03* continued by horns, together traversing the soundspace from height to depth... *4'06* High and deep line remain

....

Slow motion melody and polyphonic web ***(B)***

4'15 Slow horn melody

4'51 Polyphonic web of strings on continuous timpani background

5'42 Slow horn melody... *6'22*

Single horn tones remain

....

Repetitive patterns and a flash ***(C)***

6'31 Shimmering wave patterns, *6'40* Golden chord, *6'45* sudden flash of sound up to high tremolos... *6'59* Repetitive oscillating patterns spreading downwards in a polyphonic web

....

Climax of repetitive melody ***(D)***

7'54 Strings gather in a unison melody, repeated up to a climax of timpani rolls... *8'38*

Relief in distant music ***(E)***

8'40 Distant organ emerges, *8'52* organ and strings sustained, rising horn chord spectra, *9'23* strings ascend high, *9'30* joined by bright flute tremolo clusters and deep horns... *9'46*

Deep horns remain

9'55-16'l5

Tremolo space ***(A)***

9'55 Transparent string tremolo cluster expands, is joined by timpani, recedes... *10'44*

High line of strings remains

....

Repetitive melodic garlands expanding in a polyphonic web ***(C)***

10'54 Deep horns and continuous timpani roll enter; flutes and violins begin a continuous movement in melodic garlands, *11'05* ascending, *11'09* expanding to a space-filling polyphonic web, *11'47* slowed down, thinning out... *11'56*

Timpani rolls and single strokes remain

....

Climax of accelerated repetitive patterns ***(D)***

12'32 Shimmering flute oscillations *...12'40*

12'41 Transparent high-register harmonies in string ...22'53

12'53 Shimmering oscillations in flutes and violins... *13'04*

Timpani roll remains

13'07 Slow waves in wind instruments, endlessly rocking between two harmonies while strings play quiet oscillations. 23'22 chorus enters, endlessly repeating a Kyrie Eleison motif, 13'24 accelerating, faster and faster, crescendo... 13'36 with motif rhythm reinforced by timpani... culmination at *14'02* followed by agitated surges of strings.

Distant music ***(E)***

14'20 The distant orchestra emerges, playing quietly rotating patterns,

14'40 Horns and woodwinds of the main orchestra begin a slow motion polyphony *...15'52*

A few horn tones and timpani rolls remain and fade out

I6'l6-29'll

Idyll ***(B)***

16'16 Melodic interlude of pastoral and playful character, ending in a solo flute cadence *(17'17-17'53)*

....

Endless repetitive patterns ***(C)***

17'54 Rising and falling melodic-harmonic arches, *18'52* gently expanding in a web of incessantly falling lines... *19'22*

Soft timpani alone

19'28 Melodic-harmonic wave patterns, *19'40* slow layer of high-register tremolo patterns added... *20'25*

Timpani roll crescendo

20'32 Fast medium-register tremolo patterns... *20'47*

Soft timpani alone

20'54 Gentle waves endlessly rocking between two harmonies, with soft, slowly descending oboe on top, *21'32* thinning out... *21'55*

Soft timpani alone

22*'02* Melodic-harmonic wave patterns, *22'14* a layer of slow high-register tremolo patterns added... *23'03*

Loud timpani rhythms

....

Climax of accelerated repetitive patterns ***(D)***

23'09 Harmonic-melodic curves repeated in endless cycle, *23'35* accelerating... faster and faster, crescendo, *24'13* culminating with timpani, *24'16* calming down... *24'23*

Timpani rhythms

Distant heavenly music with soprano, soaring and expressive. ***(E)***

24'34 Prelude in main orchestra, *25'10* continued by distant orchestra, *25'20* soprano solo... *27'58.*

27'50 Distant bells and rising brass instruments, *28'20* Birdsong ... *28'50*

Bells and soft instruments continue

29'12-34'30

Climax: GREAT CRY! ***(D)***
29'12 Crescendo in strings and timpani, *29'19* **LOUD SOUND MASS** of chorus and instruments; the chorus sustains a chord for several minutes, while the orchestra plays a mixture of melodic fragments and fanfares with rolls on eight timpani. Final crescendo to a **GREAT NOISE** of timpani and suspended cymbals *(31'40-31'50)*

Silence

Heavenly music ***(E)***
31"59 Gentle music with harps, string tremolos, glissandos on piano strings and an angelic chorus, ending in a **GREAT LIGHT** of instrumental sound *(33'58-34'30)*

The form of the work is additive. Sections of music of contrasting character, marked A B C D E in the survey, are joined together in a consistent overall architectural design.

(A) is a space-filling string tremolo cluster. (B) is music characterized by slow-moving melody. The (C) sections are characterized by repetitive patterns and space-filling polyphonic webs.

(D) together with (E) constitute a climax and subsequent relief. In (D), repetitive patterns are intensified and accelerated towards a climax, followed by gentle distant music in (E).

The score notation of (A), the tremolo strings, is shown in *Ex. IV-III,* corresponding to *1'10 - 1'53* in the recording. A notation of (C), an expanding polyphonic web, is seen in *Ex. IV-IV,* corresponding to 7*"20-7'36.*

The overall form of the work is ABCDE/ ACDE / BCDE / DE.

Fig. 4.1 shows the timing and characteristics of the different sections.

In this music, as its title indicates, the impression of transparent space is prevailing. Like Ives' pair of orchestral contemplations and Schoenberg's *Colors, The Music of the Spheres* has a background of sound which reappears throughout the work, a high line of bright strings and flutes and a low sheet of timpani rolls, strokes and rhythms, supplemented by deep horns. The continued reappearance of the background creates a coherence underlying the contrasting sections of music, and the distance between the high line and the low sheet creates the impression of a free view through a large open space. In the (A) and (C) sections, the space is filled with bright, vibrating, oscillating sound yielding impressions of transparence. In the (E) sections, the use of distant organ, bells and distant orchestra widens the spatial perspective.

0'00 Tremolo space	*9'55* Tremolo space		
4'15 Slow motion melody		*16'16* Melodic idyll	
6'31 Repetitive patterns	*l0'54* Repetitive garlands	*l7'54* Endless repetitive patterns	
7'54 Climax Repetitive melody Crescendo	*l2'32* Climax Repetitive patterns	*U3'09* Climax Repetitive patterns, Crescendo, accelerando	*29'12* Climax Repetitive fanfares, Crescendo, Great noise
8'38 Relief Distant music	*14'20* Relief Distant orchestra	*24'34* Relief Distant heavenly music with soprano	*31'59* Relief Heavenly music, Angelic chorus, Great light

Fig. 4.1. Overall form of The Music of the Spheres

In this work, Langgaard has composed an abundance of repetitive patterns of cyclic movement in the form of melodic and harmonic oscillations, waves, curves and garlands. These patterns evoke two kinds of temporal experience which are directly opposed.

In the (C) sections, cyclic repetition in unchanged tempo leads to the dissolution of the sensation of forward-directed time so that the temporal experience approaches the time of being. Temporal succession is converted to spatial presence by continuous regular repetition.

At *20'54,* a veritable lullaby is heard, a quiet melody accompanied by endlessly rocking harmonies, related to the time of being. This music is akin to the experience of an unborn baby, gently rocking in the timeless fluid space of the womb.

In the (D) sections, cyclic repetition is used with the opposite effect. The repeated patterns are incessantly accelerated, leading to an accumulation of tension and a strong impetus of forward-directed motion, which culminates in an ecstatic or terrifying climax. A passage of ecstatic repetition is shown in *Ex. IV-V,* corresponding to *13'20-13'40* in the recording. Cyclic repetition in accelerating tempo leads to the experience of forward-moving time directed towards a goal.

Train moving away

Repetitive cyclic movement is a prominent feature in a short movement of Langgaard's *2nd String quartet (1918),* the second movement, subtitled *Train Moving Away.* The string quartet is available on a dacapo CD, played by the Danish Kontra Quartet.

Train moving away

> The duration of the movement is *2'21.*
>
> The music emulates the characteristic train sounds heard at the beginning of this century, the rotating wheels and the movements of the connecting rods of the engine, the fast rhythm patterns of wheels passing the gaps at rail joints, the rattling sound of wagon buffers when the train passes a switch, and high whistling sounds.

The first page of the score and a graph of the music is reproduced in *Ex. IV-VI.*

Train moving away, Ex. IV-VI

> In the graph, each square corresponds to one step of the chromatic scale vertically and one sixteenth-note horizontally.
>
> Viola and cello play a continuous cycle of repetitive motion in parallel octaves, accentuated by the rhythm of bow attacks.
>
> First violin plays long tones in gliding upwards motion, intensified by crescendo and sforzando.

Langgaard here imitates two physical phenomena related to movement and speed. One is rotation, imitated by cyclic motion. The other is the Doppler effect, which is the physical phenomenon implying that pitch is heard to rise when the listening ear approaches the sound source, and to fall when it moves away. This is imitated by a combination of crescendo and rising pitch.

The repetitive patterns of the viola and cello call forth the experience of fast tempo, and the high rising tones enhance the impression of forward motion at high speed. Later in this movement, the high sounds disappear, and the impression of rotation changes to a feeling of monotony, comparable to the time-dissolving effect of the endless repetitive patterns in *The Music of the Spheres.*

The concept of timespace

In the works discussed in the present chapter, different kinds of spatial and temporal experience can be distinguished.

Predominant *spatial qualities* are evoked in *The Unanswered Question* by the widespread sustained major chords of the strings, and in *Central Park in the Dark* by the soft, slowly changing complex chord colors. In Schoenberg's *Colors,* the impression of a water surface is produced by slowly waving cyclic movement. In *The Music of the Spheres,* vibrating tremolo clusters, polyphonic webs and oscillating repetitive patterns contribute to the impression of an open, transparent space.

Examples of *spatial-temporal qualities* are found in events and movements appearing in these works, such as the distinct gestalt of Ives' trumpet question and the fluid tunes heard in Central Park, the splashes and quiet disturbances of Schoenberg's lake, the melodic interludes in Langgaard's spheres and the Doppler effect of the train moving away.

The qualities of events and movements are spatial as well as temporal. Events stand out as a musical foreground, evoking a spatial perspective between foreground and background. Movement creates the spatial impression of direction towards a goal. Movement implies the temporal quality of duration, and a distinct event implies the temporal quality of attentive expectation.

Predominant *temporal qualities* are heard in the march-like rhythms emerging in Ives' *The Unanswered Question* and the ragged piano rhythms reaching *Central Park in the Dark,* in the tinkling tic-toc sound which disturbs the tranquillity of Schoenberg's Summer Morning, and in the ecstatic accelerations and fast rotations heard in Langgaard's works.

Relations between spatial and temporal qualities appear from the following schematic arrangement;

Spatial quality is predominant	*Spatial- temporal qualities are present*	*Temporal quality is predominant*
no tempo or very slow tempo	variable salience of tempo	clearly marked tempo
The time of being prevails	*The time of movement and events prevails*	*The time of pulse prevails*
inconspicuous change	perceptible change	perceptible regularity

Fig. 4.2. Relations between spatial and temporal qualities

States and events, movements and transformations of musical sound evoke impressions of space and sensations of time. The musical space is, however, a virtual space. In the motion of music, nothing is removed. Any kind of spatial quality, rising and falling, movement and growth, shapes and patterns, is called forth by temporal changes of sound qualities. The virtual musical space is completely integrated with musical time. The musical space is a virtual timespace.

The notion of *musical timespace* is coined by the American musicologist Charles Seeger in the introduction to his Collected Studies in Musicology. Seeger proposes a fundamental distinction between spacetime and time-space. Spacetime comprises the everyday concepts of space and time and the integration of space and time in the physical continuum. The concept of Timespace refers to the integration of temporal and spatial factors involved in the creation and consumption of products of human ingenuity. Seeger explains that:

> A single concept of timespace is, of course, quite different from two separate concepts of space and of time. It would seem to conform, however, more closely to the facts of direct music experience, in which tonal and temporal factors can be apprehended by us in an intimate fusion or integration that is quite different from the perception of the two as separate objects of attention. A concept of music timespace is therefore advanced here as one quite as necessary to study as the two conventionally accepted separate concepts of space and of time (Seeger, 1977).

In continuation of Seeger's line of thought, the investigation of the constitutive dimensions and qualities of the musical timespace is the aim of the following chapters. Chapter five deals with the microtemporal dimensions of the timespace, which are timbre, pitch height and harmony. Chapter six deals with movement, pulse, rhythm and melody, which are macrotemporal dimensions of the timespace.

5

Microtemporal listening dimensions: Timbre, Harmony and Pitch height

The microtemporal listening dimensions, discussed in chapters one and three, are perceived instantly, within a fraction of a second. The basic microtemporal listening dimensions in music are *timbre* and *pitch height.*

Timbre is the perceived quality of a complex spectrum of sound. In this spectrum, pitch height can be segregated as a separate dimension by perceptual focusing. Due to this process, pitch height adopts the nature of a spatial dimension, and the sound spectrum is perceived in two dimensions. One is the experience of the timbral quality of the sound source, the other is the experience of a certain level in a vertical spatial pitch height continuum.

Between the source-specific quality of timbre and the focusing quality of pitch, *harmony* can arise as an emergent quality. Harmony is experienced as a particular color quality of the sound spectrum.

Timbre, harmony and pitch height are three dimensions of a multivariable continuum of sound spectra. They are not distinctly delimited, but joined by gradual transitions from one dimension to another. The nature of timbre, harmony and pitch height, their relations and transitions are the themes discussed in the present chapter.

Timbre is the substance of music

Timbre is the natural resource explored and refined in music. The qualities of timbre and timbral combinations are infinitely variable, and each single timbre has its own particular quality. We recognize timbres in categories such as glass and metal, stringed instruments, brass, percussion and woodwind, male and female voices, but even superficial listening gives evidence that every violin produces its own particular sound, and every individual human voice possesses a timbral quality as unique as the face of the talking person.

In music, differences of timbre permit the distinction of instruments, voices and sound streams heard simultaneously, and differences between timbral qualities can evoke spatial impressions of foreground and background.Timbres may be heard as clearly separated simultaneous layers, or they may merge in particular fused color qualities.

In the surrounding world, timbre is the listening dimension that enables us to estimate the nature of sound sources and sounding objects, distinguish between them, recognize and identify them. The identification of timbre answers the subconscious question, "What is it?". The simultaneous subconsicious question, "Where is it?", is answered by spatial listening, enabling us to localize sound sources and sounding objects. Together, timbre perception and spatial perception provide auditory images of the variable relations between the listening mind and body and the surrounding world.

Two kinds of auditory perception are simultaneously active in the brain. One provides the basis for spatial discrimination, the other provides the basis for object discrimination. Information about sounding objects and information about spatial relations is processed simultaneously in two parallel systems on several levels, finally meeting in the auditory cortex to assemble an auditory image of the world. The neural pathways from the ears to the brain are fit for such a purpose. The pathways are divided and integrated several times to ensure the availability of neural information from both ears on four successive levels of perceptual processing. (Bloom & Lazerson, 1988). It is highly probable that this is a system permitting parallel processing of information for object discrimination and for spatial discrimination.

Jean- laude isset provides this description of the auditory potential for spatial orientation;

> The original function of hearing is not to extract the *"parameters"* of a sounding signal, but rather to induce useful indications about the environment from it. One would think that the evolution of hearing has tended towards benefiting as much as possible from the properties of sound, which spreads at distance and winds round obstacles; hearing plays an attentive role, it is particularly sensitive to changes, and it has a tendency to eliminate the *"background noises"* from consciousness - that is why an internal evolution, a spectral flux, is necessary in order that a timbre be of interest. Hearing is equipped with a well-developed mechanism permitting the evaluation of the distance and direction of a sound source, and it possesses procedures which help to maintain *"the constancy of real things"* (Koffka), just as vision does not deduce the size of an object merely from the dimension of the image on the retina. (Risset, 1986)

The auditory potential for detecting and distinguishing "real things" in the world is timbre perception. Timbre is the sounding equivalent of the nature of a sound-emitting object, conveying information of its material, size, state and the way of excitation that evokes the sound.

Gerald J. Balzano has proposed an explanation of the multivariable characteristic qualities of timbre, referring to J.J. Gibson's "The senses considered as perceptual systems";

> We get a clue from Gibson's (1966) talk of sounding things in our environment: "The train of waves is specific to the kind of mechanical disturbance at the source" (p. 81). I suggest that the kinds of things we are capable of hearing that are important for timbre perception are events like pounding, blowing, bowing, plucking, rolling, whistling, screaming, and all sorts of physical processes that words can only hint at but which are nonetheless specified in the underlying dynamics of the signal, and therefore just as potentially "available" to a perceiver as a Fourier spectrum. (Balzano, 1986)

The Fourier spectrum is the core of the classic view of timbre, introduced more than a hundred years ago in the psychoacoustic studies of Hermann von Helmholtz. A Fourier spectrum is the result of a mathematical analysis of sound, based on the theory of the French mathematician Fourier, implying that any periodic sound vibration can be analyzed and represented as a spectrum of pure sine wave tones. Helmholtz and his followers in this century adhere to the theory that a particular timbre can be adequately described as the Fourier spectrum of the steady state of the sound.

Contemporary research has demonstrated the shortcoming of this view (Risset and Wessel 1982). One main reason is the fact that the attack and temporal change of sound are just as important, or even more important for timbre perception than the steady state spectrum. The techniques of modern computer synthesis have permitted the investigation of the rapid changes in the microspace of timbre.

The nature of timbre is transition and multidimensionality

Timbres may be more or less complex, but no timbre is a simple phenomenon. Xenakis points out the limitations of the Fourier analysis;

> It seems that the transient part of the sound is far more important than the permanent part in timbre recognition and in music in general. Now, the more the music moves toward complex sonorities close to "noise", the more numerous and complicated the transients become, and the more their synthesis from trigonometric functions becomes a mountain of difficulties, even more unacceptable to a computer than the permanent states. It is as though we wanted to

> express a sinuous mountain silhouette by using portions of circles. In fact, it is thousands of times more complicated. The intelligent ear is infinitely demanding, and its voracity for information is far from having been satisfied. (Xenakis, 1971)

The sensation of timbre is a joyful challenge to the intelligent ear, and the description of timbre is a challenge to researchers in psychoacoustics.

Jean-Claude Risset and David Wessel (1982) have proposed a solution to the problem of describing the transient part of timbre in their method of analysis and synthesis. In the mid-sixties, Risset was working on computer synthesis of brass-like tones. A first attempt was to synthesize tones with fixed spectra of partials derived from analyses of trumpet tones. These synthesized tones proved unconvincing when compared to natural trumpet tones.

The next step was to record musical fragments played by a professional trumpet player and analyze the trumpet sound in the form of spectrograms, visualizing the partials of the sound spectrum and the relative predominance of certain frequency areas. The spectrograms showed that, for a given intensity, the trumpet sound has a formant structure, that is, the partials lying within a certain frequency range are enhanced as a result of the characteristic resonance of the instrument. A peak in the frequency spectrum was found between 1000 and 1500 Hz.

As a third step of the exploration, selected trumpet tones were converted to digital form and submitted to a type of computer analysis that yields a display of each partial as a curve showing the growth and decay in time of that partial. On the basis of such an analysis, artificial trumpet tones were then produced by a sound-synthesis computer program. The resulting synthetic tones proved undistinguishable from the original trumpet tones, so it was concluded that the third step of the analysis and synthesis procedure had captured the aurally important features of sound. A diagram of these features is shown in *Fig. 5.1.*

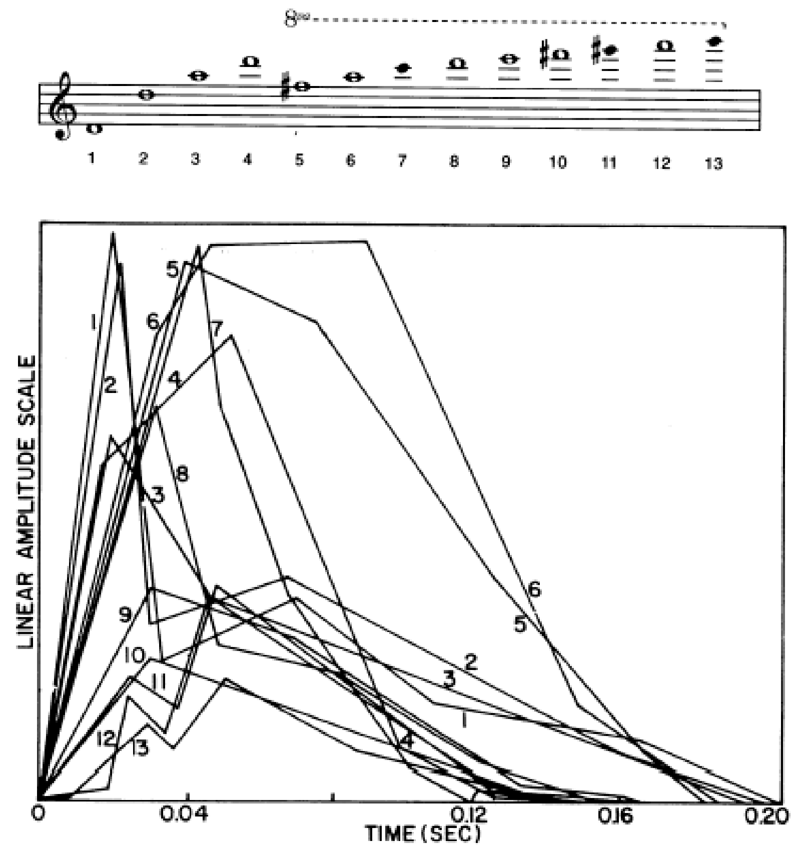


Fig 5.1. Line-segment functions that approximate the evolution in time of 13 harmonics of a D4 trumpet tone lasting 0.2 sec. (Risset & Mathews, 1969)

In this pattern of curves, partials one and two, the fundamental D4 and its octave D5, rise fast to a maximum and lose the maximum amplitude immediately. Then follow partials three to eight, of which F#6, A6 and C6 (partials number five, six and seven) reach notable high levels. The remaining partials rise more slowly to their peaks.

The diagram in *Fig. 5.1* demonstrates the transient features of the attack essential for the sensation of timbre. In less than one tenth of a second, the intelligent ear is given a large feed of sound variables permitting the identification of the sound source as a trumpet. Explorations of other trumpet tones showed different patterns of the evolution of partials. It was found that the proportion of high-order partials increases with increasing intensity of the tone.

Risset and Wessel concluded that the attack transients constitute an important part of instrument tones. If the attack segment of a tone is removed in a tape recording, the instrument is no longer recognizable.

Many tones like those produced by the piano or percussion instruments are characterized mainly by the complex temporal evolution of their transients, as they have no steady state at all. Transients are intrinsically complex, and they are not reproducible from one tone to another. Houtsma (1989) points out that high and low tones from an instrument normally have different spectra; a low piano tone typically contains little energy at the fundamental frequency and has most of its energy at higher partials, while a high piano tone typically has a strong fundamental and weaker higher partials.

The multidimensional nature of timbre has been investigated by Carol Krumhansl (1989). With David Wessel, she conducted an experimental study of the similarities and dissimilarities of 21 timbres synthesized by means a frequency modulation technique. Most of the timbres were designed to simulate traditional instruments such as horn, trombone, trumpet, oboe, clarinet, bowed string, guitar, harpsichord and piano. A few others were synthetic hybrid timbres such as "guitarnet", a hybrid of guitar and clarinet, and "striano", a hybrid of strings and piano. A group of musically trained listeners were asked to judge the relative similarities of these timbres, and the obtained data were treated by a multidimensional scaling technique.

As a result of this study, three common dimensions of timbre were found. The first dimension corresponds to the *rapidity of attack,* reflecting differences for example between the sharp attack of plucked instruments like harpsichord and guitar and the comparatively slow attack of horns or bowed strings.

The second dimension corresponds to brightness, depending upon the distribution of power in the sound spectrum. In relatively bright instruments like the oboe and trumpet, energy is concentrated in the higher components, while instruments such as horns and trombones are characterized by energy concentration in the lower components.

The third dimension, named *spectral flux,* corresponds to the temporal evolution of spectral components, reflecting differences for example between woodwind and brass-like timbres, the latter characterized by spectral contents changing with amplitude.

In addition, some timbres were found to possess specific qualities that are not explained by these three dimensions, such as the clarinet timbre which is unique in its absence of even harmonics.

The dimensions proposed by Krumhansl have been confirmed by later acoustic analyses. Donnadieu *et al.* (1994) conclude that *attack quality* is highly correlated with the logarithm of attack time, and *brightness* is highly correlated with the spectral center of gravity. The third dimension, understood as *spectral fine structure,* is well correlated with the ratio between the amplitudes of even and odd harmonics.

Pitch height is a focused aspect of timbre.

In music listening, timbre is the fundamental dimension, and pitch height arises as a focusing quality of timbre. This view is the core of the earlier quoted statement of Arnold Schoenberg;

> The tone becomes perceptible by virtue of timbre, of which the height of sound is but one dimension. Timbre is consequently the large domain, an area thereof is the height of sound. (Schoenberg, 1911)

A similar view is stated by Charles Seeger;

> The sound that we call a "note" is actually a complex of many simultaneously sounding pitches - most of them higher than the pitch we hear as the note - of varying degrees of loudness, the loudest of them being perceived by us as the note. Keen and practised ears can hear some, but not all of them. The total effect is referred to as tone quality or timbre. (Seeger, 1966)

The following represent the related viewpoints of other authors.

Risset (1986) characterizes the height of a musical tone as the result of a focusing evaluation. For sounds characterized by harmonically related partials this evaluation can be carried out without ambiguity.

Houtsma (1989) points out that a perceived pitch height is not an exact entity like the precisely defined frequency of a pure sine wave tone. Frequency is the most important contributor to the sensation of pitch height, but other aspects of sound contribute to pitch as well, such as intensity, spectrum, duration, amplitude envelope and the presence of other sounds.

Several authors indicate that the sensation of a pitch height may arise from a number of harmonically related partials even if its proper frequency is absent in the sound stimulus. A perceived tone of this kind is known as a "missing fundamental". (Roederer, 1975)

Rasch and Plomp (1982), in their survey of The Perception of Musical Tones, take as their point of departure the classic view that "pitch is the most characteristic property of tones, both simple (sinusoidal) and complex." But they make the reservation that the pitch sensation of complex tones is much more difficult to understand than the unambiguous pitch of a simple tone, and explain the perception of pitch in a complex tone as the effect of a learning process directed toward perceptual efficiency by simplification.

Walker (1991) underlines the role of the learning process, stating that "we essentially derive our pitch sensations from a set of adjacent harmonics from which our ears can ascribe a pattern based on our learning of appropriate pitch constructs."

When pitch height emerges in a timbral spectrum of a musical instrument by a perceptual focusing at a certain level of the pitch continuum, the sound is perceived in two simultaneous dimensions, the quality of the timbre of a particular instrument and the quality of pitch height. Timbre and pitch height are distinct qualities of the microtemporal continuum, permitting the distinction of sound sources and the distinction between higher and lower pitches. Between timbre and pitch height, a *diffuse* quality can arise, the quality of harmonic color.

Harmony is **an emergent quality of timbre**

Harmony is, like pitch height, an aspect of timbre. Harmony arises as a specific color quality from the presence of several simultaneous focal areas in a perceived timbral spectrum.

The simplest harmony is the musical interval, arising as a particular sound color from the interaction of the focusing qualities of two simultaneous pitch heights. An interval is not an addition, but an interaction of two components giving rise to a new emergent quality

Wright and Bregman provide this explanation;

> Musicians are well acquainted with the idea that two tones sounding simultaneously form a new whole exhibiting a quality which is more than the sum of the qualities of the individual tones taken separately. Such a quality might also be called an emergent quality. We depend upon this quality to identify harmonic intervals, and to classify them as consonant or dissonant according to their varying degrees of qualitative roughness. Tonal simultaneities built up of one or more of these intervals have been called "chords", their emergent qualities can be called "chord color", and the process by which the independent tones combine their effects to create this quality has been called "tonal coalescence", or "chord fusion." (Wright and Bregman, 1987)

The musical interval has a double nature. It permits the identification of its two constituting pitch heights, and simultaneously, it displays its specific color quality, recognizable in different positions in the pitch height continuum.

If a third tone is placed between the two tones of an interval, it interacts with the components of the interval, producing a new emergent color quality. On the keyboard of a piano, a series of different colors can be demonstrated as shown in *Fig. 5.2.*

Fig 5.2

The note (0) is a symbol that represents the complex timbral quality of a sound produced by a rounded felt hammer striking three tense metal strings which evoke resonances in a wooden soundboard of a particular form. The predominance of harmonically related partials in the sound induces auditory perceptual processing in the ear and brain to focus at a comparatively well-defined pitch height, named middle C, or C4. The sound is perceived in two dimensions simultaneously, the piano timbre quality and the focusing quality of pitch height.

The notes (1) represent two timbral qualities produced simultaneously by the piano mechanism and resonance. The resulting sound is perceived in three dimensions simultaneously, the piano timbre quality plus the focusing qualities of two pitch heights plus an emergent quality, the quality of harmonic color. The harmonic color of this particular sound is the specific transparent color named the interval of a fifth.

The following examples of interaction between piano tones each display a particular emergent harmonic color. (2) and (3) produce particularly rich and sharp colors, (4) and (5) comparatively soft and transparent colors; (6) and (7) display the saturated colors known as the major and minor triads of tonal music.

Major and minor chords played on a piano are complex timbral qualities which are perceived in three dimensions simultaneously, the piano timbre quality plus the focusing qualities of three pitch heights plus the emergent quality of a specific harmonic color.

Harmony emerges as a secondary listening dimension between the source-specific quality of timbre and the focusing quality of pitch height.

The addition of other keyboard tones increases the complexity of the interactions, as heard in (8) (9) (10) (11) and (12). As the complexity is increased, the pitch heights of the piano tones lose their focusing quality, and a gradual transition from simple harmonic color to complex harmonic color takes place. In (11) and (12), the pitch heights of the piano tones are not heard separately any more; they merge in the specific fused colors of tone complexes. These complex sounds are not perceived in three dimensions, but in two, the piano timbre quality plus the specific fused harmonic color.

This is a crucial phenomenon. The piano timbre and the pitch heights are distinct qualities. When a sufficient number of tones are played close together, the single tones lose their distinctness, merging in a diffuse quality of harmonic color. Distinct salience is superseded by diffuse, space-filling presence.

The possibility of gradual transitions and fusions between timbre, pitch height and harmonic color reveals the continuity underlying these listening dimensions. Their relationship is shown in the graphic model *Fig. 5.3.*

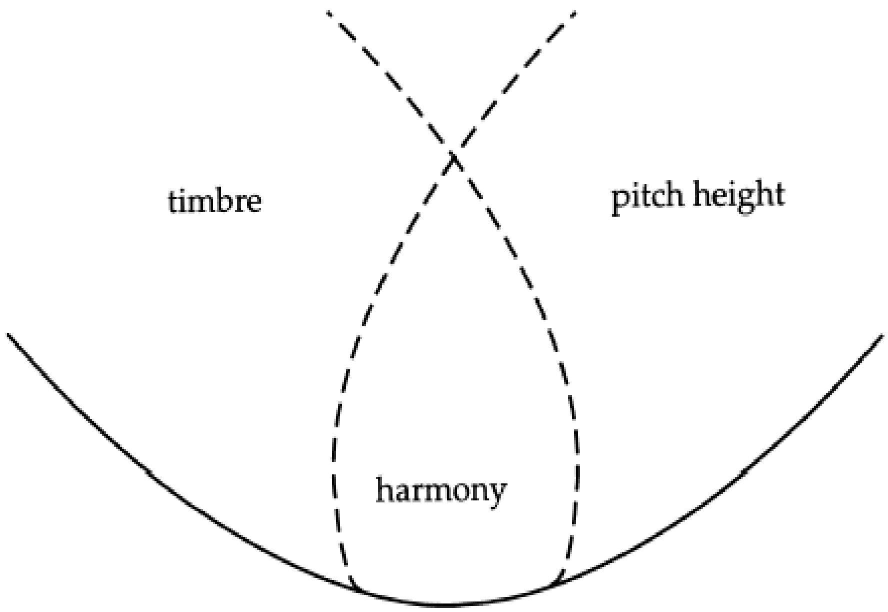


Fig. 5.3. The microtemporal timbre-harmony-pitch height continuum

***Music for 18 musicians* - A flow of pulsating harmonic color**

Gradual transitions between specific instrumental timbres, fused timbral qualities, harmonic colors and pitch heights are heard in Steve Reich's *Music for 18 musicians (1976),* recorded on CD by ECM, duration *56'31.*

The 18 musicians are violin, cello, 2 clarinets doubling bass clarinets, 4 women's voices, 4 pianos, 3 marimbas, 2 xylophones and a metallophone (vibraphone with no motor). In this music, the voices and instruments adhere to a particular chord for a long time, singing and playing pulsating notes in changing patterns within that chord.

The piece is based on a cycle of eleven chords. In the introductory section, called Pulse *(0'00-3'44),* these eleven chords are presented one by one. Then follow a number of small pieces of approximately 3 to 5 minutes' duration, each built on one chord *(3'44-53'00),* and the work ends with a repetition of the eleven chords in a concluding pulse section *(53'00-56'31)*

The eleven chords presented in the first pulse section and the timing of chord shifts are shown in *Fig. 5.4.,* with the pitch class contents of the chords notated below on a separate staff. All chords are related, as all tones belong to the A major scale. The different chord colors are created by selection, doubling and register distribution of these tones. Special prominence is given to selections of tones constituting pentatonic scales.

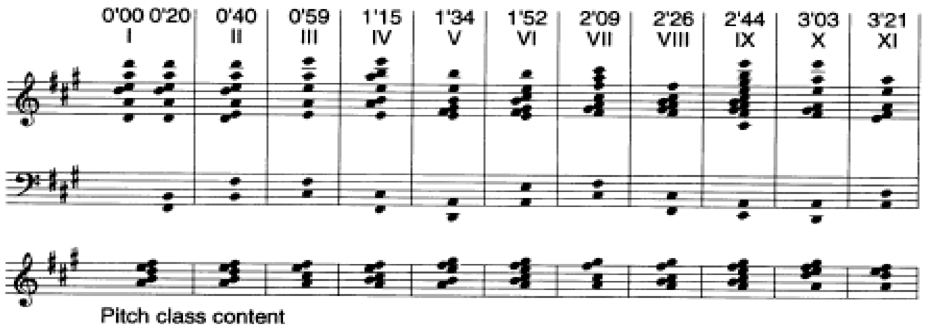


Fig. 5.4. The eleven chords of Reich's Music for 18 musicians.
Chords I and II are built on the pentatonic scale A-B-D-E-F#. Chords III and IV represent a change to another pentatonic scale, differing merely by one tone, A-B-C#-E-F#. *Chords V-IX are based on tones from the latter pentatonic scale plus an added* G#. *Chords X and XI return to the first pentatonic scale, with a* G# *added in chord X.*

The first two pages of the score, displaying the characteristic pulse patterns, are reproduced as *Ex. V-I.*

In the first pulse section, various degrees of fusion and segregation of the single components of the harmonic color are heard. Two different kinds of pulsing occur simultaneously, the regular pulse of the piano and mallet instruments and the pulsating patterns of the human breath in voices and wind instruments, growing and decreasing in crescendo-decrescendo during one full breath. This breath-related growth and decrease is imitated by the string instruments.

The appearance and disappearance of individual instruments and voices create a transparent web of continuous transformation, a flow of pulsating streams approaching and receding, coming into focus and out of focus, blending and dividing. The weighting of sound components is constantly changing, creating movable patterns of foreground and background. The growth and decrease of particular timbral qualities, the temporary salience of distinct pitch heights and intervals and the shifting of registers constitute a slowly fluctuating wave pattern, an interpenetration of soundstreams that never delimit themselves in clearly defined form. The music remains in continuous flow between merging and segregation, displaying the multifaceted variability of timbral and harmonic qualities.

Fusion of complex timbral-harmonic colors displayed in sound columns

The variety of instruments in the symphony orchestra extend the possibilities of creating fused tone complexes by the combination of pitch heights literally ad infinitum. From the fusion of many simultaneous tones, particular timbral-harmonic colors emerge. Such complex colors are heard in the works of Xenakis, Ligeti, Lutoslawski and Schoenberg described in chapters two and four. To facilitate the insight in the interval strucures underlying these complex harmonic colors, a display in sound columns is proposed here.

A sound column is a graphic representation of all tones played simultaneously at a given moment. Each single pitch height of a tone complex is plotted as a dot in a vertical column, in which one square represents one step of the chromatic scale.

As a first example, the combinations of piano tones shown in *Fig.5.2* are plotted as dots in *Fig. 5.5.*

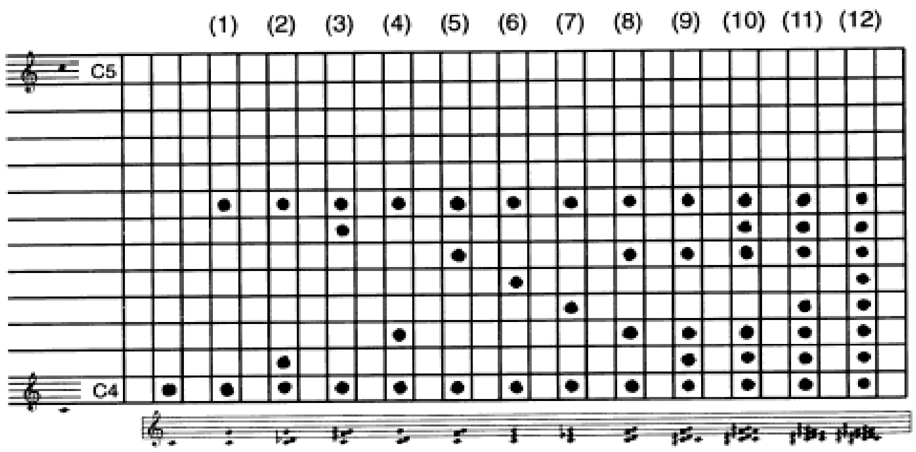


Fig. 5.5.

For identification of the different intervals, a graphic symbol is assigned to each interval. The interval symbols, displayed in *Fig. 5.6,* are meant to provide instant identification of each particular interval, and to give a suggestion of the interval quality. The sharp qualities of *minor second, major seventh* and *minor ninth* are shown by angular, arrow-like symbols, the tritone by a zig-zag line. The consonances of *thirds* and *sixths* are suggested by arched symbols, the merging qualities of *fifths* and *octaves* by straight lines connecting two pitch heights. The mildly disson *major second, fourth* and *minor seventh* are drawn as straight lines which do not connect pitch heights. Intervals larger than a minor ninth are drawn as an octave-length line plus an interval symbol.

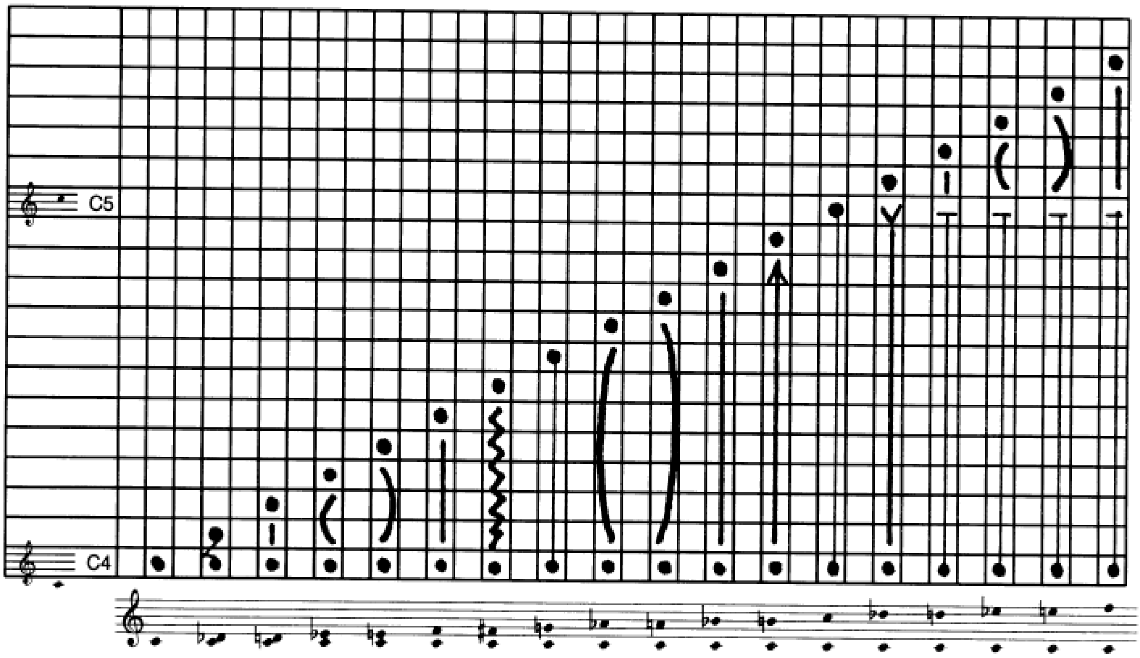


Fig. 5.6. Graphic symbols representing the intervals of the chromatic scale. For distinction of intervals, octaves and fifths are drawn as thin lines connecting two pitch heights, other symbols as thicker lines.

In *Fig. 5.7,* interval symbols are added in the sound columns of *Fig. 5.5.*

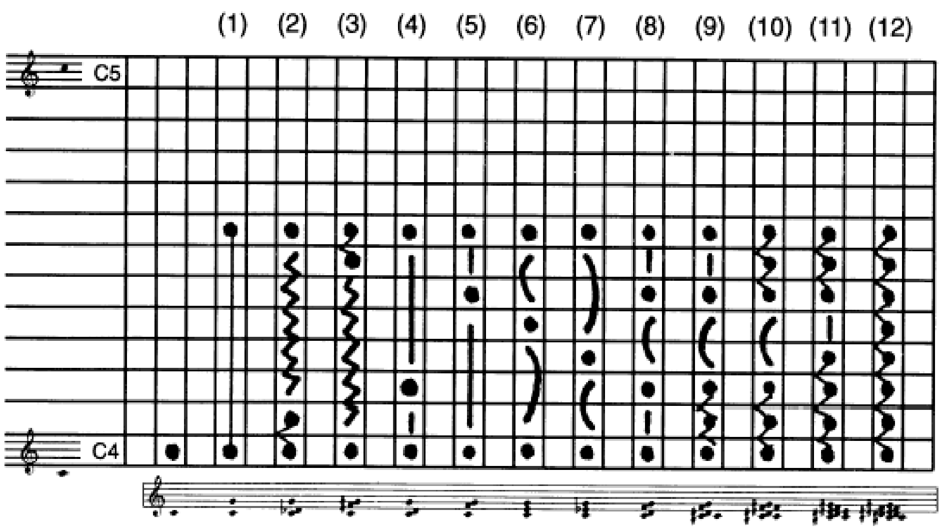


Fig. 5.7. The interval combinations displayed in the sound columns produce particular harmonic color qualities.

1) is the transparent color quality of the fifth. (2) and (3) are the rich and sharp colors produced by tritones and minor seconds, (4) and (5) the soft colors of fourths and major seconds, (6) and (7) the saturated colors of major and minor chords produced by the interactions of thirds. From (8) to (12), the interferences of minor seconds give rise to gradual fusions of complex timbres.

By means of these graphic interval symbols, the intervallic relations in tone complexes producing fused timbral-harmonic colors can be displayed. Characteristic examples are found in Xenakis' *Pithoprakta,* Lutoslawski's *Livre pour Orchestre,* Ligeti's *Atmospheres* and Schoenberg's *Summer Morning by a Lake (Colors).*

Pithoprakta **- Density and brilliance**

Xenakis' *Pithoprakta* is described in chapter two, pp. . In this work, the massed sound of sustained tone complexes is heard at *2'21* and *8'15,* where a large number of pitch heights interact, producing particular timbral-harmonic colors. The string instruments play divisi. 24 violins, 8 violas, 8 cellos and 6 double basses play a total of 46 superimposed pitch heights. The score notation of the first and second tone complexes and the corresponding sound columns are shown in *Ex. V-II.*

Pithoprakta, 2'21-3'46. Tone complex (1), Ex. V-II (a)

Tone complex (1) begins at 2'21 in the recording. This tone complex, played arco mf, is sustained in measures 60-70, and it continues as background color behind string pizzicatos, gradually diluted by the disappearance of instruments.

A xylophone plays distinct rhythms at the high A7.

The total range of this tone complex is 6 octaves plus a fifth, from E1 to B7. The single pitch heights are distributed in irregular patterns of small intervals; the column is divided in two parts by a tritone interval in the middle from C5 to F#5. Interference bands composed mainly of minor seconds appear in low, medium and high registers, for example Al to G2; C#4 to C5; C7 to E7.

The interaction of pitch heights in tone complex (1) produces a rather diffuse sound of noise-like color. The sound is not a coherent whole. Several separate registers are heard, a sharp top register above a comparatively bright middle and a dense bottom register. On this background of strings, the sharply attacked pulse and rhythms of the xylophone stand out clearly, like a solo.

Pithoprakta, 8'15-8'45. Tone complex (2), Ex. V-II (b)

Tone complex (2) emerges gradually from a web of glissandi at *8'05 in* the recording. This tone complex is heard at *8'15 - 8'28,* corresponding to measures 238-39 in the score. It dissolves in another glissando web, thinning out in high notes at *8'45.*

Tone complex (2) reaches a larger span than (1), 6 octaves plus a minor seventh, from El to D8. Half of the strings, mainly high pitches, are muted, and the intensity *is ff.*

In this tone complex, one wide-range interference band is placed in the high register from E7 to D8. In the lowest register, thirds and major seconds prevail. At the bottom, a cluster of two minor seconds produces vibrating interference.

The sound of tone complex (2) is coherent. It displays considerable presence and richness of color, metallic and brilliant at the top, comparatively transparent in the low register.

Intensity and the mode of playing exert a considerable influence on the fused timbral quality The *arco/muted* strings playing ff in tone complex (2) produce a rich, present and brilliant timbre in comparison with the more diffuse timbral quality produced by arco strings playing *mf* in tone complex (1).

Livre pour Orchestre **- Fluctuating color**

Lutoslawski's *Livre pour Orchestre* is described in chapter two, pp. In this work, the strings play characteristic timbral-harmonic colors in transition at *0'47-l'01* in the recording, corresponding to measures 18-22 in the score. The notation of this passage and the corresponding sound columns are shown in *Ex. V-III.* Lines in the notation indicate that some instruments glide from note to note.

Livre pour Orchestre. Tone complexes (1) (2) (3) (4) (5), Ex. V-III.

The changes in range of the sound columns display a dramatic contraction from (1) to (2), followed by expansion to (3), a maximum at (4), and finally a slight contraction in (5).

The five tone complexes are built as widely-spaced 10-part or 6-part chords. (1), (3) and (5) are identical with the exception of the bottom tone of (5), which is lowered one whole tone. These chords are refined constructions.

(1) contains 10 of the 12 pitches of the chromatic scale, omitting the two neighbors G and Gb. It is composed of a 46 Db major chord at the basis and a superstructure of alternating fifths and major thirds, merging in a characteristic sound color.

(2) is literally a contraction of (1). The basic 46 Db major chord moves one octave up, and the superstructure is contracted to fourth + major third + fifth.

(3) returns to the structure of (1).

(4), like (1) and (3), contains 10 of the 12 pitches of the chromatic scale. Here, the tones G and Ab are omitted. Thus, from (3) to (4), the pitch class content is merely changed by one tone, Gb replacing Ab, but the intervals and their relations are altered in an elegant way. All major thirds move a semitone, fifths are expanded to major sixths or contracted to fourths, and the bottom fourth is expanded to a major sixth, resulting in a symmetrical column of intervals.

The effect is a remarkable change in harmonic color, increased transparence, and a feeling of expansion and illumination. This effect is intensified by a crescendo.

(5) maintains the same pitch class content as (4), but returns to the former superstructure of thirds and fifths. The bottom note descends to Gb2, completing another symmetrical interval structure and adding new shadings to the color of the complex sound.

In these five measures, pitch class content, variation of interval structures, glissandi, intensity variation and the expansion and contraction of the total pitch height range interact to create a musical space of shimmering, fluctuating color. Here, Lutoslawski explores the fertile borderland between timbre and fused harmonic color.

The timbral quality of these chords is homogenous, as all the instruments belong to the family of strings. The blending of different kinds of instruments opens a further potential of color variation. This is a theme in the conversation between Lutoslawski and Tadeusz Kaczynski (1972);

> Kaczynski: One of the two elements which determine the tone colour of the individual sections is a careful selection of the notes from the scale. The other is the careful selection of instruments. The aim of such a selection is presumably the integration of the sound, and the result is a sense of unity of sound within sections. A selection of that kind based on the affinity of sounds and instruments reminds me of the way an artist operates inside a specific section of the colour spectrum. Was that your intention, I wonder?
>
> Lutoslawski: Yes, to a great extent. The use of "families" of instruments helps to clarify the tone-colour and so sharpens the contrasts. I was struck by your perceptive remark about the two ways of creating tone-colour: interaction between the timbres characteristic of the instruments in question, and the carefully selected sequence of intervals and chords. I've always thought that timbre alone, whether of one instrument or of a group of similar instruments, isn't enough to create sufficiently rich tone-colour. One can achieve this only by combining the acoustic possibilities of the instruments with the role they are given to perform. The most elaborate combinations of instrumental colour sound almost "grey" to me if the intervals and chords don't co-operate in creating tone colour.

Atmospheres **- Radiant luminosity**

In Ligeti's *Atmospheres,* described in chapter two, pp. , timbral-harmonic color emerging from the blending of different instruments is heard in the tone complexes opening the work, *0'00-l'50* in the recording.

Score notation and sound columns of *Atmospheres* are shown in *Ex. V-IV* and V-V.

The tone complexes constitute sound masses of vibrating, iridescent colors. Any kind of sharp attack is avoided, so that one tone complex seems to grow out of another. It is Ligeti's idea, written in his sketches published by Salmenhaara (1969), to begin *Atmospheres* with a "wide, soft, gentle, completely static" sound.

Atmospheres, 0'00-1'17. Tone complexes (1) (2) (3), Ex. V-IV

(1) The first tone complex is composed of 56 strings, 4 flutes, 4 clarinets, 3 bassoons, counterbassoon and 6 horns, all playing *muted pp dolcissimo.* Sound column (1) is, for the sake of clarity, separated in a high column and two attached columns displaying the intervals played by different groups of instruments.

The high columns shows the strings. The first attached column comprises four flutes on top (black dots) and six horns at the bottom (white dots). In the second attached column, the white dots represent 4 clarinets, the black dots 3 bassoons and a counter bassoon.

The strings play a large, almost chromatically filled cluster of a range of four octaves plus a minor seventh, from Eb2 to C#7. The counterbassoon joins the cluster, adding D2 at the bottom.

The woodwinds are heard in the middle register. The flutes play a pentatonic chord interlocking with a comparatively soft clarinet cluster to fill an area of minor seconds. The horns play a rather sharp 6-part cluster interlocking with an A minor triad in the bassoons to fill another area of minor seconds. Together, the wind instruments play a chromatic cluster from Ab3 to C5.

(2) During the first 48 seconds of music, the sound gradually fades away. The flutes disappear first, as seen in column (2)

(3) At *0'48* the high and low strings have faded completely, revealing 10 violas and 10 cellos playing the middle-register chromatic cluster E3 - B4 shown in sound column (3). This static cluster is given inner life by added vibrato, gradual transition to sul ponticello playing, and shifted crescendos, producing the impression that tone pairs are turned on and off.

Atmospheres, 1'18-1'50. Tone complex (4), Ex. V-V.

The fourth tone complex begins at *1'18.*. In sound column (4), the high column represents the strings. The first attached column comprises 4 flutes on top (black dots), 4 clarinets (white dots) in the middle, and 6 horns (white dots) at the bottom. The next attached column has 4 oboes on top, 4 bassoons below. The last column has 4 trumpets (black dots) on top, 4 trombones below (white dots).

With this tone complex, a colorful illumination of sound begins. The chromatic string cluster moves upward, reaching a range from Ab2 to E7. A soft, deep tuba is added one octave and a fourth below, at Ebl.

To this cluster, timbral-harmonic color is added by woodwind and brass. Flutes play a transposition of the pentatonic chord from (1). This chord is continued downwards by clarinets and horns, altogether playing the whole "black key" pentatonic scale from Db6 to Gb3.

Oboes play a chord of another pentatonic scale, while the bassoons reintroduce the A minor chord heard in (1) and (2). Trumpets and trombones play chords of a third pentatonic scale, except for trombone 4, playing B3 instead of C4 in order to avoid doubling one of the bassoons.

The brass and woodwind chords interlock in clusters of minor seconds over a range of more than two octaves, leaving holes at C6 and G3, one at the top, and one at the bottom, thus avoiding the sharpness of interferent high and low minor seconds.

The sensation of illumination is further enhanced by a crescendo, beginning at *1'23*.

In the sustained sound of the tone complexes, fluctuations appear in the high and low registers. In the middle register, areas of comparatively dense harmonic color emerge, and discernible pitches and oscillating intervals appear now and then. By interlocking chords and clusters of different timbres, Ligeti here creates a living sound mass, incessantly shimmering in fine shadings created by delicate interferences.

Ligeti has conceived a systematic distribution of intervals, chords and instruments which produces an impressive effect. He combines the rich harmonic colors of pentatonic chords with the brightness of interlocking minor second patterns in order to create a sensation of illumination, leading to an experience of radiant luminosity in sound.

Summer Morning by a Lake (Colors) - Timbral fluctuation and darkening harmonic color

A description of Schoenberg's orchestral piece is given in chapter four, pp. The first 11 measures of the score and a survey of the chord succession in these measures are shown in *Ex. V-VI.*

In this piece, the harmonic colors emerging from particular combinations of pitch intervals are set in fluctuation by variations of timbre. In the beginning of the music, the initial chord is sustained during three measures, and the impression of a slowly waving surface appears. The pitch height level and the underlying harmony remains constant, while brightness and color fluctuate calmly The timbral changes producing the fluctuation are shown in *Fig. 5.8.*

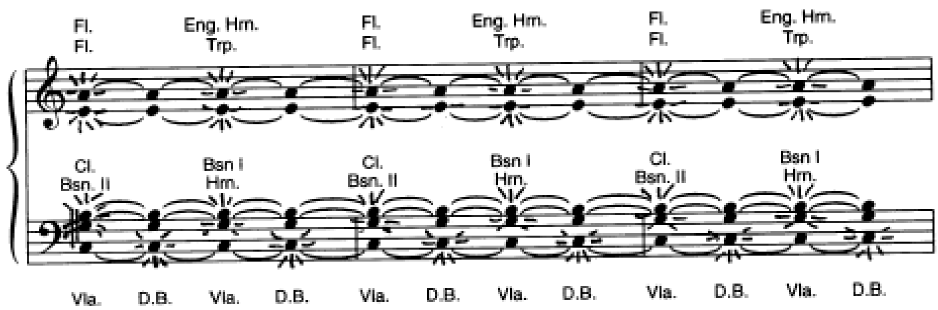


Fig. 5.8. On the first and third beats of the slow 4/4 measures, the bright upper four notes of the five-part harmony are "turned on" by the entrances of two flutes, clarinet and bassoon, alternating with English horn, trumpet, bassoon and horn. When one group of instruments enters, it briefly overlaps the preceding group, which then disappears.

In a similar way, the fundamental note alternates between viola and double bass, so that the chord is darkened on the second and fourth beats. This creates an continuous oscillation of brightness and darkness.

The wave-like alternation of instruments continues in the following measures. With measure 4, a change of harmonic chord color takes its beginning. In *Ex. V-VI,* the interval structures underlying the succession of harmonic colors are shown in sound columns.

Summer Morning by a Lake (Colors), Ex.V-VI

In the graph, numbers indicate measures of the score. Small numbers indicate chord changes on the single beats of a measure.

The sound columns corresponding to measures 1-2-3 show the initial sustained mid-register five-part chord and its interval structure of minor sixth, minor third, fourth, and fourth, merging in a particular harmonic chord color.

From measure 3 to measure 4, the pitch height surface A4 remains unchanged, but the harmonic color is altered by the second part of the chord ascending one semitone from E4 to F4, changing the interval structure to minor sixth, minor third, tritone and major third. From measure 4 to 5, the second part descends two semitones from F4 to Eb4, and stays there during the following measures.

This minute melodic movement, one semitone up, two semitones down, is imitated in the first part in measures 4-5-6, fourth part in measures 5-6-7, third part in measures 6-7-8, and fifth part in measures 7-8-9, together constituting a slow five-part canon leading to the first chord of measure 9, which is an exact transposition one semitone down of the initial chord.

As a consequence of the movement of the upper part, the pitch height surface is lowered from A4 to Ab4 in measure 6, and remains there while the subsequent dislocations in underlying interval structures create changes of harmonic color.

A particularly distinctive change occurs from the comparatively dense and rich color of measure 6, composed of major sixth, major second, major third, and fourth, to the transparent color at the beginning of measure 7, composed of fifth, fourth, minor third, and fourth. Here the melodic movement of the canon has led to a doubling of the octave C3-C4, and the resulting rather insipid harmony is instantly re-colored by the addition of a deep E2 in the bass clarinet. This note is sustained through measure 8, disappearing on the first beat of measure 9.

The initial chord appears in measure 9 in its new transposition, but its characteristic color is immediately darkened by the addition of three new tones B2 - F3 - C4 in trombone, bassoon and clarinet, followed by another addition of three tones D2 - A2 - E3 in the Double Basses. In both cases, acciaccaturas contribute to a blurring of the harmony.

On the third beat of measure 9, all these tones merge in a complex chord of low, dark string color with a brighter upper layer of woodwind and brass. The chord contains 10 of the 12 chromatic pitch classes; Db and Gb are absent, Bb is doubled.

This complex chord is sustained from measure 9 to measure 10. On the third beat of measure 10, cellos and counter-bassoon add a lower octave duplication of the five-part chord already present in the sustained sound.

The superposition of the chord onto itself, with added notes, leads to a maximum blurring of color caused by the occurrence of interference bands of minor and major seconds in the interval structure. Subsequently, when the bright upper part of the harmonic complex is "turned off" on the second beat of measure 11, the transition from colored light to diffuse darkness is completed.

Finally, the Double Basses disappear on the third beat of this measure, revealing the cellos and counter-bassoon sustaining the five-part chord quietly in the deep register.

In the right side of the graph, the superposition of the characteristic initial chord onto itself is shown as a double sound column.

Distinct and diffuse qualities

The massed sounds composed by Xenakis, Lutoslawski, Ligeti and Schoenberg are examples of diffuse timbral-harmonic colors. The four composers explore the borderland between the specific qualities of harmonic colors and the dim, dense, blurred or brilliant qualities produced by many pitch heights played close together.

In the Lutoslawski example, *Ex. V-III.* specific harmonic colors are composed by the careful choice and distribution of intervals, in particular thirds, fifths and sixths. But distinct chord colors are avoided, as the instruments glide from one harmonic color to another, creating the sensation of fluctuation.

In the sustained massed sounds composed by Xenakis, *Ex. V-Il,* harmonic colors are avoided. A range of six to seven octaves is filled with small intervals, in particular minor and major seconds which interfere, producing sensations of density and brilliance in noise-like colors.

In the Ligeti examples, *Ex. V-IV* and *V-V,* blendings and transitions between specific harmonic qualities and interferent cluster qualities are heard. In tone complex (1) (2) and (4), the dimness produced by large clusters of strings is blended with the pentatonic chord colors of the wind instruments. Furthermore, the chords of the winds are placed close together in interlocking patterns of chromatic clusters, producing interference between the instrumental timbres.

In the Schoenberg example, *Ex. V-VI,* very particular harmonic chord colors are composed by the selection and distribution of specific intervals, but distinct harmony is avoided by the fluctuation of timbre and the gliding transitions from one chord to another. In the course of the eleven measures, Schoenberg composes a transition from specific chord color to dense and blurred harmonic quality. It should not be concealed that the transition to quiet darkness is a moment of intense musical beauty. By a refined compositional technique, Schoenberg has created a sound analogy of visual phenomena, color and movement, light and darkness.

Timbral-harmonic colors are *diffuse* sound qualities, contrary to specific instrumental timbre and focused pitch height, which are *distinct* sound qualities.

Distinct and diffuse qualities are particular properties of the micro-temporal timbre-harmony-pitch height continuum. The diffuse qualities are experienced primarily as spatial qualities, evoking sensations of the "timeless" presence of a space filled with sound, related to the time of being. The distinct qualities attract perceptual attention by virtue of their well-defined salience. Distinct timbre attracts attention on the sound source and its specific nature, while distinct pitch height attracts attention on a particular level of the vertical pitch continuum. Relations between distinct and diffuse qualities call forth the experience of musical fore-ground and background, creating an impression of depth in the virtual musical space.

The microtemporal qualities of distinct timbre and distinct pitch provide a basis for the experience of macrotemporal qualities, evoking sensations of time. Regular successions of timbral attacks are perceived as pulse, and successions of different pitch heights are perceived as movement. The macrotemporal listening dimensions pulse and movement and the spatial and temporal shapes which arise from pulse and movement are the themes of the next chapter.

6

Macrotemporal listening dimensions: Movement, Pulse, Rhythm and Melody

The macrotemporal dimensions, discussed in chapters one, three and four, create the experience of time in the listening process. The basic macrotemporal listening dimensions are *movement* and *pulse.* Movement and pulse evoke two kinds of temporal experience which are qualitatively different, the experience of beginning, duration and end, and the experience of a regulated continuity of equal durations.

Between movement and pulse, rhythm arises as a secondary listening dimension. Rhythm arises when the movement of a succession of sounds is related and adapted to the regularity of a pulse. *Rhythm is a temporal shape of movement.*

Furthermore, the basic macrotemporal dimension movement interacts with the basic microtemporal dimension *pitch height,* giving rise to the secondary listening dimension melody. Melody arises when the movement of sound height is related and adapted to a pattern of pitch intervals. *Melody is a spatial shape of movement.*

The shaping of rhythm and melody is the theme of the present chapter.

Rhythm is the temporal shape of movement

Rhythm is a Greek word, and the definition of rhythm goes back to ancient Greece. The French psychologist Paul Fraisse gives this reference;

> *Rhythmos* appears as one of the key words in Ionian philosophy, generally meaning "form", but an improvised, momentary, and modifiable form. *Rhythmos* literally signifies "a particular way of flowing." Plato essentially applied this term to bodily movements, which, like musical sounds, may be described in terms of numbers.

> He wrote in *The Banquet* "The system is the result of rapidity and of slowness, at first opposed, then harmonized." In *The Laws* he arrived at the fundamental definition that rhythm is "the order in the movement." (Fraisse, 1982)

Plato's definition, *Rhythm is the order in the movement,* is adopted here. This definition describes the interaction of movement and pulse. Movement implies the awareness of *change,* pulse implies the awareness of regularity. Order in the movement is created by the integration of change and regularity in a temporal shape.

Temporal shapes can be created in three different ways; by expansion and contraction, by selection and omission of beats in a regular stream of pulse, and by the addition of pulse beats.

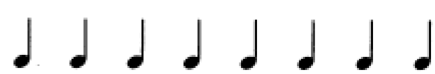
Carl Nielsen: *Jens Vejmand*
- Temporal shaping by expansion and contraction

One way of integrating the variability of movement with the regularity of pulse is the temporal shaping of a regular pulse pattern. Temporal shaping occurs when some of the equal durations delimited by the pulse beats are expanded, others contracted. The Danish song *Jens Vejmand,* composed by Carl Nielsen in 1905, serves as an example. This is the melody;

Fig. 6.1

The rhythms of this melody are variations of a basic pattern derived from a succession of eight impulses;

Fig. 6.2 (a)



Two of the durations delimited by these impulses are expanded, one is contracted;

Fig. 6.2 (b)

The lengthenings produce a grouping of elements heard as a four-beat metric pattern;

Fig. 6.2 (c)

And this temporal shape serves as a model for the rest of the melody;

Fig. 6.2 (d). The first part of phrase (1) displays a characteristic temporal shape, a jumping pattern derived from a succession of regular pulse beats by expansion and contraction. In the second part of the phrase, the initial jumping pattern is restraightened, reverting to the underlying pulse. Phrase (2) is given impetus by two jumping patterns, phrases (3) and (4) provide relaxation by repetitions of the straight pattern. This is a simple yet musically effective use of temporal shaping, combining predictability with variability.

Lengthening and shortening of durations is one way of creating a rhythmic shape. Another way of creating a rhythmic shape is the selection and accentuation of certain elements in a regular succession by differences in intensity, pitch and timbre.

Steve Reich: *Music for 18 musicians*
- Temporal shaping by selection and omission

Music for 18 Musicians, earlier discussed in chapter five, pp. 77-78, serves as an example of rhythmic shapes arising from elements marked by differences in intensity, pitch and timbre. In this work, the pulse continues with unceasing regularity for 56 minutes, and harmony is kept unchanged for periods of three to six minutes. Within this space of pulsating harmonic color, a great variety of rhythmic-melodic shapes emerge, as the instruments and voices select certain impulses of the pulse flow and certain pitch heights of the persistent harmonic interval pattern.

In the beginning of the second section of the work, starting at *8'03* in the CD recording, the gradual emergence of a rhythm pattern is heard, played by 2 clarinets, violin, cello and 2 women's voices. The score notation of this section is shown in *Ex. VI-L* The musical evolution proceeds as follows;

Time Measure

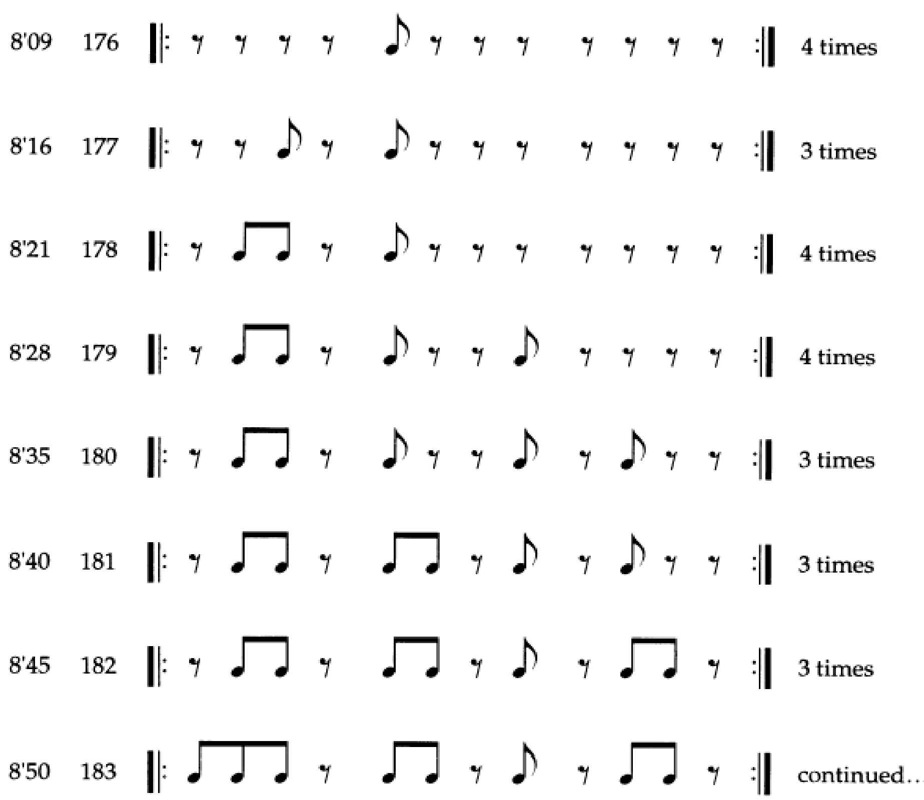


Fig. 6.3. Emergence of a temporal shape

In these two examples, an experiece of grouping in the regular succession of pulse beats is evoked. In the Nielsen melody, a four-beat grouping is evoked by the lengthening and shortening of durations as shown in *Ex. 6.2 (c).* In the Reich example, the gradually emerging rhythm pattern calls forth the experience of a recurrent 12-beat grouping. These are examples of pulse beat groupings underlying the meter of *divisive rhythm.* A pulse beat grouping is established in the perceptual process as a metric framework for the listener's expectation of coming events. Once established, the group can be divided in subgroups such as 2+2 in a group of four or 4+4+4 in a group of tvelwe.

Olivier Messiaen: *The Abyss of the Birds* - Temporal shaping by addition

An alternative to divisive rhythm is additive rhythm, where temporal patterns are created by the free addition of short durations. Additive rhythm is often found in the music of Olivier Messiaen. One example is the clarinet solo The Abyss of the Birds, which is the third movement of Messiaen's Quartet for the End of Time (1941). The beginning of this movement is shown in *Fig. 6.4.*

Fig. 6.4. Messiaen: The Abyss of the Birds.

The vertical lines in the notation are not bar lines, but guidelines for the phrasing.

In the preface of the score, the composer gives this advice to performers:

> Interpreters who feel a little strained by the rhythms can mentally count all the short values (the sixteenth-notes, for example), but only at the beginning of their work; this procedure could make the performance in public disagreeably dull and would become a real puzzle for them; they ought, in course of time, to keep in themselves the feeling for the values (which will permit them to observe the dynamics, accelerations, retards, all that which makes an interpretation alive and sensitive). (Messiaen, score note)

Following the composer's advice, the mental counting of sixteenth-notes proceeds like this:

(10) (2-2-1-2) (2-1-2-2-1-10) (2-2-1-2) (2-1-2-2-1-8) (2-8) (2-2-2-2-2-1-2) (2-4) (16-6-6-2)

Such a comparatively unpredictable alternation of long and short durations yields a feeling of flexible time, a sensation of free and easy flow. The linking of unequal values creates a temporal order liberated from the compulsion of regularity. This kind of temporal flexibility is related to the free flow of Gregorian chant, which was an important source of musical material and musical inspiration for Olivier Messiaen.

György Ligeti: *Second* String Quartet - Temporal patterns of regularity and irregularity

In the above examples by Nielsen, Reich and Messiaen, the temporal flow is related to an underlying regularity, in Nielsen and Reich the regular recurrence of a group of pulse beats, in Messiaen the implicit flow of short equal values.

In the third movement of his Second String Quartet (1968), György Ligeti has composed transitions between regularity and irregularity. The string quartet is recorded by the Lassalle Quartet on a Deutsche Grammophon CD. The first page of the third movement is reproduced as *Ex. VI-II.* This is a survey of the movement, indicated to be played "like a precision mechanism."

Ligeti: Second String Quartet, 3rd Movement

0'00-1'10 **Pulse, disintegration and reintegration**

At the beginning, synchronized pizzicato pulse with unchanged pitch is heard in all four instruments. *0'05* Slight deviations, *0'11* an accelerating stream separates itself, *0'15* all pizzicato streams are desynchronized and mingled. *0'20* Changes in pitch level clarify the separation of voices, and several tempi are heard simultaneously; *0'28* sudden loud pizzicato in one instrument attracts attention to one tempo, *0'31* the loud pizzicato spreads to other instruments and four tempi compete with each other.

0'39 One violent pizzicato slap starts a new mid-register polyphony of unsynchronized tempi, slowly accelerating. *0'46* The pitch heights of the pizzicato streams begin to glide upwards and downwards in stepless motion; *1'06* a top note and a bottom note are reached, and the pizzicatos are resynchronized.

***1'10-2'06* Transition from pulse to streaming sound mass**
A momentary steadiness of pulse and pitch height is gradually changed by slight differences in acceleration and gliding pitch.

1'23 One by one, the instruments change from soft pizzicato to double-speed fingertip tapping on the strings, merging in a quiet stream of energy-laden pit-a-pat sound.

***2'06-3'03* Interactions between the time of movement and events and the time of pulse**
A sudden swift outburst of fan-like movement releases a multitude of brief energetic tremolo entries, approaching, but not reaching a common tempo. *2'20* Slow, loud pizzicato pulses far apart in register introduce a variety of competing tempi. *2'33* Soft, fast pizzicato layers are added, approaching each others in tempo and pitch, while the loud layers disappear; *2'47* all instruments are united in a single stream of regular pulse ... *3'03*

This quartet movement displays a variety of patterns of temporal structure. Between *0'00* and *1'10,* the music develops from an initial regularity through variable states of irregularity or competition between simultaneous tempo layers back to a synchronized regular pulse. Between *1'10,* another development is heard, an evolution from steady pulse through states characterized by pulseless motion, unrelated events or competing tempi, leading to a final synchronization of the competing layers in a renewed regularity at the end of the movement.

This music is, like the works discussed in chapter two, a music of states, events and transformations. The flow of sound is in continuous transition within an overall form outlined by the occurrence of regularity at the beginning, in the middle, and at the end.

The temporal flow is characterized by transitions between pulse time, the time of movement and events and the temporal experience of sound masses in undirected motion, which is related to pulseless mass phenomena in the natural environment such as raindrops on canvas or leaves on a tree moving in the wind. Further examples of patterns of regularity and irregularity in transition are heard in Xenakis' *Pithoprakta,* discussed in relation to the concept of stochastic music in chapter two, pp. 31-33.

Perceptible temporal regularity is not a necessary precondition for music. Music can be based on structures and patterns of irregularity as well as structures and patterns of regularity

Melody is the spatial shape of movement

When the movement of sound is related to a pattern of pitch intervals, melody arises. Findings of W. Jay Dowling based on melody recognition experiments shed light on this phenomenon. Dowling has developed a two-component theory of melody, stating that

> actual melodies, heard or sung, are the product of two kinds of underlying schemata. First, there is the melodic contour - the pattern of ups and downs - that characterizes a particular melody. Second, there is the overlearned musical scale to which the contour is applied and that underlies many different melodies. It is as though the scale constituted a ladder or a framework on which the ups and downs of the contour were hung. (Dowling, 1978)

This is a description of the interaction taking place when the movement of sound in the sound height continuum is met with the process of perceptual focusing on discrete pitches.

An overlearned musical scale is stored in long-term memory, from where it can be recalled as an expectation of a certain pattern of pitch intervals.

When a movement of sound is heard, its variation of sound height is experienced in short-term memory and compared with one or several well-known interval patterns stored in long-term memory. The selection of interval patterns available for comparison depends on the previous musical experience of the individual.

If the movement of sound seems to fit into a well-known interval pattern, it is heard as a familiar kind of melody. If it does not seem to fit into a well-known pattern, the movement of sound is heard as "out of tune" or "a strange kind of melody", or as sound without a melody.

If the movement of a sonorous form can be adapted to a familiar framework of pitch intervals, it can be memorized as a melodic contour. If it cannot be adapted to a framework of intervals, it can be memorized as a sound shape.

Melody arises as a secondary listening dimension between the basic dimensions movement and pitch height. Rhythm, discussed on pp. 91-97, arises as a secondary listening dimension between the basic dimensions movement and pulse. Harmony, discussed on pp. 75-78, arises as a secondary listening dimension between the basic dimensions timbre and pitch height.

The relationships between these three secondary dimensions and the five basic dimensions are shown in the model *Fig. 6.5.* The memorized representations of the basic dimensions are indicated in the model.

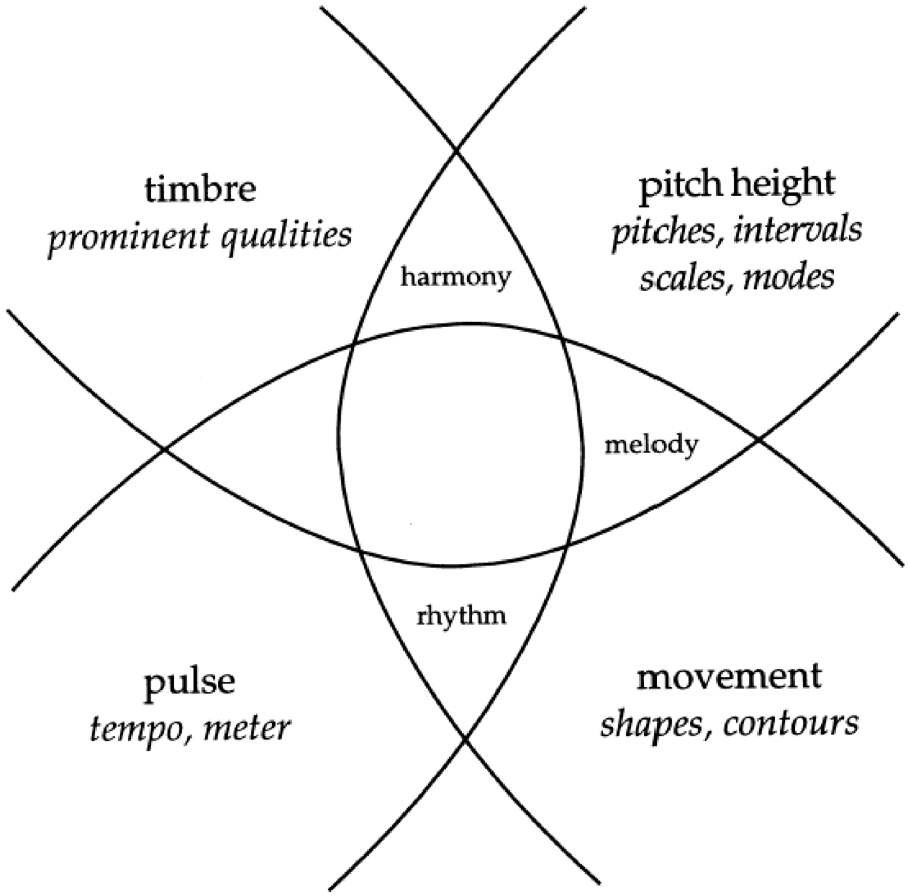


Fig. 6.5. Five basic and three secondary listening dimensions. Memorized representations are indicated in italics.

The shaping of melodic contour

In Steve Reich's *Music for 18 musicians,* a spatial shaping of melodic contour evolves with the temporal shaping of rhythm. In the section described above on pp., the melodic contours are applied to a very simple framework, consisting of a mode of two whole-tone intervals, A4 - B4 - C#4. Fig 6.6 shows the notation of the emerging melody, played by violin and clarinet and doubled by a woman's voice. The contours of the melody are drawn in *Graph VI-III.*

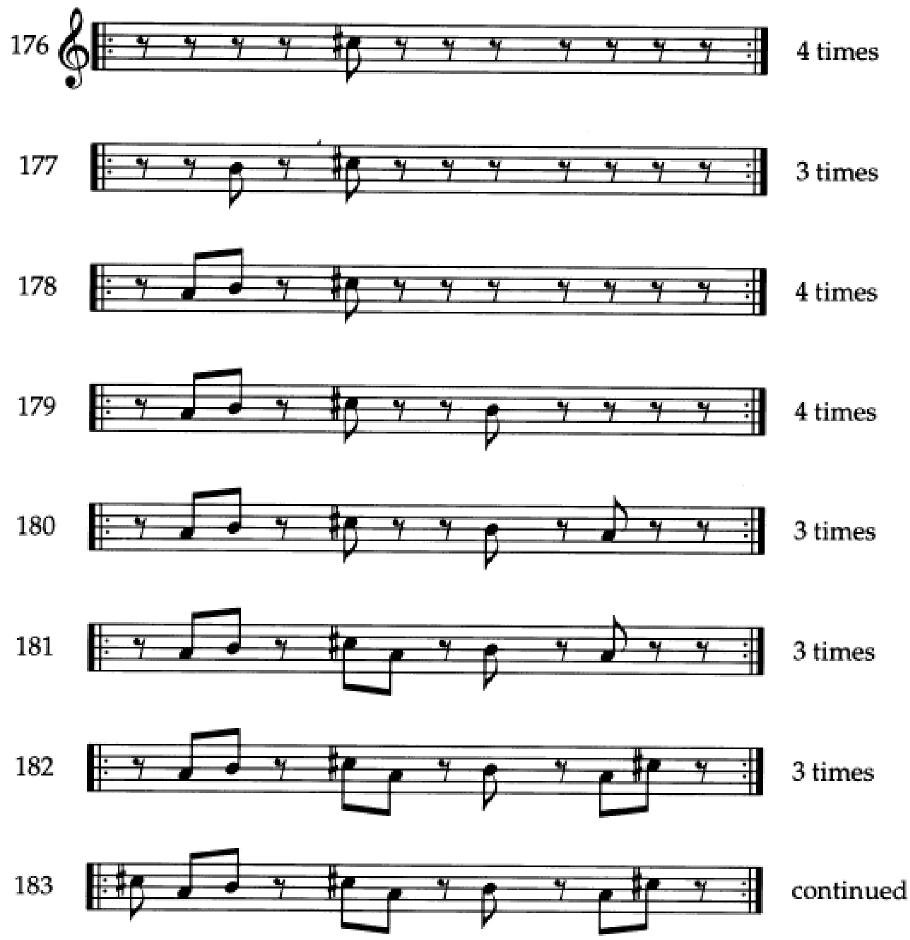


Fig. 6.6. Emergence of melody

Reich, Fig. 6.6 & Graph VI-III

With each measure, one tone is added. The melody evolves from a single note (176) to an interval (177), a direction (178), an arch-shaped contour (179) and a full arch returning to its basis (180). The addition of three more tones changes the arch into three different zig-zag contours (181-182-183).

Even if only three discrete steps of a scale are brought into play, each single contour displays a new melodic quality. This is a simple yet musically effective use of spatial shapes, combining predictability with variability.

The mode of this melody is one of the simplest possible, a mode of equal steps consisting of three tones in whole tone intervals. In its simplicity, this mode is the point of departure for the evolution of the comparatively complex melodic-rhythmic gestalts heard in the recording at *8'09-9'00* and notated in measures 176-183, *Ex. VI-I*

The mode of Messiaen's clarinet melody notated in *Fig 6.4* consists of a regular alternation of whole tones and semitones, known as Messiaen's second mode. *Graph VI-IV* shows the adaptation of contours to this mode.

The Nielsen melody is based on the major scale, which displays an irregular distribution of intervals, two whole tones and a semitone, three whole tones and a semitone. The adaptation of contours to this scale is shown in *Graph VI-V.*

Contour, mode and melodic soundspace

Melodies are memorized in two components, mode and contour. A mode is characterized by its distribution of intervals and its modal color. The modal color is an emergent quality which is specific for the interval distribution of the mode. When a melodic phrase is retained in memory, its modal color is remembered as an overall quality of the intervallic relations experienced in the melody.

The melodies of Reich, Messiaen and Nielsen display three different modal colors, one emerging from a regular distribution of whole tones, one from a regular distribution of whole tones and semitones, and one from an irregular distribution of whole tones and semitones. The latter is the basis of tonality, evolved by virtue of the function of the semitone as leading tone. This function is observed in the second phrase of the Nielsen melody, where the occurrence of a G# introduces a new mode, the A major scale.

The interaction of mode and contour produces a melodic phrase. A further essential constituent of melody is the *melodic soundspace.* The melodic soundspace is an overall shape of the succession of melodic contours retained in memory.

Melody extends short-term memory into long-term memory. The limit of short-term memory is estimated to approximately 5 seconds, but memory for melody is considerably longer. The Carl Nielsen melody notated in *Fig. 6.1* is one example. It has a duration of 15-20 seconds, and can be memorized easily. Factors underlying the extension of melodic memory are the continuous presence of the mode of the melody, the coherent succession of phrase shapes and the coherent variation of phrase range. The melodies of Reich, Messiaen and Nielsen provide examples of phrase shapes and examples of constant and variable range of melodic phrases.

Reich, Fig. 6.6 & Graph VI-III

> The Reich melody expands from one single tone to the interval of a whole tone, then to the range of a major third, A4-C#5. Within this range, a variety of melodic contours are unfolded.

In this melody, the constant range of a succession of melodic contours creates the experience of a melodic soundspace of unaltered size.

Messiaen, Fig. 6.4 & Graph VI-IV

> The Messiaen melody unfolds its initial melodic contours, marked (a) (b) (a) (b) in the graph, within the tritone range F#4-C5. Then follows a sudden expansion to a three-part shape consisting of a falling interval, a zig-zag contour and a rising line, together encompassing the range C#4-F#5, one octave and a fourth.

This succession of melodic contours creates the experience of a sound-space expanding and contracting. In the graph, the sudden expansion and subsequent contraction is shown by dashed lines connecting top tones and bottom tones of the contours.

In the Carl Nielsen melody, a gradual expansion takes place.

Nielsen, Fig. 6.1 & Graph VI-V

> From the succession of melodic contours, the overall form of the melody unfolds. The 1st, 2nd and 4th contours are shaped as arches. The 3rd contour is zig-zag shaped. Together, the contours constitute a coherent (a) (a) (b) (a) form.
>
> The first melodic phrase rises to B4. The next phrase expands the range up to C#5. At the beginning of the third phrase, the melody reaches its peak, D5. In the last phrase, the melody is rounded off in a descent from G4 to D4.

Each melodic phrase leaves an impression of its range in memory. This range is compared with the range of the next phrase. The variation of range throughout the melody is retained in memory as a shape of expansion and contraction. This shape constitutes the melodic soundspace.

The melodic soundspace is delimited by the succession of top tones and bottom tones of the melodic phrases. The top tones trace an outline of the upper limit of the soundspace, and the bottom tones trace an outline of its lower limit. The melodic soundspace can be drawn as a figure of the space between a curve connecting the top tones and a curve connecting the bottom tones. The soundspace of the Carl Nielsen melody is shown in *Graph VI-V (2)*.

Nielsen, Fig. 6.1 & Graph VI-V

In *Graph VI-V (1),* the top and bottom tones of each melodic phrase are marked by circles. *Graph VI-V (2)* shows the range from bottom tone to
top tone of each phrase and two curves connecting top tones and bott-om tones. Together, these two curves trace the shape and size of the melodic soundspace.

Characteristic features of this particular soundspace are the initial expansion, the coherent stepwise rise of the top tone curve and the final contraction.

The size and shape of the soundspace are essential for the experience of melodic form. Mode, contours and melodic soundspace are the constituent factors underlying the experience of melodic coherence and the memorization of melody.

Coleman Hawkins: *Body and Soul (1939)* - A swinging soundspace

The 1939 recording of *Body and Soul* by Coleman Hawkins is a unique example of subtle shaping of melodic contour and rhythm.

The original recording is reissued on several labels. Here, the French Jazz Tribune CD issued by RCA and BMG France, distinguished by its authentic sound quality, is used as reference. This is an outline of the timing and form;

Coleman Hawkins: Body and Soul

0'00	Piano intro	4 measures
0'10	A section	8 measures
0'31	A section	8 measures
0'51	B section	8 measures
1'11	A section	8 measures
1'32	A section	8 measures
1'52	A section	8 measures
2'13	B section	8 measures
2'33	A section	8 + 1 measures

Fig. 6.7. Transcription of Coleman Hawkins: Body and Soul, three A sections
Adapted from Schuller (1989)

This music is characterized by tension and balance between pulse time and the time of movement. Double bass, piano and percussion provide a stable four-beat pulse. The bass accentuates the first and third beat, percussion and piano the second and fourth beat. On this background of predictable regularity, the soloist moves freely in melodic phrases of inventive variability.

Fig. 6.7 shows a transcription of the two first A sections, measures 1-8 and measures 9-16, and the final A section, measures 57-65. In the transcription, the subtle and flexible timing of the live melodic line is reflected in the complexity of notated rhythm.

The melodic phrases in *Fig. 6.7* are drawn as melodic contours in *Graphs VI-VI (1) (2)* and *(3).* The graphs show the variety of melodic shapes and their temporal relations to the four-beat pulse pattern.

The first A section is a rather close paraphrase of the original Body and Soul tune. This is the beginning of the tune;

Fig. 6.8

In his improvisation, Hawkins shapes and reshapes the tune. In the following description, correspondences between parts of the original melody and Hawkins' reshaped melodic contours are indicated by the numbering of phrases.

Body and Soul. First A section, measures 1-8. Graph VI-VI (1) & Fig. 6.8.

(1) Hawkins' phrase follows the contour of the tune.
(2) A turning note is transformed into a zig-zag shape.
(3) All the notes of the tune are played, with ornaments added. The contour rises twice to the top tone Eb4 of the original tune.
(4) Hawkins imitates the falling motion of the tune, keeping the top note Db and the two target notes F3 and Eb. A second peak is added to the curve of the tune.
(5) The tune is transformed to a two-peak shape.

In this A section, Hawkins stays close to the underlying melody, but invents new melodic contours. He creates coherence by giving the same shape, a two-peak curve, to the contours (2) (3) (4) (5), and he keeps the two-peak shape in the transition (6) to the next section.

The second A section is an intensified variation of the first A section.

Body and Soul. Second A section, measures 9-16, Graph VI-VI (2)

(7) The melodic range is expanded to F4-Bb2. These two tones, F and Bb, are the tones accentuated in the original tune.
(8) The zig-zag shape of (2) is extended.
(9) The top tone Eb4 in (3) is doubled and emphasized by repetition and ornamentation. This contour borrows zig-zag features from the preceding contour.
(10) The two-peak curve of (4) is extended upwards.
(11) The closed two-peak curve of (5) is expanded to a large range.

In the second A section, Hawkins expands and elaborates the first A section. He unfolds new melodic invention and intensifies the music by extension and expansion, but maintains structural similarity between the two A sections.

The succession of contour target tones in this section display an underlying unity, as they are all Bb's and F's. Within the course of the 8-measure section, they form a large arch:

(9) Bb4 (10) Bb4
(8)F3 (11) F3
(7) Bb2

The melodic contours of the final section constitute the climax of the solo.

Body and Soul Final A section, measures 57-65, Graph VI-VI (3)

At *2'35,* three peaks of large leaps rise stepwise to the summit F5, subsequently balanced by tension-releasing falling curves at *2'41* and *2'46.* At *2'49* the pulse stops, and Hawkins rounds off the piece by a series of related short melodic shapes.

In this section, coherence is created by the arch of top tones and the falling line of bottom tones, marked by circles in the graph.

Throughout the solo, the movement towards the final climax is a process of spatial expansion. *Graph VI-VII* shows the melodic soundspace of the whole 65-bar solo, outlined by the top tones and bottom tones of each 8-measure phrase. The overall shape of the soundspace is characterized by a gradual expansion towards the maximum range of the last section.

Hawkins' solo displays freedom of spatial shaping as well as freedom of temporal shaping. The melodic curves move in weightless fashion over the regular pulse pattern, and the target tones of the curves are flexibly related to the beat, sometimes hitting a beat, more often landing unconcernedly and with ease somewhere between two beats.

Freedom in the shaping of melody is also heard in the variability of pitch height, timing, timbral quality and vibrato shading which can merely be approximated by the notated transcription and the contour graphs.

The timbral color of the instrument can change from phrase to phrase, within a phrase or from tone to tone. In the lower register, approximately below C4, the tone quality is warm, sonorous and diffuse. In the higher register, the tone is clear, bright and dense, or it may be given a sharp edge as heard in the high-register leaps of the final section. In the swiftly rising and falling melodic lines, the saxophone sound changes smoothly between rich, diffuse sonority and luminous density. This is an imponderable quality of the melodic flow.

Pitch height is not confined to the steps of the diatonic or chromatic scale, it is subtly variable, gliding, bending and colored by vibrato. The vibrato is a personal expressive feature in Hawkins' mode of playing, adding a quality of breath and bodily presence to low tones and a sensation of exhilaration to high tones.

Hawkins' solo is imbued with the quality of swing. Swing is a subjective sensation of a regularity which is not strict or mechanical, but living and flexible. The variations of timbre, pitch height and vibrato of each single tone are essential contributions to the feeling of swing. Two other factors are essential; the inherent flexibility of the underlying regular pulse pattern and the variable relation and tension between the movement time of the soloist and the pulse time of the rhythm section.

A swinging quality is inherent in the continuous four-beat pulse pattern maintained by double bass, drums and piano. On the first and third beats, the double bass plays plucked tones, approximately notated;

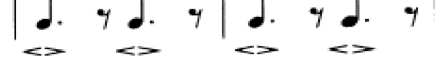


Fig. 6.9

Each plucked tone has its own brief shape, rising in volume after the attack. The resultant pulse is not a mere succession of impulses, but a flexible flow of attack and growth.

The piano plays chords mostly on all four beats, accentuating 2 and 4. In this flow of impulses, regular recurrence is combined with variability of accentuation and chord color.

The drum plays on each of the four beats, shaping the regular flow of impulses into a pattern of deviations from strict regularity, approximately notated;

Fig. 6.10

Altogether, the three-layered pulse pattern of the rhythm section displays a regularity which is unceasingly modified by minute deviations in timing, volume, accentuation and color. This integration of regularity and flexibility is the basis of swing. The attention of the listening mind is maintained by the flow of recurrent impulses, and the attention is not weakened by monotony, as the minute deviations provide incessant stimulation of renewed awareness.

Above the regular pulse pattern, the soloist unfolds his melody, deviating from the underlying beat in considerable freedom of timing and agility. The melodic shaping evokes the time of movement, related to the experience of beginning, direction, shape and end of melodic phrases.

The movement time of the soloist is characterized by unpredictability, flexibility, variable shapes and the delimited durations of melodic phrases. The pulse time of the rhythm group is characterized by predictability, stability, recurrent shapes, and endless continuity.

The simultaneous experience of the flexible time of movement and the predictable time of pulse evokes the feeling that freedom and regularity are integrated. This is the essence of swing.

The Danish jazz historian Erik Wiedemann provides this description of swing;

> The characteristic relation between swing and beat is that on one hand it is so close that there is contact, on the other hand it is so distant that there is conflict. Where contact and conflict keep each other in balance, the tension is maximum and the swing most perfect. Where there is more contact that conflict, or vice versa, the tension is diminished, and the swing loses its quality or disappears altogether. (Wiedemann, 1958)

Specialized agents at work in the mind

A theory that sheds light on the swing phenomenon is proposed by the American artificial intelligence scientist Marvin Minsky in his article "Music, Mind and Meaning". He describes the functions of the perceiving and understanding mind as interactions between different specialized "agents", presumably little specialized nerve-nets, working inside the mind. Each agent knows what happens to some others, but little of what happens to the rest, and the process of thinking consists in making mind-agents work together.

Minsky suggests that in music listening, four kinds of agents are at work, "Feature-finders" which listen for simple time-events, "Measure-takers" which note certain patterns of time-events, "Difference-finders" which compare musical figures, noting similarities and dissimilarities, and "Structure-builders" which organize musical events, patterns and figures in a coherent whole.

Following this line of thought, swing can be understood as a quality arising from the interaction and tension between measure-takers and difference-finders. Minsky states that;

> Music's metric frames are transient templates - used for momentary matching. Its rhythms are "synchronization pulses" used to match new phrases against old - better to notice Differences and Change. As these are sensed, the rhythmic frames fade from our awareness, their work done. (Minsky, 1982)

The idea of the continuous mental comparison of transient metric frames provides an explanation of the swing phenomenon. When music swings, the process of momentary matching of patterns never stops, because the measure-takers are prevented from finishing their work by the difference-finders which note the occurrence of subtle deviations from regularity. As a result of this interaction, the listening mind is kept attentive and active, and the active awareness of the mind is experienced as a living quality of the music.

In continuation of Minsky's ideas, let us suppose that a number of specialized mind-agents and sub-agents are active in music listening, carrying out specific functions related to the basic listening dimensions. Such agents could be called intensity-finder, timbre-estimator, space-estimator, shape-builder and pulse-finder.

Intensity-finder is a difference-finder which responds to alternations between sound and silence and compares changes in intensity. Sub-agents of the intensity-finder react to minute degrees of intensity variation, to sudden changes, and to gradual growth and decrease of intensity.

Timbre-estimator is a high-capacity difference-finder, comparing information from a range of feature-finders specialized in detecting characteristic features such as attack quality, brightness and spectral structure. It is capable of discerning between a vast variety of individual timbres and between families of timbre. It can note the particular quality of a complex timbre and initiate its memorization, and it can provide a basis for segregation of different streams of sound heard simultaneously

Space-estimator integrates inputs from a group of sub-agents, including feature-finders providing information about directions and distances in the surrounding world. In music listening, a specialized difference-finder is at work, distinguishing between higher and lower sounds in the pitch height continuum, and conveying information to measure-takers which provide estimations of the total range of the soundspace and the precise size of musical intervals.

Shape-builder is a structure-builder which integrates information from difference-finders comparing prominent features of the temporal and spatial movement of sound. Shape-builder creates musical gestalts by assuming coherence between sound events that have common features.

Pulse-finder integrates the activities of measure-takers which are constantly searching the flow of sound events for successions of regular impulses and patterns **that** can be related to a regularity, and difference-finders which note deviations from regularity and changes of the pulse tempo.

***Eroica* - A symphonic fairy tale**

Assuming the existence of little specialized mind-agents, let us follow their observations, reactions, dialogues and discussions during the listening of symphonic music. The mind-agents are invited to listen to the beginning of Beethoven's *Eroica Symphony (1804)* played by the Philharmonia Orchestra under the baton of Otto Klemperer, a CD recording that is the author's favorite.

The reader is invited to follow the discussions of the mind-agents in the score with timings in *Ex. VI-VIII*

Eroica Symphony, First movement. Measures 1-57, Ex. VI-VIII

0'00 Intensity and space: This is something big and impressive! Timbre: Remarkable fused sound color, unique as a fingerprint, of large range and substantial density. I think I'll forever be able to recognize this piece merely by its first chord.

0'04 Pulse: Those two large outbursts were not enough to give me a tempo feeling, but here it comes, a stream of impulses nicely ordered in groups of six.
Shape: I agree that the music really begins here. A well-shaped curve rising and falling ...
Space: ... passing through a triad and returning to its initial tone. The register of the melody reminds me of a voice; I could easily get somebody to hum that tune, and I would recommend it for memorization.

0'09 Pulse: Stop talking and watch out! The music seems to run off its track.
Timbre: I don't care about your track. It's more important that the scene is being lit up by a stream of brightness.

0'12 Shape: Don't worry, pulse, we're back on the track again. But your six-impulse pattern has been reshaped in a three-beat wave form... Space: ... discreetly present in the transparent field between a high and a low soundstream.

0'17 Shape: And now the stream is set in curved motion, the melody absorbs the tempo impulses, and pulse is invited to an excursion in space.
Pulse: I appreciate that. But don't forget that it is the tempo that infuses energy and life into the melody.
Shape: It's running towards a goal... *0'20* ... which it reaches right now.

0'20 Pulse: Now the steady impulses are back, and the tempo increases.
Shape: The conductor is just trying to pep up that old triad tune he already played once.
Timbre: You are not really listening. The tune may be the same, but the sound is now a wonderful blend of two soundstreams - a bright and airy stream blending with a smooth, mellow line.
Space: Yes, the melody has taken off from the ground and is now flying in free flow ... *0 25* ... but here it reappears deep down ...

0'25 Timbre ... in a good new blend of dark and bright string timbre.
Shape: It's like call and response, sending the same message up and down ...

0'27 ... now it flies up again.
0'27 Timbre: But it is not as weightless as before. The soundstream has substance, with a little bit of fluffiness on top.

0'31 Shape: Listen, here's a smart trick. The composer has turned the triad of the tune upside down.

0'34 Pulse: He has also upset the impulse pattern. I was sure there were three beats grouped together; now it's two.

0'36 Shape: Not in this melody.

0'38 Pulse: It is two-beat, as I told you (Intensity nods his head in agreement). Even your admirable triads move in a two-beat pattern now.
Shape: This is a bit boring. Wake me up if something happens.

0'45 Pulse: Get up, you lazy brute, the impulses are beginning to jump!
Shape: Short-long, short-long, that's much better.
0'47 Pulse: Get out of the way, you snail! We're running double-speed now.
Space: That's wonderful energy for a multistream expansion.

0'50 Intensity: Stop arguing, now there's plenty of sound for everybody.
Pulse: Yes, these double-speed vibrating impulses make me ecstatic.
Timbre: Just like cikadas on a hot summer's day.
Space: Giving the air a quality of omnipresent ambience.
Shape: And the melody is also omnipresent. It is on top, at the bottom and in the middle.
Timbre: The trumpet, joining in for the first time, adds the final touch.
Intensity: I knew from the beginning that this was going to be something big...

1'01 Intensity: Hey! What happened?
Shape & timbre: We've just agreed to try out a brand new rhythm quietly in a variety of colors, one by one.
Pulse & Space: And we fill the background, so that these new individual shapes are not completely on their own.

1'07 Timbre: Would you like to hear them again?
Shape: With small, interesting alterations?
1'12 Intensity: I thought you were listeners, not performers. But it sounds like fun, I'll join you!

1'15 Everybody: We've been yearning for this powerful feeling of unity right from the beginning...

In the language of musical analysis, the adventures of the feature-finders, difference-finders, measure-takers and structure-builders can be retold in the following way.

Measures 1-2

The first chord of the symphony evokes the *musical space,* diverting the attention of the listener from the events of the surrounding world by the attraction of powerful and colorful sound. The appearance of the second chord creates the musical time by virtue of the duration experienced between the two musical events.

Measures 3-6

In the space still filled with the resonance of the second chord, attention is focused on the timbre and movement of the cello theme and the pulse beats of the violins and violas.

Within a melodic soundspace of one octave, the movement of the cello unfolds a coherent spatial shape, which invites the listener to let the motion of sonorous forms in the musical space replace the experience of events and movements in the surrounding world.

Simultaneously, a sensation of pulse time is evoked by a stream of impulses, which offer continuous stimulation of auditory attention together with the experience of ordered regularity. The listener is now seriously tempted to forget about the space and time of the world and set out for a journey in the virtual musical timespace.

The movement of the cello theme evokes the feeling of a three-beat meter. The theme is initiated by a pattern of contraction and expansion;

Fig. 6.11 (a)

The temporal shape of this pattern evokes the sensation of a three-beat grouping;

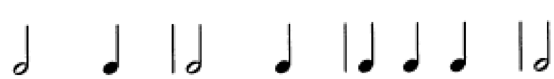


Fig. 6.11 (b)

Due to the three-beat grouping, the movement time of the cello theme is synchronized with the pulse time of the violins and violas in a joint regularity.

Measures 7-8

The established three-beat pattern is challenged by the appearance of a competing pulse in the high violins. This deviation from regularity enhances the awareness of the listener.

Measures 9-12
The disturbance is, however, absorbed in a slow flow of movement adapted to the three-beat feeling. Order is reestablished, and in measures 10-11 confirmed by the emergence of a new harmonic color on every third beat.

Measures 13-14
A melodic contour is applied to the underlying impulse pattern, resulting in a vigorous forward-directed movement.

Measures 15-18
The initial theme reappears, expanded to a larger soundspace of several octaves, colored by a blending of the instrumental timbres of flute, clarinet and horn.

Measures 19-21
The tail of the theme is repeated in new timbral-harmonic colors, and the soundspace of the theme is expanded downwards.

Measures 22-24
The soundspace is filled with new harmonic colors, and the tail of the theme is inverted and dislocated in relation to the meter.

Measures 25-32
The established order is exposed to a severe challenge. In measures 25-26, the three-beat meter is disturbed by syncopations. Subsequently, it is completely superseded by a massively accentuated two-beat meter in measures 28-32.

Measures 33-36
The dominance of the intruding two-beat pattern is broken by renewed syncopations in measures 33-34, and the tension accumulated by the conflict of meters is released in hectic movement in measures 35-36, leading to an expansion of the soundspace.

Measures 37-45
In the expanded soundspace, filled with energetic string tremolo, the initial theme returns in powerful octave duplications, magnified to the heroic dimensions of the first chord of the symphony.

Measures 45-54
After the massive fusion of instrumental timbres, intensity falls to a minimum, and a transparent space is opened, tinged with the harmonic colors of the undulating strings. On this background, the temporal shape of a new theme appears in a succession of distinct melodic contours,

colored by a variety of instrumental timbres in different registers. The contrasts between distinct instrumental timbres and diffuse background color evoke the impression of depth in the virtual musical space.

Measures 55-57
The illusion of spatial depth disappears, as all instruments are once more united in a massive fused timbral color. Simultaneously, the shape of the melodic movement is united with the three-beat metric frame.

This music is a multivariable complex of temporal and spatial relations, movement and pulse, rise and fall, segregation and fusion of timbres, expansion and contraction of the soundspace, similarity and dissimilarity of harmonic color, regularity and deviation, continuity and interruption, conflict and integration. These factors interact in the creation of a virtual musical timespace which provides incessant stimulation of the listener's attention and awareness, curiosity and interest.

Change and Regularity
The interaction and alternation, tension and balance between change and regularity give rise to the variability of music.

In the beginning of *Eroica,* the changeable movement of sound interacts with the ordered regularity of pulse, creating rhythm as the order in the movement. The variable contour of the movement of sound interacts with an orderly pattern of well-defined pitch heights, creating a melody.

The interaction of the microtemporal variability of timbre and the focusing properties of pitch heights creates harmonic color.

The basic listening dimensions can be traced back to the fundamental concepts of change and regularity. Movement and timbre are listening dimensions related to the experience of change, pulse and pitch height are listening dimensions related to the experience of regularity.

The nature of the macrotemporal dimensions movement and pulse is described in chapter one, pp. 13-15. According to the origin of these listening dimensions, the experience of musical movement is related to the awareness of coherent change, and the experience of musical pulse is related to the awareness of continuous regularity.

Movement represents macrotemporal change, and Pulse represents macrotemporal regularity.

The nature of the microtemporal dimensions *timbre* and *pitch height* is described in chapter one, pp. 12-21. and chapter five, pp. 68-75.

The experience of timbre is related to the rapid change of intensity and energy distribution in a sound spectrum. *Timbre represents microtemporal change.*

The experience of pitch height is based on the focusing at a particular level of the pitch height continuum, related to a regular distribution of harmonic partials in a sound spectrum. *Pitch height represents microtemporal regularity.*

The correspondences between listening dimensions, change and regularity are shown in *Fig. 6.12.*

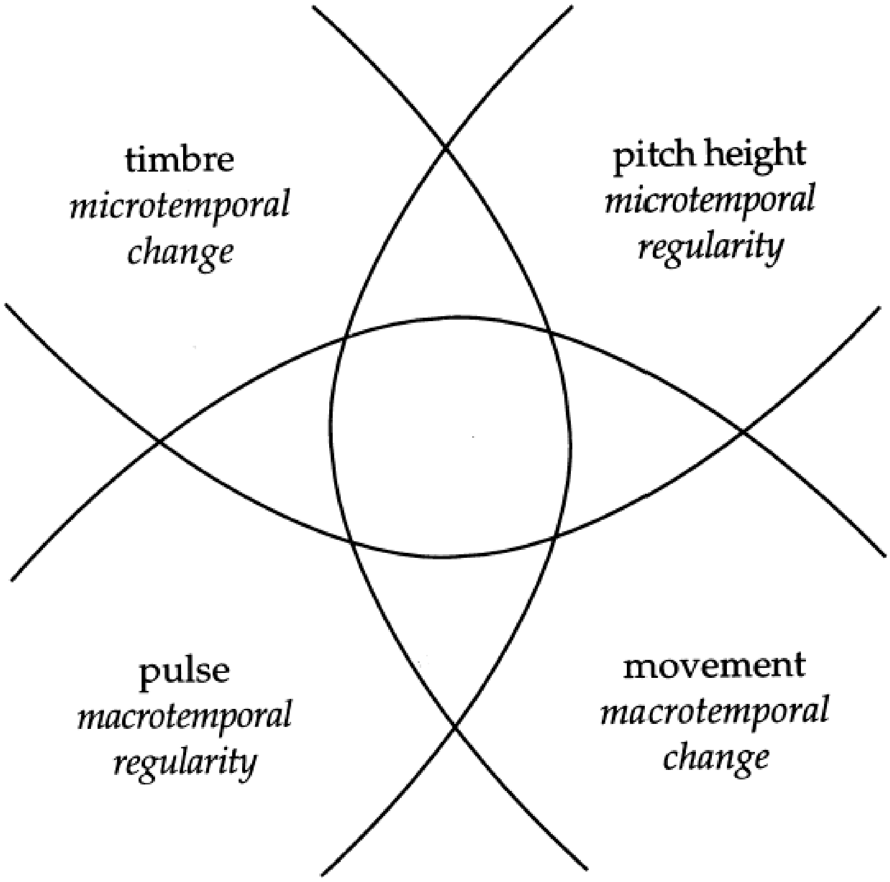


Fig. 6.12. Change and regularity

7

Density, Extension and Color of the Soundspace

The experience of the virtual musical space is called forth by the differences and changes of sound. The illusions of spatial relations are evoked by the experience of density and transparence, focusing and diffuseness, and differences in intensity.

In the *Eroica* symphony, *focusing* qualities of sound are heard in the distinct instrumental timbres and distinct pitch heights, and *diffuse* sound qualities are heard in the harmonic background colors. *Transparent* sound is heard in the blending of timbres in measures 15-18, where flute, clarinet and horn play the theme in parallel octaves. *Dense* sound is heard in the merging of all instruments in the initial chords of the symphony and the joint movement in measures 55-57.

The prominence of distinct pitch heights calls forth the vertical dimension in the musical space, experienced as differences between high and low sounds. Contrasts between distinct timbre and diffuse timbral-harmonic color call forth the depth dimension in the musical space, experienced as differences beween proximity and distance. Crescendos and diminuendos evoke illusions of approaching and receding sound.

The movement between the pitch heights of a melody evokes the experience of the melodic soundspace, delimited by the highest and the lowest sounds of the melody, cf. pp. 101-107.

In the *Eroica* symphony, the initial cello theme moves within a melodic soundspace of one octave. In measures 15-18, the soundspace of the theme is expanded by octave doubling. When the theme returns in measures 37-42, it is further expanded to a range of four octaves, played in unison by flutes, oboes, clarinets and bassoons, horns and trumpets, cellos and double basses. Here, the soundspace of melodic movement is enlarged to a total soundspace of several registers.

The total soundspace is experienced as a virtual space in the mind. The size of the soundspace, its shape, expansion and contraction are essential for the musical experience. The investigation of the qualities of the total soundspace, its size and shape, transparence, density and color, and a discussion of the relations between spatial and temporal qualities of music are the themes of the present chapter.

The Unanswered Question **- An extended space of transparent color**

Charles Ives' introduction to his orchestral work, subtitled "A *Cosmic Landscape* " and a survey of the music is found in chapter four, pp. 51-53.

Throughout the piece, the strings provide a background of sustained or slowly changing harmonic colors, evoking the impression of spatial transparence. On this background, the atonal trumpet question stands out as an distinct melodic gestalt seven times, answered six times by the woodwinds. The notation of the strings and the first trumpet question is shown in Fig. *7.1*.

Graph VII-I is a survey of the soundspace of the whole work, displaying the size, shape and interval structures of the soundspace.

The Unanswered Question, Graph VIM

In the graph, each single string chord is drawn as a sound column. The numbering refers to the measures of the score. One measure may be represented by one, two, three or four columns.

The appearance of a trumpet question is indicated by a Q, and the tones of the question are marked by x'es in the graph. The appearance of a woodwind answer is indicated by an A.

The size and shape of the total soundspace is outlined by curves connecting the top tones and the bottom tones of the sound columns.
A significant feature of the soundspace is a fall from the four-octave space G2-G6 in measures 1-3 to another four-octave space C2-C6 in measures 8-9, heard as a Dominant-Tonic relation. The fall occurs once more, as measures 1-13 are repeated in measures 14-26.

Another significant feature of the soundspace is the contraction in the second half of the piece. From the four-octave space of the G major chord in measures 27-29, the soundspace is contracted to the narrow space C4-E5 of a C major chord in measure 45. From there, the soundspace gradually expands again, reaching the four-octave space G2-G6 in measures 55-61.

Fig. 7.1. The Unanswered Question - Score page 1

The string chords are related to major-minor tonality. The harmonic colors which fill the space can be described as follows;

The Unanswered Question, Graph VII-I, and Fig. 7.1, measures 1-13

> The four-octave interval G2-G6 is colored by the two tones B3 and D5, producing a sensation of a transparent space delicately tinged with the harmony of G major. During measures 1-2-3, 00-16 in the recording, the listener has time to dwell on the sensation of harmonic transparence and to change perspective of listening, singling out each separate pitch height of the harmony by involuntary or deliberate focusing. The same is the case in measures 4-5, where the harmonic tinge changes from G major to B minor.
>
> With the second chord of measure 5, continued in measure 6, attention is focused on the pitch height G4 exactly in the middle of the sound-space, doubled by second violin and viola (white dots in the graph). This predominant doubling prepares the salience of the major second interval F4-G4, which is dissonant in the triadic context, producing the quality of a dominant seventh chord in C major. The doubling of voices here is unique; it is the only voice doubling in the piece, and the major second interval between string voices occurs nowhere else in the piece.
>
> In the following measure 7, an unambiguous resolution to C major is avoided. Second violin jumps to D5, contributing to a rather blurred chord color composed of a major tenth plus two minor sevenths. Resolution follows with the second chord in measure 7, leading to the four-octave C2-C6 space in measures 8-9, filled with the saturated coloring of a major sixth and a minor sixth on top. After another change of color in measures 9-10 follows an A minor harmony in measures 11-12. This is a chord of considerable brightness, produced by the minor sixth E5-C6 on top. In this transparent harmony-tinged space, attention is now focused on the movement of the viola in mid-register, continued in the descent of the cellos in measure 13.
>
> The flow of harmonic colors in measures 1-13 is repeated in measures 14-26, leaving room for the appearance of the first and second trumpet questions in measures 16 and 23.

The tones of the trumpet question never coincide with the tones of the string harmonies, so the question is clearly separated from the background. But a meeting between the trumpet and the strings occurs once. This happens when the fifth question appears in the contracted space of measure 45. The score notation is shown in *Fig.* 7.2, and the relationship between the soundspaces approaching each other is shown in *Fig. 7.3*.

Fig. 7.2. The Unanswered Question, measures 43-52

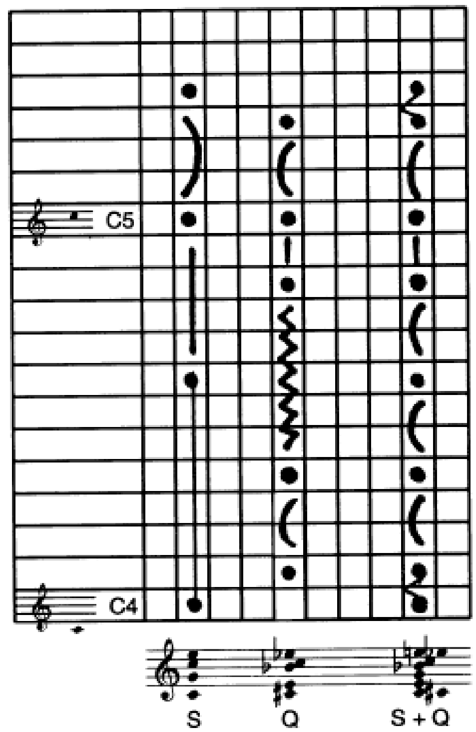


Fig. 7.3. Measure 45: The tones of the trumpet Question (Q) fit into the C major chord of the strings (S). Played together, they merge in a brilliant harmonic color (S+Q)

The melodic soundspace of the question has a range of a major ninth, C#4-Eb5. It fits exactly into the the soundspace of the strings, which has the range of a major tenth, C4-E5. When the two soundspaces are superimposed, an area of density appears in mid-register, and the space loses its transparence for a moment.

A symbolic meaning can be ascribed to this meeting of the trumpet and the strings. The strings represent "The silence of the druids, who know, see and hear nothing". Even if the silent druids do not answer the question, they approach it by contracting the space of the cosmic landscape to the size of the question.

Another area of density with an implicit symbolic meaning is heard in measures 49-50-51, where the woodwinds gather in a dense cluster of minor seconds, C4-Db4-D4-Eb4. This cluster represents the "secret conference of the woodwinds" pointed out in Ives' introduction, p. 51 The woodwinds represent human beings, who have been busy throughout the piece hunting for "invisible answers" to the question. Now they try once more by sticking their tones close together in a cluster. But the cluster does not match with the range of the question, the woodwinds "realize a futility" and disperse in disagreement.

Central Park in the Dark **- The color of silent darkness**

Ives' introduction to *Central Park in the Dark* and a survey of the music is found in chapter four, pp. 53-56. Throughout this work, the strings provide a background of soft, slightly blurred harmonic colors played in a repeated cycle. On this background, tones, tunes and melodic fragments, rhythms and noise appear and disappear. It is Ives' intention to let the strings evoke impressions of "night sounds of nature, bugs, leaves on trees, sounds of silent darkness, sounds natural and unnatural."

The string chord cycle is shown in score notation and sound columns in *Ex. VII-II*

Central Park in the Dark, Ex. VII- II

The string chord cycle consists of a ten-bar phrase of 29 chords in slow, pulseless motion. The fundament of the changing chords is a very slow cycle of four deep notes played by the double basses. Each bass note has its particular kind of chord superstructure.

In the graph *(b),* numbers refer to the ten measures notated in *(a)*. One measure may be represented by one or several columns. Black dots indicate single tones, and white dots indicate tones doubled in several instruments.

Above the Ab1 in measures 1-2 the strings play augmented triads separated by a tritone interval. In measures 3-4-5, columns of fourths are heard above a Bb. In measures 6-7-8, chords of alternating tritones and fifths are played above F#1. In measures 9-10, the strings play columns of fifths above the deepest note Eb1.

One deviation from the regular pattern of fifths occurs; the tritone interval E2-Bb2 in the last chord of measure 9. As all the other chord patterns display exact similarities of structure, one cannot help but wonder if this deviation is deliberate or due to an error of writing. In the critical notes of the score, no comment is given to this chord. The color quality of this chord is, however, not particularly different from the surrounding chords.

The four kinds of interval structure produce characteristic chord colors. The augmented triads are heard as a rich sonority, the fourth chords are denser and less brilliant. In the section of mixed tritone/fifth chords, the sound appears to be divided into a bright upper stream and a lower dark stream. In the final section of piled fifths, the sound merges in a coherent harmonic color. The regular distribution of intervals in these chord patterns give rise to colors of comparatively blurred qualities, evoking impressions of "night sounds."

Comparison of Ives' orchestral pieces with the works discussed in chapter five, p. 79-90, shows the variability of density and color in the total soundspace. The densest sound is heard in *Pithoprakta,* where an even distribution of small intervals fill the whole range of the soundspace. The most transparent sound is heard in *The Unanswered Question,* produced by the spacing of harmonically related pitches in large intervals. Between these extremes, the overall sound quality can display variable degrees of density and transparence, coherence and separation, blurredness and clarity, darkness and brightness, saturation and dilution.

Density and brilliance is heard in *Pithoprakta,* transparence and saturation in Livre pour orchestre, gradual increase of darkness and blurredness in *Summer Morning by a Lake (Colors).* In *Central Park in the Dark,* one chord structure is heard as separate layers in space, another as a coherent sound. In *Atmospheres,* simultaneous layers of timbral-harmonic colors permeate each other, creating the impression of luminosity in an open space. In *The Unanswered Question,* the contraction and interaction of timbral layers result in a transitory closing of the spatial perspective.

Further examples of transparence and density of the soundspace are found in the music of two rock groups, Pink Floyd and Sepultura.

Pink Floyd: *Set the Controls for the Heart of the Sun*
- Dominance and disappearance of pulse in the soundspace

This work of Pink Floyd is issued in their album *Ummagumma (1969)* on the EMI label. It is the intention of the piece to create a musical image of a journey in space.

Set the Controls for the Heart of the Sun

0'00-53 Creation of the virtual space
In the beginning of the piece, the listening dimensions are activated one by one.
0'00 Intensity and metallic timbre of a cymbal emerges and grows.
0'03 Pulse emerges in the cymbal timbre, and the space is filled by the rapid growth of timbral intensity. *0'10* The timbre is set in vibration,
0'18 a deep sustained tone is added.
0'28 Movement and melody appear in a repeated slow motion melodic formula. *0'33* Rhythm is added in a repeated drum pattern.
0'38 The melodic formula is doubled by a higher instrument. Melodic movement in parallel octaves evokes the impression of a transparent space.

0'54-2'35 Text and regular form
A human voice appears in the foreground, joining the melodic formula, which continues in parallel octaves in voice and two instruments. *0'54-1'45* A blues-like pattern is formed by repetition, transposition and variation of the melodic formula; *1'46-2'35* this pattern is repeated.

2'36-3'10 Melodic evolution
Instrumental improvisation begins to unfold ornamented melodic curves, while the human voice recedes into the background, creating a repeated rhythm pattern by toneless whispering. The voice gradually fades and disappears at *3'10.*

3'10-4'58 Increasing activity and spatial density
Tempo and intensity of the continuous rhythm pattern in drums begin a gradual increase. *3'31* Melody rises to a high register, fades and disappears at *4'10.* Noise streams, cymbal clashes and irregularly rotating sound masses appear and grow, filling the space with several layers of sound in motion and reaching a climax at *4'58*

4'59-6'25 Transparent space
After the climax, a wide space is suddenly left open between high floating streams of clear, bright timbre and the low pulsating stream of the repeated melodic formula. *5'32* High impulses gather in a garland of purling sound.

> ***6'00-6'25 Free flow in space***
> The low pulsating stream disappears, and the high streams continue in timeless soaring movement. Reverberation enhances the impression of a vast open space.

6'25-7'44 Transition from free flow to regularity
Pulse reappears softly, re-establishing the transparent space between high and low soundstreams. *6'36* Rhythm is added, *6'54* slow melody is added. At *7'20* the high soundstream disappears. *7'24* Deep sustained tones are added, *7'45* the initial melodic formula returns.

7'59-9'20 Text and regular form reappears and dissolves
The human voice returns, and the blues-like pattern of melodic formulae takes shape again. *8'47* The high floating stream of clear bright timbre reappears, the voice takes up its whispered rhythm pattern, and drums and instrumental pulse continue softly. The impression of a transparent space between high and low soundstreams is recreated. Finally, the music fades and disappears.

The music evolves from an initial phase of emergence through a phase of regular form to a state of free flow, and then gradually returns to regular form. In this process, spatial images evoked by movement, bright timbral qualities and the rise and fall of pitch height are balanced against the regulated time evoked by pulse and rhythm.

When pulse and rhythm are salient, they attract auditory attention, so that a sensation of regulated time is predominant, and the spatial qualities of sound are heard as concomitant phenomena. When rhythm and pulse disappear between *6'00* and *6'25,* the spatial qualities of the music come to the fore, and the idea of forward-moving time seems to lose its relevance.

The experience of space and the experience of pulse time here appear to be of complementary nature. A similar complementarity between temporal and spatial dominance is heard in *The Unanswered Question* and *Central Park in the Dark,* discussed in the present chapter and in chapter four, pp. 51-56.

Throughout the Pink Floyd work, the soundspace is experienced as transparent, even in the section of increased activity and density, *3'10-4'58.* This transparence is achieved by the use of clear, smooth and undistorted timbres. The soundspace of the following piece of music is different.

Territory **- The Density of Distortion**

Territory (1993) by the rock group Sepultura, issued on the CD album *Chaos A.D.* published by Roadrunner Records is a protest against war of conquest, direct and violent in its musical expression.

Territory

0'00-0'31 Introduction

With immediate intensity, two streams of timbre thrust themselves forward, a sizzling metallic sound of a cymbal playing a four-beat pulse reinforced by explosive sound on 2nd and 4th beats and a dark, hollow drum playing a slightly irregular rhythm pattern.

0'07 Distorted, pulsating guitar and bass sound stands out like a screen of noise in front of rhythm and pulse; *0'14* the noise screen changes to a darker sound color, *0'21* the noise is shaped in a repeated energetic rhythm pattern. *0'29* Pulse and rhythm disappear, leaving a space filled with vibrating sound.

0'31-1'54 Verses and refrains in four-beat measures

4+8+8+8 measures;

0'31 A repeated drum rhythm pattern establishes a 4-measure period.
0'38 The 4-measure period is confirmed by the succession of four blocks of colored noise played twice. This is an instrumental anticipation of the refrain.
0'51 Verse 1; *Unknown man/Speaks to the world*
Sucking your trust / A trap in every world
is shouted with rough unpitched throat voice,
accompanied by eighth-note pulse patterns
of unpitched noise and pitched bass.
1'04 Refrain; *War for Territory* is shouted in two different vocal colors on a background of blocks of pulsating instrumental noise.

4+8+8+4 measures;

1'16 Repeated energetic noise rhythm pattern.
1'23 Verse 2; *Choice control / Behind propaganda*
Poor information / To manage your anger
is performed like verse 1.
1'36 Refrain; *War for Territory* is performed like refrain 1.
1'48 Diffuse cloud of sound waning little by little, while rhythm gains intensity and forward motion.

1'55-2'32 Additive rhythms in eight-beat measures

4+4+4 measures;

1'55 A repeated pattern of additive rhythm (2+1+3+2) is accentuated by two different noise colors.
2'07 Rhythm changes to a repeated pattern (3+3+2) of blocks of snarling noise. *2'15* rotating sound is added.
2'20 Verse 3 returns to the (2+1+3+2) rhythm pattern;
Dictators' speech / Blasting off your life
Rule to kill the urge / Dumb assholes' speech
is shouted like verse 1, with echoing vocal response.

2'32-3'22 Streams of pulse, rhythm, movement and melody in four-beat measures

8+4+4 measures;

2'32 Rotating pulse and rhythm patterns come to the fore.
2'45 Syncopated bass rhythm.
2'51 Return to rotating patterns.

8+4+4 measures;
2'57 Screen of pulsating bass and guitar sound with melodic formula repeated riff-like.
3'10 Brief climax of penetrating screaming high guitar interference on a background of syncopated rhythm.
3'16 Rapid melodic arabesques. *3'22* drum break

3'25-4'14 Verses and Refrain

3'25 Verse 4; *Years of fighting /Teaching my son*
To believe in that man / Racist human being
is recited in rough throat sound.
3'37 Verse 5; *Racist ground will live / Shame and regret*
Of the pride / You've once possessed
is recited with increased brightness and intensity of voice.
3'49 Refrain; *War for Territory* is shouted with growl added.
4'02 Pulse and rhythm disappear, leaving a cloud of sound with internal movement of brighter streams ... *4'14*

4'14-4'45 Streams of pulse and rhythm with enhanced distortion in four-beat measures

4+8+8 measures;
Rotating pulse and rhythm patterns come to the fore, akin to an earlier section (heard at *2'32*), with enhanced presence due to an obtrusive scratching sound quality produced by increased distortion. *4'45* Abrupt end.

This piece is characterized by a rich variety of space-filling sound qualities. The soundspace is filled with screens, surfaces, clouds, walls and mobile shapes of vibrating noise in variable colors. Pulse, rhythm and movement are shaped in streams of noise. Pitch height does not appear as a clear singularity, but as an aspect of a sound complex including noise components. Interference, roughness and distortion of sound in varying degrees arouse the incessant attention of the listening mind, producing sensations of obtrusive presence and density The whole soundspace is filled with vibration, leaving no open fields and no possibility of escaping the mental impact exerted by the mind-engaging quality of distorted sound. The emotions provoked by this music are enjoyed intensely by some people, while other people loathe this kind of experience.

The musical intentions of this piece and the Pink Floyd piece are complete contrasts. *Set the Controls for the Heart of the Sun* creates a virtual image of a limitless open space, while the rough sound of *Territory* closes the spatial perspective completely by occupying the auditory awareness of the listener with strong, interferent vibrations.

Flow, expansion and emotion

Continuum - An expanding flow of timbral-harmonic colors

In Sepultura's *Territory,* the soundspace is filled with obtrusive timbre. In Ligeti's *Continuum* for harpsichord *(1968),* the soundspace is gradually filled with streams of pulsating timbre, vibrating and rotating in transitory rhythmic and melodic patterns, leading to an wide expansion of the soundspace.

Continuum is recorded by Elisabeth Chojnacka on a Wergo CD. This is a description of the evolution of the music;

Ligeti: Continuum

0'00 A sharply attacked trill on a minor third suddenly emerges, *0'11* color is added, *0'20* the trill grows into a pulsating tone web, *0'33* changes color in rotating motion, *0'39* gradually receding in a simple trill...

0'55 Distinct pulse and harmonic color is added, *1'04* arpeggio patterns are set in motion, *1'11* the arpeggio spreads, rotates and adopts more complex colors while irregular rhytmic patterns emerge...

1'32 A clear harmony stands out, pulsates, *1'37* develops into a gradually thickening web, *1'52* is divided in two rotating streams, one rising, the other one falling, spreading wide apart, *2'09* the sounds-treams are set in energetic oscillation, *2'19* erupting in large and violent space-filling vibration, *2'26* again dividing in a high and a low stream, spreading apart...

2'45 The low stream stops, leaving reverberation, the high stream conti-nues in a trill, *2'51* rises, *2'54* thickens, *3'14* ascends higher and higher, slightly accelerating, *3'32* is concentrated in a thin line of vibrating energy, *3'39* is focused in one frenetically repeated high tone accompa-nied by pulsating keyboard noise, *3'54* stops, reverberates, *3'56* disap-pears.

This music is a flow of sound in continuous transformation. The fast, inces-sant stream of even notes creates auditory illusions of emerging rhythmic patterns, transient melodic lines and fluctuating timbral-harmonic colors.

Fig. 7.4 shows the first page of the notated music, corresponding to *0'00-0'28* in the recording. Ligeti gives this instruction to the performer;

Prestissimo = extremely fast, so that the individual tones can hardly be perceived, but rather merge into a continuum. Play very evenly, without articulation of any sort. The correct tempo has been reached when the piece lasts less than 4 minutes (not counting the long fermata at the end). The vertical broken lines are not bar lines - there is neither beat nor metre in this piece - but serve merely as a means of orientation.

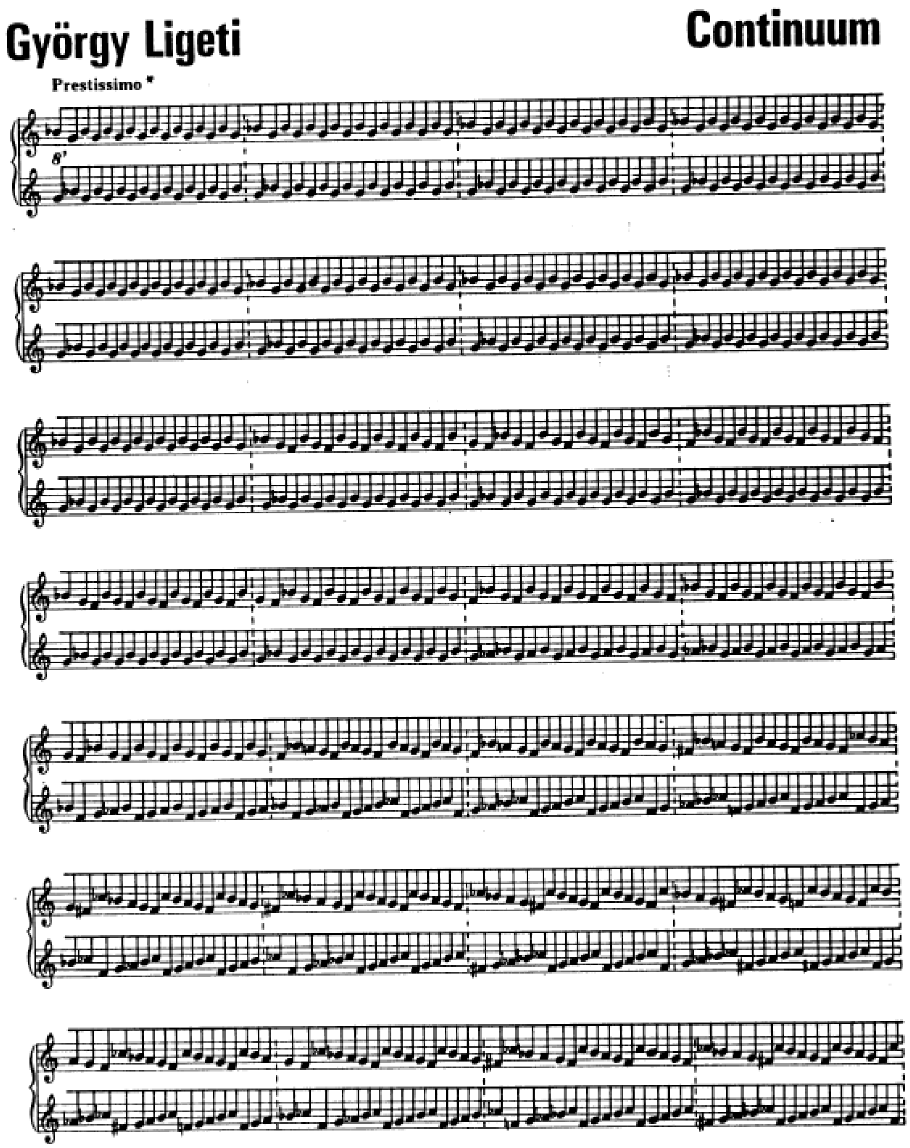


Fig. 7.4. Continuum, First page

In the recording, a section between two broken lines corresponds to a duration of a little more than one second. The tones within a section are perceived simultaneously as a fluctuating harmonic color.

The gradual expansion of the soundspace and the distribution of intervals underlying the emergence and transformation of harmonic colors and melodic lines are shown in *Graph VII-III.*

Continuum, Graph VII-III

In the graph, the numbering refers to the 205 sections of the notated music. The tones played within each section are drawn in a pitch height column, displaying the interval distribution and range of this particular moment of the musical flow.

The piece begins with a vibrating minor third G4-Bb4 (1-9), colored by the addition of F4 in (10), growing to a vibrating band of minor seconds (20-42) thinning out in a simple trill F#4-G#4 (50-55). Pulse and color are added by the D#4 (56-66), followed by expansion and fluctuating colors (67-86), leading to an outspread B major harmony B3-F#4-D#5 (87-88).

Now a large symmetrical expansion takes its beginning. B major changes to B minor (89-91), colored by A3 (92-95) and G3 (96-102). The soundstream gradually expands in a web of variegated harmonies and is divided into two streams of interference bands (115-125), defining the upper and lower limits of a three-octave space F#2-F#5 and leaving a void in the medium register. In (126) the violent outburst of energy in two heavily vibrating tritone areas expands the total soundspace to five octaves plus a major second, F1-G6.

Subsequently, the intervals change to harmonious thirds and sixths (132-138), then to transparent fields of minor sevenths and major seconds (139-143), expanding the soundspace to its maximum of five octaves and a minor seventh, C#l-B6.

From here, the high trill B6-C#7 continues (144-149), grows (150-169) and decreases (170-185). It is contracted to a minor second trill Eb7-Fb7 (186-192) and finally concentrated in one high repeated tone, Fb7 (193-204).

Ligeti's harpsichord piece is a continuum of interactions and transitions between listening dimensions. The sharply attacked tones of the harpsichord possess the double quality of bright metallic timbre and distinct pitch, and the continuous stream of rising and falling tones evokes the simultaneous experience of pulse and movement. In the pulsating streams of timbre and pitch, rhythmic structures, melodic lines and harmonic colors emerge and disappear. The secondary listening dimensions rhythm, melody and harmony arise from the interactions of the basic dimensions timbre, movement, pulse and pitch height.

This music is an exploration of the temporal continuum described in chapter one, pp. 19-21 The temporal continuum is divided into four sub-areas by the processes of auditory perception, the microtemporal areas of timbre and pitch height and the macrotemporal areas of pulse and movement. Ligeti explores these temporal sub-areas by approaching the limits of transition between one area and another. The pulse of the rapid attacks is so fast that it approaches the limit of approximately 16 beats per second, where the transition from perceptible pulse to perceptible pitch takes place. The expansion of the soundspace downwards is so large that the lowest pitches approach the same limit. Simultaneously, the soundspace is expanded upwards, so that the highest pitches approach the upper limit of perceptible pitch.

The accumulated totality of these processes calls forth a strong emotional response in the listener, experienced as a climax when the total soundspace is expanded towards the limits of pitch perception.

Nørgård's *Second Symphony* - An infinite flow of tempo layers

A similar strong emotional experience of expansion is called forth by the listening of Per Nørgård's *Second Symphony (1970).* Throughout the symphony, its total soundspace is expanded slowly and gradually, leading to a climax at the end.

The symphony is recorded on a Point CD with Jorma Panula conducting The Aarhus Symphony Orchestra. It is scored for 33 strings, 3 flutes alternating with piccolos, 2 oboes, 2 clarinets, 2 bassoons, 4 horns, 3 trumpets and 3 trombones, electric organ, vibraphone, grand piano with lid removed, amplified harp, and tubular bells. This is a brief survey of the work;

Nørgård: Second Symphony

0'03-3'30

The first section is an initial creation of sound. From the beginning, whispering sound and a quiet tone emerge out of nothing. The tone is renewed by several instruments; close neighboring tones occur, producing interference, and the sound is gradually intensified and set in motion.

3'30-22'30
The main section of the symphony is an extensive flow of simultaneous soundstreams in different tempo layers. In the soundstreams, melodic and rhythmic shapes are brought out in a variety of ways.

Distinct trumpet tones, representing a slow tempo layer of the symphony, appear as regular landmarks in the symphonic flow. The flow is disturbed four times by screens of pulsating noise. The last screen is a climax of intensity, density and expansion.

22'30-23'20
After the climax, a few sharp impulses and quiet floating sounds are heard, related to the initial emergence of tone, noise and interference.

Repeated listening of Nørgård's Second Symphony reveals the astonishing property of the music that each listening is different from the previous one. The symphony is a multilayered flow of timbres, streams, shapes, events, movements and transformations. In every renewed listening, other occurrences, layers, relations and perspectives attract the listener's attention, leading to a new experience of the totality of the music. These are some of the states, events and movements heard in the symphony;

Nørgård: Second Symphony

0'03-3'30:

0'03 A quiet soundstream emerges. It is twofold, composed of diffuse noise and a focusing tone, akin to the simultaneous tone and noise of the japanese Shakuhachi flute.

1'42 The interference of a quarter-tone interval is heard, giving rise to high difference tones and interference beats akin to the interferent sound of Balinese Gamelan.

2'00 The soundspace is filled with diffuse sound. *2'09* A distinct trumpet tone stands out

2'21 Vibration of interference.

2'36 Foreground and background of distinct and diffuse sound.

2'58 Oscillation arises. *3'05* Density and volume of sound increases.
3'17 melodic movement appears. 3'27 The sound is set into vibration by tremolo.

3'30-22'30:

3'30 A distinct trumpet tone stands out, and a flow of pulse is released in a stream of even notes played by the flutes. A sensation of reverberance of the trumpet tone is evoked by noise-like timbres of strings and metal percussion.

3'50 The continuous flow of pulse creates a sensation of forward-directed movement. Shapes of melodic movement in different simultaneous tempo layers appear, grow and recede.

4'53 A loud trumpet tone stands out, followed by a trail of noise.

5'36 The continuous regularity in the flow of soundstreams evokes the sensation of cyclic movment.

6'10-6'38 A pattern of expectation, occurrence of the expected event and memory of the event appears. A crescendo at *6'10* arouses the listener's expectation of a coming event, the event occurs at *6'18* in the form of a trumpet signal, and a subsequent trail of noise *6'23-6'38* maintains the memory of the signal.

7'40 The entry of trumpets and trombones disturbs the established regularity. The sound of the brass instruments stands out like a transparent screen of pulsating noise in front of the forward-moving flow of other instruments. The conflict between these two layers of sound continues for a whole minute.

9'30 Melodic gestalts appear in violins, *9'40* Rhythmic shapes in cellos.

10'00-10'45 A pattern of approaching, arriving and receding appears. A crescendo at *10'00* evokes the sensation of sound which approaches a goal and reaches it in the form of a trumpet signal at *10'18.* Subsequently, a diminuendo *10'21-10'45* evokes the impression that the sound moves away and disappears.

12'55 A second screen of noise appears, *13'30* reinforced by the distorted sound of a high horn.

14'13-14'20 Brief dissolution of the flow. *15'12-15'22* Salient flute melodies appear on a dense, coherent background.

15'44 Tremolo sounds and sharp attacks are heard, *16'10* distorted flutter-tongue sounds stand out. March-like rhythms at *16'24* lead to an outburst of activity with a obtrusive pulsating pattern of bells in the foreground.

17'03 A long, calm wave begins its course. *17'17* The wave is disturbed by penetrating signals, intensified activity and march-like rhythms which lead to a third screen of noise screen at *17'42,* accentuated by syncopated pulse patterns at *17'58.*

18'25-20'37 Melodic arches and rhythmic shapes come to the fore. Here, the music approaches the tradition of symphonic music.

20'58 A forward-moving march arouses increasing activity. *21'54* The soundspace is filled with low bells, distinct piano chords and high piccolo flutes. Increasing loudness culminates in a large expansion of the soundspace at *22'10-22'30.* The total soundspace is filled by a vibrating sound mass with penetrating piccolos on top and rumbling double basses at the bottom.

22'30-23'20:

22'30 The expanded soundspace is left wide open for the intense presence of gently gliding sound, disturbant flute signals, quiet vibrations and a transient veil of delicate sound which finally gathers in whispering noise and a single tone.

23'20 The symphony ends, having reached a state similar to its beginning.

In this symphony, an evolution from a musical microspace to a musical macrospace and a subsequent return to microspace take place.

The music begins in microspace and microtime. The microspace is the focused timbre of a single tone, surrounded by the diffuse timbre of whispering noise. The time in this space is the microtime of timbre and pitch height. A minute expansion of the microspace occurs at *1'42,* where interference arises in a quarter-tone interval. At *2'09,* a brief impression of macrospace is evoked by the interval between the initial tone and the salient trumpet tone. At *3'17,* the sensation of macrotime is called forth by melodic movement.

In the main section of the symphony, *3'30-22'30,* an expanding macrospace of pitch height intervals is unfolded by the movement of melody, and the experience of macrotime is evoked and maintained by pulse and movement in different tempo layers, culminating in a wide expansion of the soundspace.

After this expansion, the macrospace is kept open for a while by high and low sounds which appear and disappear like reminiscences of the large sound mass. Finally, the soundspace is contracted to the microspace of a single tone.

A particular feature in the symphony is an interchangeability of temporal and spatial experience which occurs when a crescendo precedes a salient event, followed by a diminuendo. This crescendo-event-decrescendo pattern can be heard in two different ways. One is the pattern of *expectation, event and memory,* which is a temporal experience. The other is the pattern of *approaching, arriving and receding,* which is a spatial experience. In the description above, the temporal interpretation of the musical pattern is indicated at *6'10,* and the spatial interpretation at *10'00.*

A related experience in nature is the approaching, breaking and receding of a sea wave, accompanied by the increasing intensity of sound towards a climax, followed by decreasing intensity.

The infinity series

The movements and melodic shapes, harmonic colors and screens of noise appearing and disappearing in the symphony and the layers of fast, medium, slow and very slow tempo originate in Nørgård's infinity series.

The infinity series is unfolded from a single interval by projection of the interval downwards and upwards in the pitch height space. The projections create two new intervals, which are again projected downwards and upwards, creating further new intervals. The generation of the infinity series is explained in detail in *Ex. VII-VII.*

The basic series of the symphony, unfolded from a rising semitone interval, and its spatial contour are shown in *Ex. VII-VI.* Essential properties of the series are its gradual expansion, its unfolding of characteristic melodic shapes, and its self-reproduction in a slower tempo layer.

The infinity series, Ex. VII-VI

Gradual expansion of the soundspace

The notation of the first 64 tones of the basic series and its continuation until tone 4096 is marked (1). Above the notation, the tones of the series are drawn in a contour graph, odd-numbered tones as black dots, even-numbered tones as white dots, in accordance with the explanation of the series in *Ex. VII-VII.*

The soundspace of the series is expanded whenever the series comes to a power of 2, that is, at tones 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, and 4096.

The initial semitone interval (1-2) is expanded one step down and one step up by the tones (3-4). Similar expansions, one step down and one step up, occur when the series comes to tones (7-8), (15-16), (31-32) and (63-64).

Each expansion creates a new, larger interval. The slowly expanding range of the soundspace is traced by an envelope curve in the graph, and the intervals created when the series comes to tones 128, 256, 512, 1024, 2048 and 4096 are indicated.

Melodic shapes

In its course, the series unfolds characteristic melodic shapes.

Tones (1-6) constitute an M-shape, tones (7-8) a rising axis, tones (9-14) another M-shape, tones (15-16) another rising axis. The two M-shapes are unfolded within the same soundspace, a minor third.

In the following section of the series, tones (12-22) constitute a W-shape, tones (23-24) an axis, tones (25-30) an M-shape, tones (31-32) an axis. The W-shape and the M-shape are unfolded within the same soundspace, a fourth interval. The succession of shapes and axes in the two sections together is

M / M / W / M /

An identical distribution of shapes and axes can be observed in the continuation of the series, tones (33-64).

Self-reproduction

In the contour graph of the basic series, every fourth tone is marked by a circle. The succession of these tones constitute a reproduction of the basic series. This new series is notated above, marked (4). It is four times slower, and it is transposed one whole tone, from G4 to A4. The graph displays the contours of the new series. The characteristic M-shapes, axes and intervals of the basic series are recognized here.

The process of self-reproduction continues. In the contour graph of series (4), the tones 16, 32, 48 and 64 are marked by an extra circle. These tones constitute the beginning of a new series, notated above the graph. It is 16 times slower than the basic series, and it is transposed another whole tone upwards, from A4 to B4.

The infinity series is an early example of a fractal form, that is, a form which mirrors and reproduces its own shapes and structures infinitely in different orders of magnitude. Nørgård actually discovered this series before Benoit Mandelbrot in 1975 coined the term"fractal". (Gleick, 1987)

In the symphony, various versions of the series are brought into play. The first section, *0'03-3'30,* is based on a quarter-tone version of the series, and the main section, *3'30-22'30,* is based on the semitone version described above. Between *17'44* and *22'30,* a third version, evolved from the interval of a fourth, is superimposed on the semitone series.

In the main section of the symphony, six tempo layers of the semitone series are brought into play. The flutes play the basic series (1) in a continuous stream of pulse and melody. Horn, woodwinds, strings and harp play melodic shapes and fragments related to the tempo layers of series (4) and (16) or created by the selection of particular tones of the basic series heard in the flutes. In this multi-layered melodic flow, waves of timbral-harmonic colors appear and disappear, emerging from the variable interval patterns of the series.

Ex. VII-IV shows the beginning of the main section of the symphony. The flow of tempo layers begins on tone 256 of the semitone series, so the first part of the series is omitted. Tone 256 is Eb5. This tone is played distinctly by a trumpet at *3'30* as a signal which releases the flow of pulse and melody.

The three slowest tempo layers are accentuated by the solo trumpet, a group of percussive instruments and the brass section.

The *solo trumpet* plays the 64 times slower series. These trumpet tones stand out as landmarks in the symphony, appearing approximately every 20th second, corresponding to 8 measures of the score. The Eb5 heard at *3'30* is tone no. 4 of the trumpet series, identical with tone no. 256 of the basic series.

The 256 times slower series is heard as a succession of instrumental outbursts, played by a group of instruments with percussive attack and salient timbre, chimes, vibraphone and piano, plus the distinct plucked sound of harp and the sustained sound of electric organ. The outbursts occur approximately every 80th second, corresponding to 32 measures of the score.

Released by a trumpet tone, the instruments continue playing for a while and then fade away, like a kind of long reverberation of the trumpet. The impression of reverberation is several times reinforced by a noise-like sound of strings playing molto vibrato, or by pizzicato pulse patterns.

The slowest tempo layer, the 1024 times slower series, is constituted by a succession of screens, appearing four times in the symphony. A screen is heard as a pulsating pattern of loud trumpets and trombones, which stands out in front of the flow of other instruments. These instruments are not completely drowned out, but heard more or less clearly through the screen. The sharp timbres of the trumpets and trombones accentuate a large interval created by the expansion of the series. These intervals are indicated in *Ex. VII-VI.* The first screen accentuates tones (1023-24), the second screen tones (2047-48), and the last screen tones (4095-96). The notation of the last screen is shown in *Ex. VII-V.* The screens are the great events in the symphony, celebrating the points of expansion of the basic series. The composer takes the liberty of inserting an extra screen which accentuates tones (3071-72), even if this it not a point of expansion. By this addition, the large gap between tones 2048 and 4096 is bridged in the middle.

The timing of the tempo layers in relation to the recording is indicated in table form in *Fig. 7.5.*

Time of recording	*Score measure*	*Basic series no.*	*Trumpet series no.*	*Outburst series no.*	*Screen no.*	*Screen Tones*
3'30	58	256	4	1		
4'53	90	512	8	2		
6'18	122	768	12	3		
7'42	154	1024	16	4	1	Bb3-F5
9'00	186	1280	20	5		
10'19	218	1536	24	6		
11'39	250	1792	28	7		
12'55	282	2048	32	8	2	A3-F#5
14'08	314	2304	36	9		
15'22	346	2560	40	10		
16'34	378	2816	44	11		
17'44	410	3072	48	12	3	B3-E5
18'49	442	3328	52	13		
19'57	474	3584	56	14		
21'04	506	3840	60	15		
22'10	538	4096	64	16	4	Ab3-G5

Fig. 7.5. The first tone in the main section of the symphony is tone no. 256 of the basic series. The trumpet series is 64 times slower, the outburst series 256 times slower, and the screen series 1024 times slower.

The relation between the three slowest tempo layers and the total sound-space of the main section of the symphony is shown in *Graph VII-VIII.*

The slow tempo layers of Nørgård's Second Symphony, Graph VII-VIII

The *trumpet series* is drawn in the middle of the graph, displaying its characteristic distibution of M-shapes, axes and W-shapes.

Every fourth tone of the trumpet series is marked by a circle. These tones constitute the *outburst series,* accentuated by a group of percussive instruments including the vibraphone. The vibraphone plays the tones of the series in octave doubling, shown in the upper part of the graph. The timing of the outbursts in the recording is indicated on top of the diagram.

The tones of the *screen series* are identical to tones 1024, 2048 and 4096 of the basic series. These tones are marked by a radiation symbol in the trumpet series. Tone 3072, where an additional screen is inserted, is marked in the same way. The screens are celebrations of the appearance of the intervals Bb3 - F5 between tones (1023-24), A3 - F#5 between tones (2047-48) and finally Ab3 - G5 between tones (4095-96). The lower tones of these intervals are played by the trombones, marked by a radiation symbol in the lower part of the graph.

Each screen is expanded to a duration of approximately one minute. Screen 1 is heard *7'42-8'40,* Screen 2 *12'55-13'50,* the inserted Screen 3 *17'44-18'14,* preceded by loud brass accents beginning at *17'17.* The final screen is of shorter duration, but its expansion is prepared for a long time.

The final screen of Nørgård's Second symphony, Graph VII-VIII

The final expansion is prepared earlier in the symphony by the appearance of high-register tones and melodies in the flutes and piccolos, first time at *7'42.* In the upper part of the graph, the high tones of the flutes are indicated by black dots At *17'44,* the piccolos reach the top tone A7 of the symphony, and they take part in the pulsating rhythms of Screen 3, playing a shrill E7.

The appearance of the final screen extends the range of the total soundspace to El-Ab7, six octaves plus a minor third. The space is filled by the interactions of instrumental timbres. Penetrating piccolos are on top, playing rhythm patterns on G7, interfering with Ab7. Oboes and clarinets play G6, trumpets C6, oboes and clarinets G5, violins and violas play the interferent sustained tones Ab4 and G4, and the trombones accentuate Ab3, which is the low tone of the screen interval. At the bottom, the double basses take a dive from C3 down to the rumbling sound of the deep E1. The cellos contribute with C2, played with hard-pressure bow-scraping.

The final expansion is fulfilling and yet surprising. It is prepared by the preceding noisy screens, the high entrances of flutes, the slow and gradual expansion of the layers of the series, and numerous occurrences of tension and relaxation. But the deep dive of the low strings is a surprise. The low registers have been left untouched until now, except for a few bell tones. All of a sudden they are filled. Simultaneously, the noisy brasses and woodwinds draw the attention towards the high registers. Competing powers pull in different directions.

At this point, emotional response is released. The wide expansion of a total soundspace filled with vibration, the accumulation of expectation throughout the symphony and the coincidence of fulfilment and surprise call forth a strong emotional experience in mind and body. The sound of the virtual musical timespace arouses the experience of a vibrating bodyspace.

The soundspace is a multi-layered pattern of timbres

In Nørgård's symphony, the movement and pulse of the soundstreams and the appearance and disappearance of different instruments create patterns of tones, harmonic colors and noise, change and regularity, density and transparence, coherence and interruption, order and disorder. All these patterns are created by streams, layers and impulses of timbre. The totality of the timbral patterns constitutes the total soundspace of the music.

The relations between different streams and layers of timbre in the soundspace can be described as *segregation and fusion, interaction and permeation.*

In Nørgård's symphony, segregation of streams of instrumental timbre provides the basis for the simultaneous perception of different tempo layers. Fusion of timbres are heard in the emerging and disappearing timbral-harmonic colors. Permeation occurs when a screen of brass instruments and streams of other kinds of timbre are heard simultaneously through each other. Interactions of timbres are heard in the vibrating sound mass of the final screen.

Further examples of segregation, fusion, interaction and permeation are found in works discussed in the previous chapters.

Segregation of streams and layers of timbre is a predominant feature in all kinds of symphonic music and chamber music. In Beethoven's *Eroica,* one example is the second theme, played by the wind instruments one by one. The instruments are clearly distinguished from each other and from the background of strings. *In The Unanswered Question,* the distinct trumpet timbre is segregated from the diffuse background of strings.

Fusion of many instrumental timbres create massed timbral qualities in *Eroica* and in Xenakis' *Pithoprakta.*

Permeation of timbres is heard in the *Eroica* symphony when flute, clarinet and horn play the main theme in octave doublings. In Ligeti's *Atmospheres,* layers of wind timbres and string timbres permeate each other, creating the impression of luminosity.

Interactions between streams of timbre are heard in the fluctuating wave patterns arising in Ligeti's *Continuum* and *Atmospheres* and in Lutoslawski's *Livre pour orchestre.*

The total soundspace of music consists of streams, layers and impulses of timbre superimposed on each other. The superimposition results in microtemporal and macrotemporal patterns of change and regularity, density and transparence, continuity and discontinuity.

8

Micromodulation

Micromodulation is the ninth listening dimension

In the previous chapters, eight listening dimensions have been discussed, the five basic dimensions intensity, movement, timbre, pitch height and pulse, and the three secondary dimensions rhythm, melody and harmony which arise from the interactions of basic dimensions. The relationships between these dimensions are shown in the model *Fig. 6.5*.

The remaining open field in the model represents *micromodulation.* Micromodulation arises from the interaction between timbre and pulsation. Examples of micromodulation are vibrato, tremolo and flutter-tongue.

Vibrato is a micromodulation of timbre arising from a pulsating variation of intensity and pitch focusing in the timbral spectrum. The pulse pattern interacting with timbre may be fast or slow, regular or irregular, resulting in different shadings of vibrato.

Tremolo is a micromodulation of timbre arising from pulsating variation of intensity and attack quality. The flutter-tongue playing of wind instruments is a specific kind of tremolo, produced by the transformation of a continuous stream of timbre into a rapid succession of attacks.

Interference is a particular kind of micromodulation, arising when two pitch-focused timbral spectra interact with each other, producing pulsating interference beats or a focusing at an emergent pitch.

Musical effects related to vibrato, tremolo and interference are trills, glissando and pitch bending. Complex and irregular forms of micromodulation are fluctuation, shimmering and distortion and the noise-like timbral qualities produced by special ways of playing such as the collegno and sul ponticello effects of stringed instruments.

In the model *Fig. 8.1,* Micromodulation is included as the ninth listening dimension.

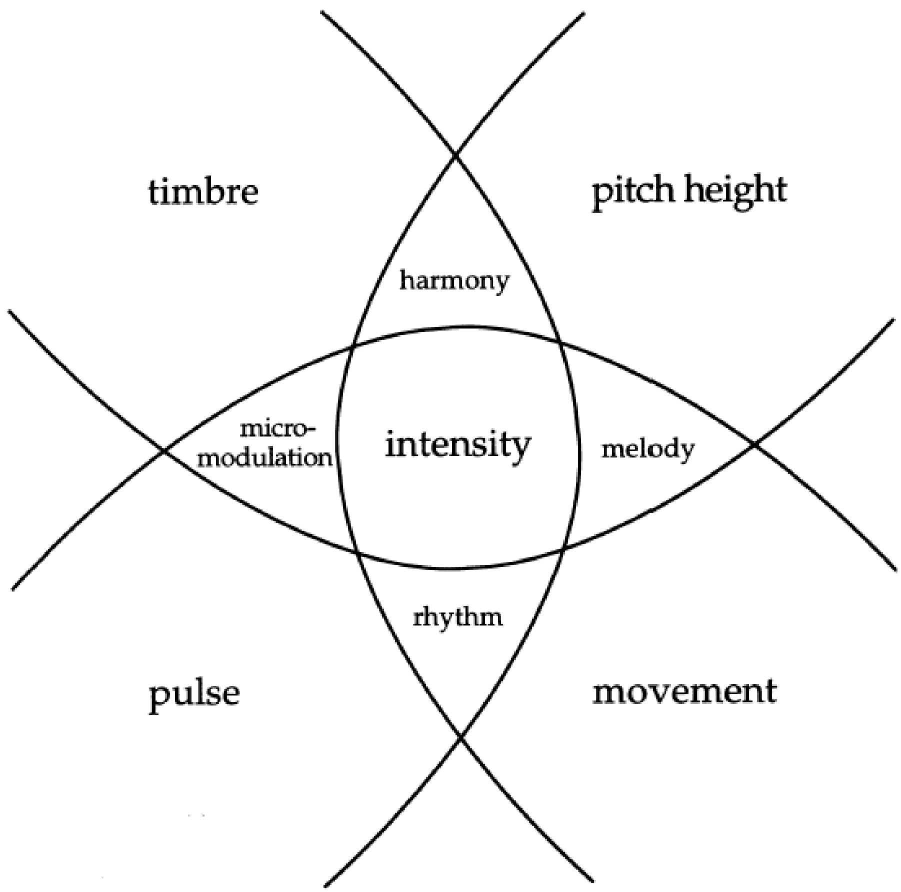


Fig. 8.1. Nine listening dimensions

Vibrato, tremolo, interference, distortion

Various kinds of micromodulation are heard in the music of Xenakis, Ligeti, Langgaard, Nørgård, Coleman Hawkins, Sepultura and Beethoven discussed in the previous chapters. Some examples are the following;

In Nørgård's *Second Symphony,* the obtrusive sound of vibrating *interference* appears at *1'41-2'10.* Another kind of micromodulated sound is produced by violas and cellos playing *sul ponticello 3'26-3'30,* preceding the trumpet tone which releases the pulsating stream of the flutes. *At 4'45-5'00,* the string group produces a characteristic sizzling sound by playing *molto vibrato,* adding a reverberation-like continuation to a trumpet tone. Noisy *flutter-tongue* of brasses and woodwinds is heard at *15'41-16'34,* combined with the string tremolo accents. *Distortion* is heard in the brassy sounds of cuivré horns and accentuated trombones beginning at *17'17,* continued by the sharp sound quality of the screen of trumpets and trombones at *17'42.*

In Lutoslawski's *Livre pour Orchestre,* interference arising in polyphonic glissandi and bundles of gliding quarter-tones create impressions of fluctuating sound color and multidimensional motion. In Ligeti's *Continuum,* fluctuating harmonic colors emerge from the micromodulating interaction of timbre and pulse.

String *tremolo* is heard as a space-filling quality in Beethoven's *Eroica* at *0'50-1'00* in the recording, measures 37-44. In Langgaard's *The Music of the Spheres,* tremolo is the foremost agent in creating the vibrating, space-filling sheets of sound heard as the beginning of the work, *0'00-1'52* in the recording. A slow micromodulation is heard in the deep timpani rolls below the tremolo strings.

A section of Xenakis' *Metastasis, 1'37-2'18 m* the recording, is characterized by eruptions of penetrating noise. Several kinds of micromodulation are heard here, *tremolo, noise-colored tone* produced by strings playing near the bridge of the instrument, *flutter-tongue* and quarter-tone *pitch bending.* The corresponding score page is reproduced as *Ex. VIII-I.*

Metastasis, 1'37-2'18, Ex. VIII-I

During the whole passage, the strings play tremolo, alternating between subito piano (measures 58, 64, 68 and *77)* and subito forte fortissimo (measures 59, 65, 69 and *77).* The *fff* passages are played sul ponticello, near the bridge. The trombones add deep noisy timbre from measure 60 and glissandi from measure 69. Trumpets enter in measure 73 with sharp flutter-tongue tones; in measure *77* the horns join in, first horn playing loud quarter-tone pitch bendings, second horn playing flutter-tongue.

The resulting sound is rich, complex and multilayered, strong and penetrating. This eruption of noise is related to a personal war memory of Xenakis;

> Athens - an anti-nazi manifestation - hundreds of thousands of people droning out a slogan which is repeated in the shape of a gigantic rhythm. Then, the fight against the enemy. The rhythm is splintered in an enormous chaos of high penetrating sounds; whistling of bullets; crackling of machine guns. The sounds begin to rarify. Little by little, silence redescends on the city. (Xenakis/Matossian, 1981)

In *Metastasis,* micromodulation is employed to convey sensations of violence and disturbance. Related effects are heard in the music of Sepultura;

Territory

In Sepultura's *Territory, distortion* is a prominent quality, heard in screens of noise *0'07-0'37, 0'39-0'50* and *1'04-1'16,* pulsating noise *1'23-1'35,* another screen *1'48-1'53* and rhytmic shapes of noise *1'54-2'55.* The text is throughout performed with distorted voice midway between singing, shouting and growling. A guitar plays screaming interferent sound *3'08-3'14. A scratching* quality of sound is added *4'32-4'44,* concluding the piece.

In this piece, distortion has a double function. It occupies the listener's attention by engaging the full potential of auditory perception, and it signals anger.

Micromodulation conveys emotional expression. In Coleman Hawkins' recording of Body and Soul, described in chapter six, the modulation of the saxophone tone communicates subtly shaded emotion.

Body and Soul, Graph VI-VI

In the contour graph of Hawkins' solo, the vibrato of long tones is indicated by wavy lines.

Hawkins' melodic line is modulated by vibrato, portamento and pitch bending integrated with refined variation and shading of timbre, volume and fullness of tone. Not only the flow and form of melody, its shape, expansion and contraction, but also the quality of every single tone is crucial for Hawkins' musical expression.

The continuous stimulation and maintenance of the listener's attention and awareness is an essential function of micromodulation. In the beginning of Ligeti's *Atmospheres,* the awareness of space-filling sound is maintained by vibrato and interference;

Atmospheres, 0'00-2'14, Ex. V-IV and 2'16-2'50, Ex. VIII-II

> The initial sound mass *0'00-0'48* has a quietly shimmering quality due to the interferences of the chromatic string cluster and superimposed brass chords. At *0'48-1'18* the sustained cluster of violas and cellos is given inner life and suppleness by added vibratos and crescendos. The following tone complex, *V18-2'14* is characterized by a bright, luminous, shimmering quality emerging from the interferences of timbres in chromatic clusters.
>
> A score page of the following section, *2'16-2'50,* is shown in *Ex. VIII-II.* Here, Ligeti literally composes a vibrating sound mass consisting of accelerating patterns of undulating tones. The increasing speed of vibration is directly visible in the score.

Micromodulation is essential for the naturalness of sound

Natural sound is never static. The timbral spectrum of natural sound is a pattern of incessant variation and modulation. In the human voice, the micromodulation by vibrato and tremolo reflects and communicates the emotions and the physical state of the speaking or singing person.

In contrast to natural sound, a fixed spectrum of artificially synthesized timbre which lacks variability does not maintain the awareness of the listener. After a while, a fixed sound spectrum seems uninteresting. The essential difference between fixed and variable spectra of timbre was discovered by John M. Chowning in his experiments with synthesis of timbral spectra by means of frequency modulation in the 1960's and 70's. He states that,

> Many natural sounds seem to have characteristic spectral evolutions which, in addition to providing their "signature", are largely responsible for what we judge to be their lively quality. In contrast, it is largely the fixed proportion spectrum of most synthesized sounds that so readily imparts to the listener the electronic cue and lifeless quality. (Chowning, 1973)

When Chowning tried to imitate the the singing voice by means of electronic synthesis, he found that the impression of the lively quality of the human voice is only achieved if periodic and random vibrato is added to the sound spectrum. (Chowning, 1980). The importance of micromodulation is confirmed by other researchers. Risset and Wessel (1982) conclude that systematic as well as unpredictable variations of the timbral spectrum are essential cues for naturalness. Carterette (1989) states that "jitter and nonlinearity may be at the heart of musical perception. If a sound is too pure it has no musical role."

Micromodulation creates a microspace in the musical macrospace

Besides providing naturalness, micromodulation is a decisive factor for the perceptual fusion of a soundstream and the segregation of simultaneous soundstreams. Mc Adams (1982) has investigated the effects of periodic frequency modulation (vibrato), random frequency modulation (shimmer) and very slow frequency modulation (portamento) as found in inflectional changes in the voice or expressive pitch changes in musical instruments. He concludes that coordinated modulation of spectral components in the form of vibrsto, shimmer or portamento is a strong cue for the fusion of complex tones. Risset (1986) confirms that micromodulations contribute to fusion if they are synchronous, to separation if they are not.

The perceptual fusion of a soundstream by the coordinated micromodulation of its spectral components is essential for the perception of the quality of a particular instrument and the distinction of this instrument from other instruments. The specific micromodulation of timbre in an instrument is the basis for recognition of that instrument, and the particular micromodulation of a human voice is the basis for the recognition of that voice as the voice of one particular individual person.

Micromodulation permits perceptual focusing at one specific sound source and the distinction of that sound source from other sound sources. The specific micromodulated timbre of an instrument permits the separation of the sound of that single instrument from other instruments in an orchestra. The particular micromodulated timbre of a human voice permits the distinction of that single voice in a crowd of talking persons. Micromodulation of timbre creates the microspace of an individual entity within the multiplicity of sound in the total soundspace.

Timbre and micromodulation are microspatial dimensions of the sound-space, focusing the listener's attention on one particular sound source. Pulse is equally a microspatial listening dimension, focusing attention on the regular recurrence of a stream of impulses from a single sound source.

The macrospatial dimensions of the soundspace are movement and pitch height, which evoke the impressions of direction and distance, height and depth in the virtual space.

The relations between microspatial and macrospatial dimensions are shown in the model *Fig. 8.2.*

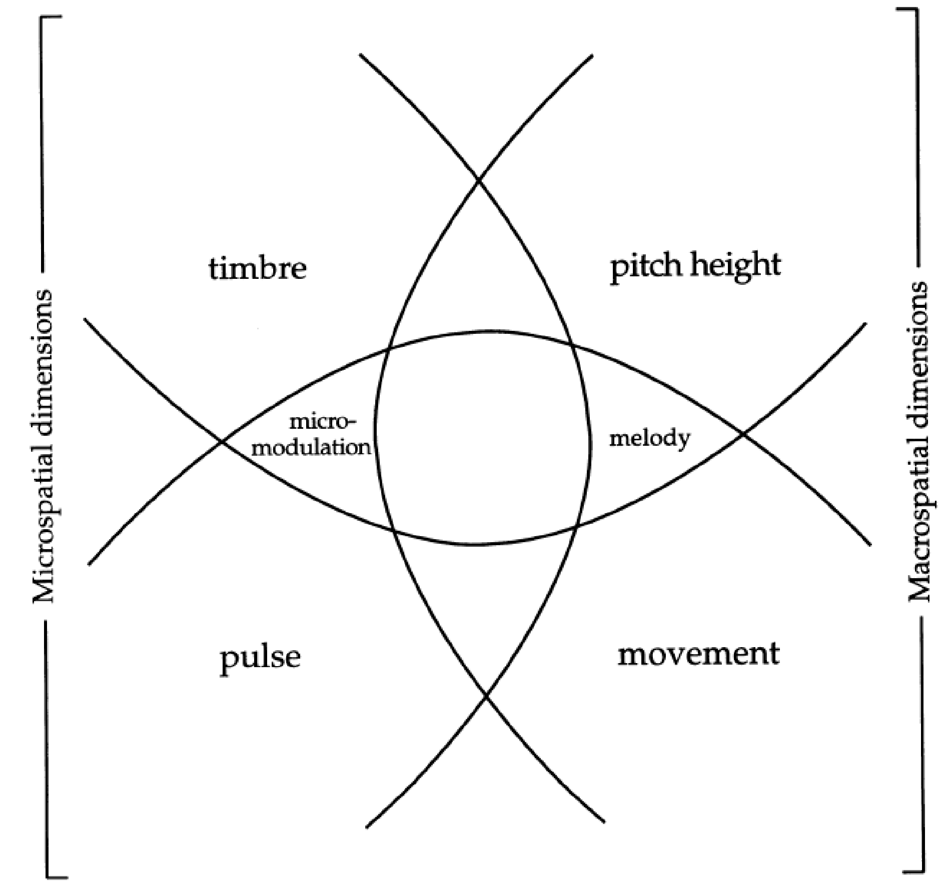


Fig. 8.2. Microspatial and macrospatial dimensions

9

A Model of the Musical Timespace

The virtual musical timespace is evoked by the experience of sequences and patterns of differences in timbre, pitch height, movement and pulse.

Two of these dimensions are microtemporal, timbre and pitch height. Pitch height is segregated from the microtemporal continuum of timbre by a process of perceptual focusing evoked by a pattern of regularity in the timbral spectrum. In the temporal continuum, pitch height represents the experience of *microtemporal regularity,* and timbre represents the experience of *microtemporal change.*

The two dimensions movement and pulse are macrotemporal, evoking the experience of time. Movement represents the experience of *macrotemporal change.* The experience of movement evokes the sensation of goal-directed time and its duration from the beginning to the end of the movement. Pulse represents the experience of *macrotemporal regularity.* The experience of pulse evokes the sensation of continuous regulated time and the durations between subsequent impulses.

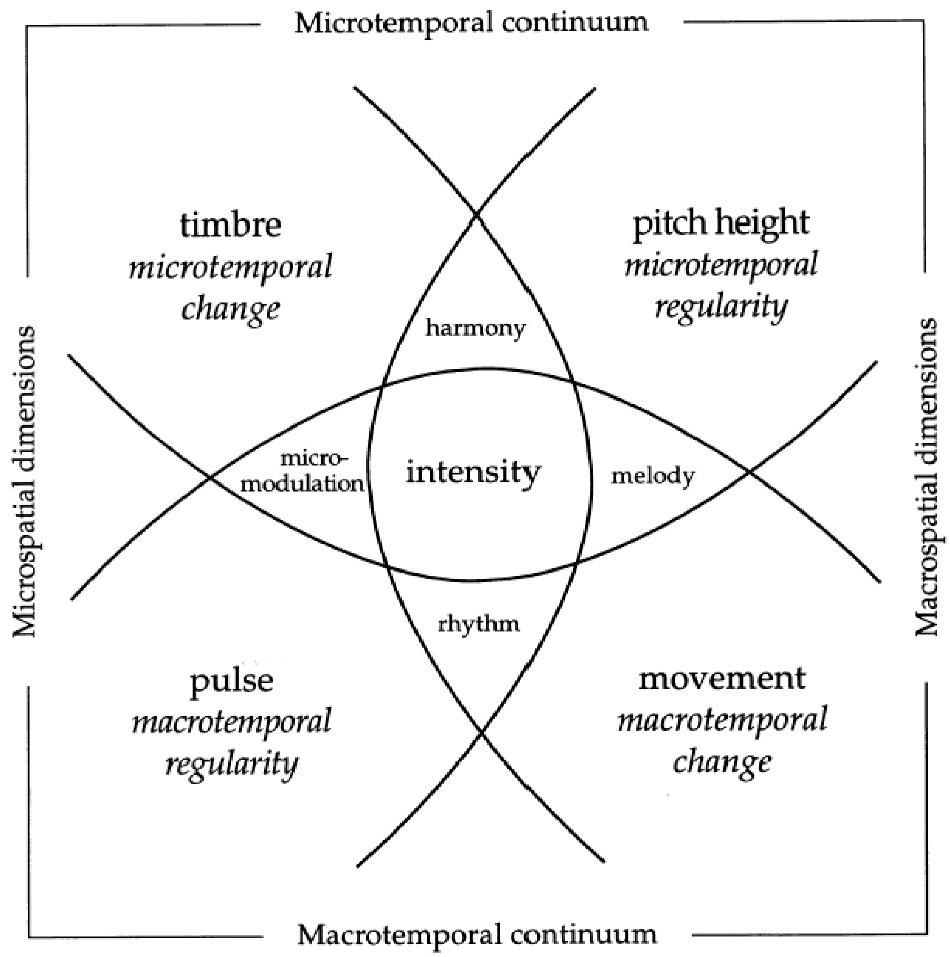
The time of movement and the time of pulse are qualitatively different. They are polarities of the macrotemporal continuum. One polarity is the continuity and regularity of pulse, the other is the change and discontinuity of movement. Between these polarities, patterns of regularity and change, continuity and discontinuity are perceived.

The virtual space of music is evoked as a mental illusion by the sequences and patterns of differences in the microtemporal and macrotemporal dimensions. The impression of a virtual *macrospace* is evoked by the illusion of movement and the experience of a vertical continuum of high and low pitch. The impression of the *microspace* of a single sound source which can be distinguished from other sound sources is evoked by a particular pulsation and micromodulation of timbre.

In the virtual macrospace, relations between different sound sources are perceived as patterns of height and depth, proximity and distance, segregation and fusion, density and transparence.

The origin of the spatial and temporal experience of the virtual musical timespace is the perceptual segregation of the temporal continuum in the four sub-areas of timbre, pitch height, movement and pulse. Each area represents a specific property of the temporal continuum. Timbre is the experience of microtemporal change, and pitch height is the experience of microtemporal regularity. Movement is the experience of macrotemporal change, and pulse is the experience of macrotemporal regularity.

The relations between the microdimensions and the macrodimensions of the musical timespace are shown in *Figure nine.*



Notes

Preface

"What kind of theory will you apply to this music ?" The music in question was the organ work *Nebulosa (1969)* by the Swedish composer Bengt Hambræus. This work deserves a CD recording.

Chapter 1 - The Basic Listening Dimensions

11 Fredens & Fredens (1991) p. 13

13 McAdams (1987) pp. 21-25

16 Music is flux...
Risset (1986) p. 9. Author's translation.

16 Evans (1989) pp. 117-130

17 I cannot unreservedly agree...
Schoenberg (1911). Reprint 1949, p. 503. Author's translation.

19 The sensing of timbre...
Takemitsu (1987) p. 10

19 "The Unity of Musical Time"
Stockhausen (1961) pp. 211-221

Chapter 2 - States, Events and Transformations

23 As to the scandal...
Bois (1967) p. 6

26 Fig. 2.1 is reproduced from Xenakis (1971) p. 3.

27 Fig. 2.2 is reproduced from Xenakis (1971) p. 10.

29 The musical form...
Ligeti (1960b). Reprint in *Melos,* 1967 no. 5 p. 169. Author's translation.

32 As a result of the impasse...
Xenakis (1971) pp. 8-9

35 The use of quarter-tones...
Kaczynski (1972). English edition (1984) pp. 54-55

36 The linear polyphony...
Xenakis (1955) p. 2-4

37 With the serial system...
Bois (1967) p. 16

37 Ligeti (1958) p. 63

37 I composed interlacing patterns...
Ligeti (1971) p. 511-512. Author's translation

Chapter 3 - Space, Time, Flow and Memory

40 Schubert: *An die Musik. (1817).* D. 547 b (Op. 88, No. 4)
Text: Franz von Schober.

42 Because we spontaneously compare...
Ligeti (1966) pp. 23-24. Author's translation.

42 Music is only there...
Maegaard (1966) p. 73. Author's translation.

42 Nørgård (1966) p. 53

43 The capacity of memory structures...
McAdams (1987) pp. 22-23

44 Music is essentially movement...
La Rue (1970) p. 1

Chapter 4 - Time, Space and the Environment

48 The elements of music...
Langer (1953) pp. 104-119

49 Kramer (1988) p. 5

56 Maegaard (1976) p. 85

57 Wellesz (1921) p. 124

57 Through this change of chord color...
Webern (1912) p. 44. Author's translation

57 Deutsch, Max (1980) p. 20

59 In the Music of the Spheres...
Viinholt Nielsen (1993) p. *77.* Author's translation

67 A single concept of timespace...
Seeger (1977) p. 6

Chapter 5 - Timbre, Harmony and Pitch height

69 Bloom & Lazerson (1988) p. 111

69 The original function of hearing...
Risset (1986) p. 16. Author's translation.

70 We get a clue...
Balzano (1986) p. 309

70 The train of waves...
Gibson (1966) p. 81

70 It seems that the transient part...
Xenakis (1971) p. 244

71 Risset and Wessel (1982) pp. 25-58

72 Fig. 5.1 is reproduced from Risset and Wessel (1982) p. 31.

73 Krumhansl (1989) pp. 43-53

73 Donnadieu et al. (1994) p. 311

74 The tone becomes perceptible...
Schoenberg (1911). Reprint 1949, p. 503

74 The sound that we call a "note"...
Seeger (1977) p. 283

74 Risset (1986) p. 16

74 Houtsma (1989) p. 152

74 Roederer (1975) p. 42

74 Rasch and Plomp (1982) pp. 6-7

74 Walker (1991) p. 213

75 Musicians are well acquainted...
Wright and Bregman (1987) p. 64

84 One of the two elements...
Kaczynski (1972). English edition (1984) pp. 40-41

84 Salmenhaara (1969) p. 177

Chapter 6 - Movement, Pulse, Rhythm and Melody

91 Rhythmos appears...
Fraisse (1982) p. 149-150

98 Actual melodies...
Dowling (1978) p. 341

104 The transcription in Fig. 6.7 is quoted from Schuller (1989)
pp. 442-443

108 The characteristic relation between swing and beat...
Wiedemann (1958) p. 81. Author's translation

109 Music's metric frames...
Minsky (1982) p. 10

Chapter 8 - Micromodulation

147 Athens - an anti-nazi manifestation...
Matossian (1981) p. 70. Author's translation.

148 Many natural sounds...
Chowning (1973) p. 526

149 Chowning (1980) p. 10.
Synthesized emulations of female and male voices are heard in Chowning's composition Phoné (1981), issued on CD by Wergo. The CD booklet contains ample information on the early development of frequency modulation as a compositional tool.

149 Risset and Wessel (1982) pp. 42-44

149 Carterette (1989) p. 86

149 McAdams (1982) pp. 279-298

149 Risset (1986) p. 17

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