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MUSIC LISTENING, MUSIC THERAPY, PHENOMENOLOGY AND NEUROSCIENCE

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Dissertation submitted for the Degree of Doctor of Philosophy
Institute of Communication and Psychology
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— Hvad der er Musik for en, er Støj
for en anden — og omvendt.

**What is music for one,
is noise for the other – and vice versa.**

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I dedicate my work to the memory of two friends who were enthusiastic ethnomusicologists, Max Jardow-Pedersen (1940-2009), and Hans Peter Larsen (1946-2009).

Abstract

The thesis investigates music listening, music phenomenology and neuroscience related to music therapy. Parts of a previous publication, *The Musical Timespace*, are included.

Music phenomenology

Criteria for phenomenological investigation are proposed, and the approaches of three important authors in music phenomenology are compared. Thomas Clifton paves the way for the phenomenological exploration of time and space in music. Lawrence Ferrara designs a practical method for phenomenological description. Don Ihde devises ground-breaking methods for the phenomenological investigation of sound.

Music therapy research applies variations of the method proposed by Lawrence Ferrara, in order to permit phenomenological descriptions of music and music therapy sessions.

The philosophy of Don Ihde constitutes a basis for the development of *experimental listening*, a novel method for the phenomenological investigation of music.

The neurosciences and music

The outcome of four international conferences on the neurosciences and music is discussed and validated on the basis of analyses of research procedures and results, and noteworthy studies are highlighted.

The Musical Timespace

In consequence of findings in auditory science, parts of the text in *The Musical Timespace* have been omitted, resulting in a concise version of the book. The concise version represents an investigation of the experienced musical space and the listening dimensions in music. Five musical properties are considered the basic listening dimensions in music; intensity, timbre, pitch, movement and pulse.

Present Moments: A new GIM program

A collaborative research project has resulted in the design of a new program for Guided Imagery and Music Therapy, based on music from the 20th and 21st Centuries by Bartok, Corigliano, Messiaen, Tavener, Pärt and Tormis.

Subcortical and cortical procession of music in the brain

Descriptions of the auditory system in relation to the general brain functions clarify the neural basis for music listening. A novel experiment in neuroimaging, which documents the brain's responses to a complete piece of music, is reported.

Embodiment

Investigations of embodiment in different philosophical and scientific disciplines are reported, including forms of vitality and the effects of neurotransmitters in the brain and the body.

A review of the attempts at establishing *neurophenomenology* as a new research paradigm leads to the conclusion that the integration of the first-person perspective of phenomenology and the third-person perspective of neuroscience remains an unfinished project.

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Chapter 1. Introduction

The present thesis includes parts of a previous publication, *The Musical Timespace* (1996), in accordance with the "senior's model" for PhD theses in Music Therapy Research at Aalborg University. The background of the relationship between this book and music therapy is the following;

The Musical Timespace presented an investigation of the listening dimensions in music. Soon after the publication of the book, Lars Ole Bonde suggested that this investigation might be useful for describing clinical improvisations in music therapy, and invited Inge Nygaard Pedersen and the author to a conversation on that theme. This conversation was published in Danish in *The Nordic Journal of Music Therapy*, in two parts (Bonde 1997a, 1998). The conversation confirmed the relationships between the approach of the book and the experience of space and sound in music therapy improvisations. Included in the conversation were discussions of recorded music therapy improvisations, presented in publications of Gary Ansdell (1995) and Colin Lee (1996). Bonde suggested that *The Musical Timespace* represented an attempt at putting forward "a language for phenomenological description that is as exact as possible, especially in relation to the qualities of sound" (1997a:143).

Reviews of the book by Bigand (1997) and Bonde (1997b) have pointed out certain limitations in its theoretical underpinning, in particular a lack of discussion related to cognitive science and music phenomenology. In order to remedy these limitations, the present thesis presents investigations of neuroscience and music phenomenology in relation to music therapy and the listening dimensions in music.

Chapter two explores the potential of phenomenological description in music listening and music therapy research.

Chapter three reports the outcome of four conferences on the neurosciences and music, and discusses the validity of neuroscientific research.

Chapter four presents a concise version of the author's publication *The Musical Timespace*.

Chapter five describes a project in collaborative research, which resulted in the design of *Present Moments*, a new program for Guided Imagery and Music Therapy.

Chapter six summarizes research that is important for understanding the functions of the auditory system in the brain.

Chapter seven focuses on investigations of embodiment, including body listening, forms of vitality, and the effects of neurotransmitters in the brain and the body.

Chapter eight discusses the results and limitations of the present project, and presents suggestions for future research.

Chapter 2. Music phenomenology: A Tool for Describing the Listening Experience.

Research questions

What are the basic ideas and approaches of phenomenological description of music and sound?

How is music phenomenology rooted in phenomenological philosophy?

How is phenomenological description of music applied in music therapy research?

Can the approaches of experimental phenomenology be applied in music phenomenology?

Introduction

The aim of this chapter is to clarify a basis for the phenomenological description of music as heard, and to elucidate the application of phenomenological music description in music therapy research. The central sources for this investigation are the writings of Thomas Clifton, Lawrence Ferrara and Don Ihde, three scholars who, in very different manners, have yielded important contributions to the field of music phenomenology. Clifton is the enthusiastic investigator, Ferrara the pragmatic researcher, and Ihde the reflecting philosopher. This chapter will present ideas of these three pioneers stated in their early manifestos and later book publications.

The music phenomenologies of Clifton, Ferrara and Ihde are based on the phenomenological philosophies of Edmund Husserl, Martin Heidegger, and Maurice Merleau-Ponty. The second section of this chapter traces the foundations of music phenomenology in major works of these philosophers, notably Heidegger's *Being and Time* and Merleau-Ponty's *Phenomenology of Perception*. No particular work by Husserl is pointed out, as his philosophy branches into many different publications, many of which are posthumous.

For understanding Husserl's concepts, the clarifications of the Danish phenomenology scholar Dan Zahavi and his American colleague Shaun Gallagher have been instructive. The writings of another Danish scholar, Ulla Thøgersen, have served as a useful guide to Merleau-Ponty and phenomenology in general. A main entry to insight in music therapy theory and practice has been the volume on Music Therapy Research edited by Wheeler (2005), in particular the chapters on Phenomenological Inquiry (Forinash and Grocke 2005:321-334), First-Person Research (Bruscia 2005:379-391), and Approaches to Researching Music (Bonde 2005:489-525).

The theme of this chapter is the phenomenological approach to music listening. Adjacent fields of investigation, such as music performance and the application of phenomenological psychology in research interviews¹, are outside the scope of the present text.

2.1 The aim, basis and practice of phenomenology

Phenomenology is a means of discovering unnoticed aspects of the world. Phenomenological inquiry uncovers the wealth and complexity of human experience and provokes the sense of wonder (Merleau-Ponty 2002:XV, Clifton 1983:296, Ihde 2007:203, Thøgersen 2004:32).

Phenomenology is not a finished system, but an evolving practice. The philosopher is a perpetual beginner. Phenomenology is a style of thinking, a special type of reflection, and the means of understanding phenomenology is the practical application of phenomenology (Merleau-Ponty 2002:VIII, XV, Ihde 1977:14, Clifton 1983:18, Varela 1996:335).

¹ Dissertations by Grocke (1999) and Pedersen (2006) present noteworthy applications of phenomenological psychology for the analysis of interviews.

Philosophical basis

Three philosophers have established the philosophical basis preceding and underlying music phenomenology: Edmund Husserl (1859-1938), Martin Heidegger (1889-1976) and Maurice Merleau-Ponty (1908-1961). Husserl presented his phenomenology in *Logische Untersuchungen* (1900-01) and *Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie* (1913). A large number of his manuscripts have been published posthumously. Heidegger was Husserl's assistant, and he dedicated his major work, *Sein und Zeit* (1926)² to his mentor. Merleau-Ponty heard Husserl's lectures in Paris, studied the publications of Husserl and Heidegger, and had access to unpublished manuscripts in the Husserl archives in Belgium. His major work is *Phénoménologie de la perception* (1945).³

Heidegger's and Merleau-Ponty's philosophies are indebted to Husserl's published works as well as his manuscripts, even if they dissociate themselves from some of Husserl's standpoints. Husserl's manuscripts anticipate crucial fields of investigation, such as Heidegger's emphasis on the importance of the lifeworld of the human being, and Merleau-Ponty's emphasis on the centrality of the body. In continuation of Merleau-Ponty's philosophy, Mikel Dufrenne (1910-1995) adds an aesthetic perspective to phenomenology in his *Phénoménologie de l'expérience esthétique* (1953).⁴

Phenomenology investigates the first-person experience of the world. This investigation comprises two inseparable aspects: to describe the world, and to describe the nature and structure of the conscious experience itself. Consciousness is not self-enclosed, it aims toward something, it is open to the world and directed towards its objects and manifestations. The philosophical term for this directness is "intentionality" (Zahavi 2003b:14, Thompson 2007:22).

Phenomenology is not based on introspection, it does not purport the existence of a self-contained inner world (Merleau-Ponty 2002:XII, 66). Gallagher and Zahavi (2008:8) point out that "The phenomenologist studies perception, not as a purely subjective phenomenon, but as it is lived through by a perceiver who is *in the world*, and who is also an embodied agent with motivations and purposes."

Seven basic guidelines for phenomenological investigation are the following:

1. Suspend the natural attitude

The first step of a phenomenological investigation consists of suspending presuppositions about the world. Husserl names the beliefs we take for granted "the natural attitude", and his term for evading them is the Greek word "epoché", which signifies "suspension" or "putting brackets around".

It is a goal of phenomenology to observe the world in an unbiased way in order to achieve a clearer and more precise view of the experienced world (Thøgersen 2004:32, 74). This does not mean that we have to disregard our "natural attitude" completely. On the contrary, we can reflect upon the natural attitude and take a stand on its manifestations. A fundamental assumption pertaining to the natural attitude is the belief in a reality which exists independently of our perception and consciousness. It is a task of phenomenology to perform a critical investigation of this belief, which is deeply rooted in science and daily life (Zahavi 2003b:44).

2. Adopt the phenomenological attitude

The phenomenological attitude implies investigation of phenomena as they appear to conscious-

2 English translation: *Being and Time* (1962)

3 English translation: *Phenomenology of Perception* (1962). Second edition (2002) with a different pagination. The present text refers to the 2002 edition.

4 English translation: *The Phenomenology of Aesthetic Experience* (1973)

ness, the way they appear to consciousness, and the conditions for appearance in consciousness. Husserl coined the maxim "We will go back to the things themselves" (1901:7),⁵ and Heidegger pointed out that a phenomenon is "that which shows itself in itself" (Heidegger 1962:51, Ihde 1977:29).

To go "to the things themselves" does not mean to study things as isolated objects in the world, separated from the the observer's activity. On the contrary, it means to investigate the relationship between the object and the process that allows the appearance of the object in consciousness. Husserl calls this investigation "leading back" to the way the world manifests itself to us, and terms it "phenomenological reduction" (Husserl 1970). Husserl refers to the original meaning of the latin word "re-ducere", to "lead back" (Gallagher & Zahavi 2008:25). It is important to keep this meaning of "reduction" in mind, because it is different from a more current meaning of the word, "to diminish".

In Husserl's terms, the object of experience is called *noema*, the process of experience is called *noesis*, and the phenomenological reduction investigates the correlation between noema and noesis. Directing our consciousness toward the world is an active process, which constitutes the objects in the world. This does not mean that consciousness creates or constructs the object. Nor is conscious experience a passive reception of the object. Constitution is a process which permits the object to appear and present itself. Zahavi clarifies this process with reference to Husserl and Heidegger:

"Constitution must be understood as a process that allows for manifestation and signification, that is, it must be understood as a process that permits that which is constituted to appear, unfold, articulate, and show itself as what it is. As Heidegger was to observe: "'Constituting' does not mean producing in the sense of making and fabricating; it means *letting the entity be seen in its objectivity*." (Zahavi 2003b:73)

The process of constitution discloses a structure of consciousness which can be considered invariant, that is, underlying every kind of conscious perception. Merleau-Ponty states that the main achievement of phenomenology is to establish this unbreakable connection between consciousness and the world, "to have united extreme subjectivism and extreme objectivism" (Merleau-Ponty 2002:XXII, Thøgersen 2004:90). In other words, the distinction between "subject" and "object" taken for granted in the natural attitude is suspended in the phenomenological attitude.

3. Perform phenomenological variations

It is the aim of phenomenology to describe how the phenomena appear to consciousness, not to explain them. The way to an adequate description is to observe the phenomenon again and again until it discloses its essential features. The appropriate method is "phenomenological variation" (Ihde 1976:29-32, 1977:34-35, Thøgersen 2004:76). Husserl proposed the use of "free imaginary variation" to distinguish between accidental and essential properties of an object. However, he did not establish this approach as a proper method, and it cannot be considered a truly distinctive feature of his phenomenology (Zahavi 2003b:39, Ferrara 1991:66).

An operational approach is the method of perceptual variation (Merleau-Ponty 2002:268-271, Ihde 1976:30-31). In visual perception, it is an easy task to perform variations by changing the angle of observation or changing the visual focus from an object to a background. Similarly, in auditory perception it is possible to change focus from a sounding object to the background of environmental sound.

Perceptual variation reveals an invariant structure of consciousness, which underlies every kind of perception, the relationship between focus and fringe, or center and periphery (Ihde 1976:37-39). It is possible to perform perceptual variations in any music listening situation, including the unique event of a live performance. However, elaborate description of music as heard requires repeated listening to recorded music.

5 "Wir wollen auf die 'Sachen selbst' zurückgehen." Husserl: *Logische Untersuchungen Zweiter Theil* (1901), p. 7.

4. Aim at intersubjective corroboration

Phenomenological inquiry is not confined to the experience of one individual. According to Heidegger, the understanding of being in the world implies the understanding of others (1962:161). It is Merleau-Ponty's stance that a personal existence resumes a prepersonal tradition (2002:296). Phenomenological description invites and requires intersubjective comparison and corroboration (Gallagher and Zahavi 2008:28). Phenomenological investigation is destined for others through intersubjective validation (Varela 1996:339).

Ihde's phenomenological approach involves intersubjective research and classroom investigation (1976:xix, 33, 1977:69-74). According to Ihde, "it remains important that all variations be checked and cross-checked and not taken in their first and most superficial sense" (1976:33).

5. Explore time-consciousness

When we perceive events in the world, we do not perceive each event as an isolated "now", but as part of a continuation within a field of presence. We hear a melody as a continuity, where each tone is connected to the previous tones, and connected to the succeeding tones. In the field of presence, we experience a "now" in relation to the "now" that has just been, and the "now" which will immediately appear. Husserl describes the consciousness of the just-past as *retention* and the consciousness of the upcoming future as *protention*. The field of presence is a continuum which is constantly modified, as each "now" is changed into a past (Husserl 1964:49-50, 62, 76-79).⁶

The structure protention - perception - retention is an invariant structure of consciousness underlying the generation of a field of lived presence (Gallagher & Zahavi 2008:78). Merleau-Ponty directly states that consciousness constitutes time (2002:481). In the perception of sound and music, it is possible to perform temporal phenomenological variations by directing the focus of attention towards the beginning of the sound, the full sonorous quality, or the running-off of the sound (Ihde 2007:108). Similarly, it is possible to vary one's field of observation from the narrow focus on a single tone to a broad or wide temporal focus, which encompasses larger segments of the musical course.

Phenomenological investigation does not exclude verification by means of printed scores. Clifton (1983) supports and documents his phenomenological observations with numerous score excerpts, and Ferrara develops a method for analyzing the "sound-in-time", which implies accurate score references (1991:206-216). However, as Lochhead has pointed out (2006a: 68-70), the primary function of musical notation is prescriptive, not descriptive. The score is a "recipe" for performance, and it serves to define a musical work apart from its performances. For the phenomenological description of music, listening is the primary source. Additionally, score reading can enhance the listening experience by clarifying musical details, visualizing simultaneous layers of the music, and facilitating the overview of the musical form.

6. Include the lifeworld as the prerequisite for phenomenological investigation

Consciousness is not separated from the world. As conscious beings, we are already in the world, and the others are already there with us. For Heidegger, this implies that the fundamental philosophical task is to clarify the meaning of being in the world. Consequently, he coins the term "Dasein", "being-there", for a human being (Heidegger 1962:31-32, 152). Dasein is already situated in a social, cultural and historical situation, participating and acting in a field of signification, and thus phenome-

⁶ Husserl gave his lectures on the phenomenology of internal time-consciousness 1904-10, and they were published by Heidegger in 1928 (Husserl 1928/1964).

In *The Concept of Nature* (1920), The philosopher Alfred N. Whitehead (1861-1947) proposed a similar description of the temporal field, concluding: "What we perceive as present is the vivid fringe of memory tinged with anticipation." (Whitehead 1920/2004:73).

In *Principles of Psychology* (1890), the psychologist William James (1842-1910) discussed the concept of "the specious present", indicating that the "now" we perceive as present includes a small but extended interval of time. (Anderson & Grush 2009:278).

nological investigation is inevitably interpretation (Heidegger 1962:62, 191. Merleau-Ponty 2002:IX-XII, 162, Ihde 1976:20, Zahavi 2003a:36-37).

Conducting a phenomenological exploration, the investigator has to inquire his own lifeworld critically. Husserl called for the suspension of presuppositions and paved the way for exploration of essence, structure and presence. But an absolutely pure experience is not possible. The investigator's lifeworld is the basis for pre-understanding, and experience and description can never be completely segregated from the lifeworld (Ferrara 1991:34). Heidegger's approach invites further investigation of existence, culture and history. It invites hermeneutical inquiry by means of variation of the object's context, reflections on the investigator's lifeworld, and intersubjective validation and corroboration.

7. Regard the body as the origin and enduring basis for phenomenological investigation

Consciousness is not separated from the body. Husserl pointed out that the body is involved in all conscious functions, and Heidegger and Merleau-Ponty adopted this fundamental idea, with which they were familiar from the manuscript of Husserl's second book of *Ideas*, which was published posthumously (Husserl 1989:XV-XVI, 160-61, Heidegger 1962:143). Heidegger acknowledges that Dasein is a bodily being, but avoids thematizing its bodily basis (Zahavi 2003a:69, Thøgersen 2004:136). This thematization is Merleau-Ponty's extensive project. "The body is our general medium for having a world" is Merleau-Ponty's fundamental statement (2002:169). The body is the basis for perception:

"Our own body is in the world as the heart is in the organism: it keeps the visible spectacle constantly alive, it breathes life into it and sustains it inwardly, and with it forms a system." (2002:235).

The body is the basis for action, and for understanding space (2002:291-295), and bodily experience imposes meaning in the cultural world (2002:169-170, Thøgersen 2004:122-131, Matthews 2006:50-53). Dufrenne states, in his discussion of music:

"It is primarily our body that is moved by rhythm and that resonates with harmony. (...) The body is the always already established system of equivalences and intersensory transpositions. It is for the body that unity is given before diversity" (1973:339).

Evan Thompson, in his book *Mind in Life*, spells out the gist of Merleau-Ponty's philosophy: "The brain is an organ, not an organism, and it is the organism, animal, or person that has conscious access to the world" (2007:242).

In music listening, one is inevitably aware of the music's immediate bodily impact in the form of emotional response and bodily entrainment. For phenomenological investigation, it is a task and a challenge to describe the primary bodily reactions to music and to reflect on these reactions as part of the natural attitude. Furthermore, it is important to explore the effects of repeated listening and the effects of different contexts, and to survey and assess the varieties of experience due to cultural and intersubjective differences.

2.2 Phenomenological description of music

Music Phenomenology has a history of more than a hundred years. In the beginning of the 20th century, publications and academic discussions regarding music phenomenology were abundant in Germany. Noteworthy scholars were Paul Bekker, Ernst Kurth, Hans Mersmann and Roman Ingarden (Grüny 2008, 2010). Later in the century, studies by Alfred Schutz and F. Joseph Smith clarified the

theoretical foundations of music phenomenology, with reference to Husserl and Heidegger (Schutz 1944/1976, Smith 1976, 1979).

In the United States, a tendency to bring phenomenology into musicology arose as a noteworthy current in the 1960's and 70's, stimulated by the publication of the English translations of Heidegger's *Being and Time* (1962) and Merleau-Ponty's *Phenomenology of Perception* (1962). University professors Don Ihde, Thomas Clifton, and Lawrence Ferrara encouraged their students to integrate phenomenological thought in their analytical studies, and inspired a considerable number of PhD dissertations, as documented by Ferrara (1991:154-168) and Mazzoni & Miraglia (1995:315-319). Composer James Tenney and musicologist Judy Lochhead applied phenomenological approaches in elaborate studies of 20th century music (Tenney 1964, 1977, Lochhead 1982, 1986).

Notwithstanding the merit of these studies, a discussion of their themes is beyond the limits of the present investigation. The following pages will centre on the ideas of Don Ihde, Thomas Clifton, and Lawrence Ferrara, whose publications constitute a basis for the phenomenological description of music and sound.

2.2.1. Don Ihde (1970): "Listening" and "Auditory Imagination"⁷

In his article "Listening", Don Ihde presents a policy statement for establishing a phenomenology of music. The aim of the phenomenological investigation is to reveal unnoticed aspects of the musical experience. For this purpose, Ihde prescribes to suspend the "natural attitude" of listening to music, replacing it with a "phenomenological attitude". This implies that focused attention on the music must replace personal and traditional routines for listening. A means for achieving this is to ask directive questions to the musical experience. Here, Ihde follows Husserl's claim that the phenomenologist must reconsider his habitual or learned presuppositions. Further, Ihde recommends that the Husserl-inspired focusing should be followed by a Heidegger-inspired process, letting the phenomenon "show itself in itself" by gradually excluding irrelevant factors (Ihde 2007:217-218, Heidegger 1962:51).

Visual imagery

Ihde is aware that the traditional description of music is dominated by visual metaphors and spatial terms such as "movements", "up" or "high" and "down" or "low", and he discusses the possibility of abandoning visual metaphors. However, in his initial investigations he found that "a rearrangement of spatial considerations helped to point out unnoticed characteristics" (p. 220), and concludes that the visual-spatial imagery cannot be completely rejected in the phenomenological description of music.

Movement and silence

According to Ihde, music's "movement" is not equal to movement in the surrounding space. Music's mode of presence is different. Searching for the characteristics of music's presence, Ihde notes the *fragility* of the musical phenomenon. He notices that focusing on the music produces an increasing openness to distracting sounds in the environment as well. This is evident in the concert hall, where coughing and scratching disturbs the music, and the attentive listener wishes for quietness. Ihde describes the auditory focusing as a "gesturing toward the sound", and the wish for quietness as an enhanced attentive focusing which is "a gesture toward silence" (p. 222). This implies that attentive listeners become aware that the possibility of silence is the background for music. Sounds appear out of silence and disappear into silence.

Ihde notes another prominent feature in music listening, the ability to be aware of just-past sounds and to anticipate expected sounds. In the listening process, the listener is aware of the "coming into

⁷ "Listening" was first published in 1970 as a journal article. "Auditory Imagination" was first published in 1970 as a book chapter. Both were reprinted as book chapters in Ihde: *Sense and Significance* (1973), and subsequently in the second edition of Ihde: *Listening and Voice* (2007:217-223 and 203-215).

being” and the ”passing from being” of musical sounds. Ihde comments, not without enthusiasm:

”Through the creation of music humans can manipulate the mysteries of being and becoming, of actuality and potentiality, and through the vehicle of music they can legislate the schedule of a phenomenon’s passage from its total being to its absolute annihilation” (p. 223).⁸

The auditory field

In ”Auditory Imagination”, Ihde presents further perspectives of listening. The directional focus of consciousness displays a structure of *core* and *fringe*, or *focus* and *field*. We may focus on one instrument in a symphony, in which case it constitutes the *core* or foreground of the experience, while the other instruments become *fringe* or background, or we may expand our focus to the totality of orchestral sound. The listener can vary his focus in order to investigate different aspects of the auditory field, thus performing perceptual variations. However, it takes an effort to expand one’s focus toward the total field, because the directional focus on the core has a tendency to obscure the awareness of the field.

The auditory field is different from the visual field. It surrounds the listener, contrary to the visual field, which remains in front of the spectator. The listener is immersed in the auditory field that displays no definite boundaries. Sound surrounds the listener, and simultaneously appears to invade his body and consciousness (2007:205-207).

2.2.2. Don Ihde (1976): *Listening and Voice*

Ihde’s 1976 book is an elaborate reflection on the phenomenological investigations he performed for a number of years. He maintains the original text and pagination of the book unaltered in the enlarged second edition (2007).

Phenomenological variations

According to Ihde, the first aim of phenomenology is to recover and appreciate the fullness and richness and complexity of sensory experience (pp. 13, 20-21). This is achieved by *doing* phenomenology, that is, conducting phenomenological variations of the experience. The whole book is a guide to performing phenomenological variations. In this process, intersubjective verification is important. Ihde emphasizes: ”In every case the use of the stylistic ”I can ----“ in this book has been checked against the experience of others” (p. 31)

Global experience

It is an essential prerequisite for Ihde that the unity of the senses is primordial, and experience is bodily and global. Ihde argues that the isolation of the senses is a belief sedimented in tradition and reinforced by empirical science. Practicing auditory phenomenology does not isolate the sense of hearing. It represents a relative focus on a dimension of global experience (p. 43-45, 61). Sound and music permeate and engage the experiencing body. We hear not only with our ears, the sound also reverberates in our bones and stomach, and the movements and rhythms of music enliven the body (p. 81, 155-156).

Auditory awareness

Ihde’s listening project encompasses all kinds of sounds in the world. His point of departure is the

⁸ Ihde’s comment corresponds to a recent statement by a creative Danish musician, the pianist Carsten Dahl: ”When you strike a tone, it is surrounded by something. An initiative. And a silence. By *space*. What *ignites* the tone is important: The silence surrounding the actual action.” (Carsten Dahl interviewed by Peter Nicolai Christensen in the Danish newspaper *Politiken* January 15, 2012). Original text: ”Når du tager en tone, er den omgivet af noget. Et initiativ. Og en stilhed. Af *space*. Det er dét, der er vigtigt. Det, der *antænder* tonen. Stilheden uden om selve aktionen.”

everyday awareness of the sounds of things. The sounds of things capture our attention, and we can discriminate and identify different sound sources with great accuracy. By knocking or striking objects, we can distinguish metal, glass, wood, ceramics, plastic, hollow barrels, massive logs, thin or thick walls. Striking an object reveals its material and size, solidity or hollowness. And listening can reveal shapes, surfaces and interiors. A pair of dice rattled in a box sound different from a pair of marbles. High heels on hard tiles or the creaking of a door reveal the meeting of two surfaces. Clapping, shouting and talking evoke impressions of the size, walls and interior of a room. (pp. 7, 60-61, 67-73).

First and second phenomenology

Ihde distinguishes between a first phenomenology based on Husserl and a second phenomenology related to Heidegger. "The phenomenology of essence, structure, and presence in Husserl leads to the phenomenology of existence, history, and the hermeneutical in Heidegger" (p. 20).

First phenomenology is a philosophy of presence. It aims at grasping "the things themselves", uncovering and describing the structures and essential possibilities which appear in the experience of perception (pp. 19, 25-26). For this aim, we have to get rid of our presuppositions by suspending our everyday beliefs of the nature of the object in question, according to Husserl's claim for "epoché" (p. 28). When the object is music, this calls for directed attention on unnoticed shapes and structures of musical sound by repeated listening, alongside with observation and description of the act of experience, the way the listener perceives the music. Feelings and mood are not excluded from the description. The crucial interest of first phenomenology is the relationship between the object which is experienced and the consciousness that apprehends the object. This relationship is a process, not a fixed connection (pp. 35-40).

Ihde points out that second phenomenology continues where first phenomenology leaves off. Second phenomenology is a hermeneutical phenomenology, which adds the perspective that experience cannot be considered in isolation. Experience must be understood and interpreted in relation to its historical and cultural context. In *Being and Time*, Heidegger states that "the meaning of phenomenological description as a method lies in *interpretation*" (1962:61, italics in the original).

Horizon

Another important prerequisite for Ihde's inquiry into the existential possibilities of auditory experience is Heidegger's consideration of the horizon, the border between the presence and absence of perception (Heidegger 1966:72-73). Awareness of the horizon is crucial for Ihde's investigation of the perceptual fields.

The visual field and the auditory field are "openings" to the world. Both fields display the structure of core, periphery and horizon. If you focus on a thing with your eyes, you are aware of a more indistinct field of other things around the focus, and if you direct your attention towards the fringe of your visual field, you discover its horizon, the blurred, roundish limit of visual perception. If you move your head, the horizon moves as well. You cannot perceive anything beyond the horizon, but you can remember or imagine what is there (p. 37-39).

The auditory field does not display the limits of the visual field, it is omnidirectional. The auditory field surrounds your body, you can hear sound sources which you cannot see, in front or behind, above or below your body. But, like vision, hearing focuses on a core sound which is embedded in a more peripheral field of other sounds. And the horizon of the auditory field is the limit where you hear nothing more. Silence appears at the horizon of sound (pp. 107-111, 165).

In everyday life, the experience of absolute silence is impossible or very rare, but we can experience silence at the horizon of sound, when a sound gradually fades out or suddenly disappears. And, as Ihde pointed out in his article on "Listening", in the concert hall we become aware that the

possibility of silence is the background for music. It is Ihde's point that focusing is only possible within a field, and the field is only possible within a horizon. "Roughly, *the horizon situates the field which in turn situates the thing*" (p. 106, Ihde's italics).

Variable focus

The method of phenomenological listening is based on investigating the relationship between focus and field and the relationship between field and horizon. In ordinary affairs, we focus the auditory attention on a core of interest such as the clink of a coin on the pavement, a car approaching, a baby's cry, or the voice of a dialogue partner. Often, we ignore the totality of the auditory field because of the directional focus. However, the focus is variable. It is possible deliberately to vary the direction of attention, and to direct the attention toward the experience of a wider auditory field (p. 90, 204-206).

In music, we can focus narrowly on a particular instrument, more broadly on the relationship between foreground and background, or panoramically on the total flow of musical sound. Varying the auditory focus and its width is a readily available mode of phenomenological variation. It is, however, difficult to detect and investigate the spatial horizon of the auditory field, because the field surrounds us and seems to extend indefinitely outward (p. 102, 108). Nevertheless, the temporal horizon of sound is accessible for inquiry, because sounds appear and disappear ceaselessly in everyday experience and in music.

Ihde's characterization of "horizon" and "silence" is not entirely consistent. In one context he states that the horizon of sound is silence (2007:222), in another that silence is a dimension of the horizon (2007:109). A possible clarification could be that the horizon of sound is the border between sound and absence of sound. Dimensions constituting the horizon are the retention of the just-past sound, the silence of the perceived "now", and the anticipation or expectation of a continuation of sound.

Time-consciousness

Ihde refers to Husserl's phenomenology of time-consciousness, which describes the temporal field of presence as a continuum which is constantly modified (this chapter p. 5). The attention on a temporal field of presence permits variations of the temporal focus. The focus may be narrow, fine or broad, concentrating on an exact event, a confined temporal evolution, or a larger span of temporal awareness (p. 89-96).⁹ Listening for the onset of a sound or a tone requires a narrow focus. Listening for the dynamic and timbral evolution of a single tone calls for a fine focus, as does listening for the "running off" or "trailing off" of a tone. Together, these modes of focusing can uncover unnoticed aspects of musical sound. The appearance and disappearance of tones which seem to come from nowhere and vanish into nowhere reveal the horizon of sound. In Ihde's words, "a sense of an auditory horizon as a *temporal boundary* does begin to show itself. (...) *Sound reveals time*". (p. 102, italics in the original text).

Surroundability and directionality

Attention on spatiality of the auditory field reveals that the auditory experience is multidimensional. Sound immerses and penetrates the listening body. Sound appears to come from a specific direction, and sound appears to surround the listener. These relationships are variable, and to a certain extent deliberately variable. Ihde emphasizes that "for the description to be accurate, both surroundability *and* directionality must be noted as copresent" (p. 77).

In everyday life, we locate many sounds coming from distinct directions. However in music listening, the sense of directionality may recede in favor of the sense of the music's immersing, penetrating and surrounding presence. The usual distinction between outer and inner seems obliterated, "audi-

⁹ In the context of music psychology, Mari Riess Jones and Marilyn Boltz present a related discussion of "focal attending" (Jones & Boltz 1989:470-472).

tory space surrounds me and may, in the striking sound of a symphony, fill my being", says Ihde (p. 214). This observation is recurrent in Ihde's book (p. 71, 76, 102, 132, 156). Merleau-Ponty reports a similar strong experience of an auditory musical space (2002:257-258, quoted this chapter p. 15).

Sound and music

Even if Don Ihde appreciates the overwhelming presence of music, he does not engage in descriptions of music. His primary purpose is to provide a systematic phenomenological method for the description of sound in general. It is his opinion that all kinds of sounds can adopt a musical character, if the listener puts himself in the "musical attitude" (pp. 77-78, 159, 191).

Judy Lochhead's application of phenomenology

Ihde's colleague and collaborator Judy Lochhead has applied his approach in musical analyses. In an article which summarizes her doctoral dissertation, she presents a detailed guideline for the phenomenological description of sound in time, and demonstrates her method in analyses of the temporal structure of music by Elliott Carter and other 20th Century composers (1986:49-93). She highlights Husserl's investigation of internal time-consciousness (Husserl 1964:50-59), and discusses Heidegger's concept of time. Heidegger distinguishes between a primordial temporal experience, which is a spread of past-present-future, and an objectified time which is measured, and can be counted (Heidegger 1962:456-480). Lochhead points out that in music of the 20th Century, we often do not hear measured time, but durational "spans" of past-present-future.

Lochhead has developed her ideas and methods for description and analysis of 20th and 21st Century music in elaborate studies. In "Hearing Chaos" (2001) she clarifies concepts of contemporary music in relation to chaos theories proposed in natural science, including Pierre Boulez' integral serialism, process music by Steve Reich, György Ligeti's complex polyphony, John Cage's indeterminacy, the expressiveness of free jazz, and Jimi Hendrix' use of noise. In "Visualizing the Musical objects" (2006a) she discusses approaches to creating descriptive maps of music on the basis of attentive and reflective listening, comparable to methods for graphic notation proposed by Bergström-Nielsen (1993:40-58). The article "How does it work?" (2006b) addresses challenges to analytic explanation of a piece by Charles Dodge for acoustic piano and computer-generated sound. A book chapter (2010) presents an analysis and graphic description of music by Wolfgang Rihm in the context of Gilles Deleuze's philosophy.

2.2.3. Thomas Clifton (1976): "Music as constituted object"

Thomas Clifton's article (1976a) presents, like Ihde's 1970 article, a policy statement for a phenomenology of music. Clifton's themes are constitution, feeling, time, synaesthesia, and play. He chooses as his object of investigation a very short piece, Anton Webern's *Bagatelle No. 1 for String Quartet Op. 9*, comprising 10 measures of music.

Constitution

Clifton's point of departure is radical and polemic. He does not accept a definition of music as an empirical object, such as "organized sound", but contends that the reality of music can only be constituted by a human act of experience. He specifies the acts of experience by which a piece of music becomes constituted as,

"those actions of the body by which feeling, understanding, time, motion, and play are all directed *toward* something. That something is the object of the act: a possession, a concern, a project, a relation, a form, or a problem" (pp. 74-75).

It is Clifton's fundamental view that music listening is not passive reception. It is an active process. The act of constitution is never definitive, it is an ongoing process, which aims at a revelation of possibilities (p. 97).

Clifton's statement indicates his basis in the phenomenological philosophy of Husserl, Heidegger, and Merleau-Ponty (this chapter, section 2.1). The constitution of music is an action of the body (Merleau-Ponty). This action is directed toward an object and its manifestations (Husserl). And the action is a concern and a project (Heidegger). The idea of concern is a central concept in Heidegger's philosophy, encompassing attention, undertaking, care, and discussion (Heidegger 1962:83).¹⁰

Feeling, concern and mutual possession

According to Clifton, feeling is an irreducible stratum of the musical experience. In particular, the feeling of concern is fundamental for Clifton. When the listener is totally concerned about his listening, he feels that his consciousness is filled with and absorbed by the music. Clifton explains this as a condition of mutual possession:

"I intend, or tend-toward the object of feeling, but at the same time submit to it by allowing it to touch me. Possession itself is thus two-directional: I possess the music, and it possesses me" (p. 76).

This kind of absorbing experience is familiar to some music listeners, and similar to the body-filling experience of music reported by Ihde (above, p. 11).

On the basis of the feeling of mutual possession, Clifton proceeds to describe feelings and bodily gestures related to his experience of Webern's *Bagatelle*. This is a condensed piece of music which invites continued questioning and scrutiny. Its ten measures are reproduced as score notation in the text. Clifton describes the music in some detail as a move from a smooth, graceful manner to spiky, spastic and violent gestures, and back to a renewed condition of serenity (pp. 78-81). He points out that this is merely a rough outline of the experience, which can be elaborated by the contributions of other listeners.¹¹ Clifton concludes that the meaning of music is a cumulative and open-ended achievement of the listener, always connected with feeling. The process of constitution is an infinite task (pp. 74-76, 81).

Time

Clifton adopts Husserl's description of time-consciousness as a field of presence, which comprises the just-past, the perceived "now", and the immediately upcoming future. Similar to other kinds of lived experience, music listening is a continuous process, which is constantly modified by the retention of the just-past and the anticipation of the upcoming future. Listening to a tone, we anticipate a number of possible continuations which may or may not be realized or fulfilled. Merleau-Ponty characterizes this process. He spells out precisely that "consciousness deploys or constitutes time", states that "my world is carried forward by lines of intentionality which trace out in advance at least the style of what is to come", and concludes that "time is not a line, but a network of intentionalities" (2002:481-484). Clifton sums up Merleau-Ponty's ideas: "In short, time is not a thing which flows at all, but, rather, it is a measure of our implications with the events of the world as lived-in" (p. 84).¹²

10 Heidegger provides the following examples of concern, in German "Besorgen": "having to do with something, producing something, attending to something and looking after it, making use of something, giving something up and letting it go, undertaking, accomplishing, evincing, interrogating, considering, discussing, determining. . . . All these ways of Being-in have *concern* as their kind of Being" (Heidegger 1962:83, ellipsis and italics in original text)

11 Cf. Experimental listening of the Webern piece, this chapter pp. 52-53 and appendix 2.03, p. 184.

12 J.J. Gibson, the founder of ecological psychology, has proposed a related understanding of time: "Events are perceivable but time is not" (Gibson 1975).

The synaesthetic act

Merleau-Ponty's phenomenology is the stepping stone for Clifton's considerations of the sensory integration of auditory, visual and tactile qualities. Merleau-Ponty states that,

"Synaesthetic perception is the rule, and we are unaware of it only because scientific knowledge shifts the centre of gravity of experience, so that we have unlearned how to see, hear, and generally speaking, feel" (2002:266).

In Merleau-Ponty, Clifton finds support for his description of the auditory experience in terms of visual images and tactile qualities. It is Clifton's view that these kinds of description, such as the experience of the rising line which initiates Webern's *Bagatelle*, are not merely verbal descriptions, but irreducible body-based experiences (pp. 86-87). He understands the experience of musical movement as a bodily behavior. "In the presence of a composition, we move; if it "changes tempo", it is because we do so", says Clifton (p. 88). His idea of inner motion in the body may have seemed controversial in 1976, but it is in accordance with current research on the bodily response to music, such as entrainment and emotional impact.

Clifton describes the movements in Webern's *Bagatelle* as lines and surfaces, sometimes moving in a two-dimensional space, sometimes standing out in a three-dimensional space (p. 85). His descriptions are comprehensible, but cannot be considered definitive. Applying a method of perceptual variation can yield different descriptions of spatial relations in Webern's piece. To his descriptions of time, space and feeling, motion and musical form, Clifton adds the experience of tactile qualities in the music, such as soft, hard, rough or gritty sounds (p. 87).

The play act

According to Clifton, play is a constitutive element in music, alongside feeling, time, and synaesthesia. Clifton discusses two aspects of play that he considers essential in music; ritualistic behavior and heuristic behavior.

Common for rituals and music is the directed activity that constitutes meaning. Important for both is "the experience of being absorbed in an activity whose continuation is desired." (p. 89). Participation is an act of will, which implies cognition, feeling, and continuity, and aims at an experience of achievement or accomplishment. Clifton's inclusion of ritual as a constitutive aspect of music underscores his view of music listening as a deliberate and totally engaging activity.

Moreover, the involvement in ritualistic behavior is obvious in music performance and musical improvisation. Clifton's characterization of music constitution quoted above, "actions of the body directed toward a concern, a project, a relation, a form, or a problem" is appropriate as a description of improvised interplay.

It is Clifton's reason for including heuristics as an essential aspect of music that the listener can never be sure how the music will continue from moment to moment. This incites heuristic behavior, which consists in utilizing one's personal experience to find or discover goals and solutions.¹³ With reference to Husserl's idea that a vague or "empty" anticipation precedes the goal of an action (Husserl 1969:167), Clifton states that "it remains true that the next event is simply unknown – but not unknowable." (p. 91). This is equally true of the events in a musical improvisation.

Clifton sums up his considerations and investigations by concluding that the process of constitution never ends, because the web of relationships formed by the perceiving "I" is infinite. The search for truth is an ongoing revelation of possibilities (pp. 96-97).

13 Kenneth E. Bruscia describes characteristic features of the heuristic research method proposed by Moustakas (1990:15-27). Heuristic research includes "searching for what one already knows tacitly, using one's intuition, *indwelling* in the experience with unwavering attention" (Bruscia 2005:382).

2.2.4. Thomas Clifton (1983): *Music as Heard. A Study in Applied Phenomenology*

In *Music as Heard*, Clifton elaborates on the ideas he proposed in his 1976 article. The book was published five years after Clifton's death, but affords no information about the author or the editing of his manuscript. The book includes a preface and an elaborate introductory chapter, and further chapters provide a multiplicity of musical examples, descriptions and analyses, reflections on the application of phenomenology in music listening, and references to phenomenological philosophy.

Definitions of music

On the first page of his introduction, Clifton presents two definitions of music. As the more precise definition, he states that,

"music is the actualization of the possibility of any sound whatever to present to some human being a meaning which he experiences with his body – that is to say, with his mind, his feelings, his senses, his will, and his metabolism" (p. 1).

This is an unconventional definition of music, but it makes sense. The listener intends to hear certain sounds as music, which implies that the sounds assume musical significance. The significance is experienced with the senses, feelings and mind, which are aspects of bodily experience, as is metabolism. It may seem unusual to connect musical experience with the metabolism in the body, but research in the physiology of music listening has provided evidence that music has an immediate impact on the autonomous nervous system, which regulates heart rate, digestion, respiration and perspiration (see chapter seven).

Ahead of the precise definition, Clifton presents the preliminary definition that "music is an ordered arrangement of sounds and silences whose meaning is presentative rather than denotative" (p. 1). This description is more conventional, and in accordance with widely accepted definitions, such as the one proposed in *How Musical is Man?* by John Blacking: "Music is a product of the behavior of human groups, whether formal or informal: it is humanly organized sound" (1974:10).¹⁴

However, Clifton is more radical. The order in the arrangement of sounds is not necessarily a composer's intention. "Order is constituted by the experiencing person, who is just as likely to experience it in a collection of natural sounds, as in improvised music or a finely wrought fugue by J.S. Bach" (p. 4). This comprehensive concept of musical order implies that the listener may hear all kinds of sounds as music, if he decides to do so (pp. 2, 141).¹⁵ Both of Clifton's definitions encompass the successions of sounds created in music therapy improvisations.¹⁶

Clifton suggests that music theorists ought to attach more importance to the sensory qualities that characterize all sounds, in particular timbre, gesture, dynamics, texture, and duration, and less importance to pitch and intervals (p. 6).

Embodied meaning

Clifton defines musical meaning as *presentative*. Musical meaning does not necessarily include representation or reference to something else (pp. 2-3). The musical sounds themselves present significance, because the motion experienced in the music is related to activities which are known by the body, such as gesture, ascending and descending, movement toward, movement away, beginning

14 Blacking adds that his idea of sonic order is liberal, including types of sound organization that may only be appreciated by a composer and his friends (1974:11-12).

15 This is in agreement with Ihde's standpoint that any type of sound can adopt a musical character (2007:77,159).

16 Musical improvisation can be defined as "any combination of sound and silence spontaneously created within a framework of beginning and ending" (The British Association of Professional Music Therapists 1985:4, quoted by Darnley-Smith & Patey 2003:40)

and ending, interruption, rest and tension (pp. 20-21, 32-35). Clifton adheres to the view that such phenomenal meanings of music have their basis in primordial corporeal knowledge which precedes possible metaphorical descriptions (pp. 45-48, 70).

According to Clifton, the adequate attitude towards music implies total attention. The true music listener is "one whose very being is absorbed in the significance of the sounds being experienced" (p. 2). Clifton designates this attitude "musical behavior", and emphasizes that musical behavior comprises perceiving, interpreting, judging, and feeling. Musical experience is inextricably attached to value and meaning (p. 9). As basic constituents of music, Clifton points out space, time, motion, and feeling (pp. 14, 22).

Space in motion

It is Clifton's basic assumption that musical space and musical movement are inseparable, and that the musical space is different from the physical space of acoustical events (p. 69, 138, 153). When the listener feels real concern for the music, the distinction between the listener and the music disappears, "such that the spaces formed by music are actually inhabited by my being there¹⁷, in the space-time world of that piece" (p. 138).¹⁸ This kind of experience may be shared by a large number of music listeners, but not by all music listeners. Merleau-Ponty confirms that music evokes a particular kind of space:

"When in the concert hall, I open my eyes, visible space seems to me cramped compared to that other space through which, a moment ago, the music was being unfolded" (2002:257-258).

Clifton makes an effort to describe how music appears in this "other space". He regards the body as a system which integrates auditory, visual, and tactile functions, and states that space is presupposed in every perceptual act (p. 137). He dissociates himself from Victor Zuckerkandl, who contends that "the space we hear is a space without places" (1956:276). On the contrary, according to Clifton's notion of the musical space, "we do experience the phenomenal positions of high and low, far and near, behind and in front of, and enclosing-enclosed" (p. 142). In his descriptions, Clifton visualizes the musical space.

Clifton describes the musical space as a three-dimensional space which encompasses lines, surfaces, textures, sound masses, and depth. He selects examples from a wide range of music history: Gregorian chant, parallel organum, Bach and Beethoven; Schubert, Chopin, Brahms, Wagner and Mahler; Debussy, Stravinsky, Schoenberg, Berg, Riley and Ligeti.

Gregorian chant affords Clifton rich material for describing the motion of musical lines as ascending and descending, bending, undulating, turning and twisting. And, according to Clifton's description, these lines are not one-dimensional. Gregorian chant carries words as well as tones, and tones and syllables display patterns of accents. According to changes in vowel sound, the width of the line appears to vary in thickness. Another spatial aspect of the vocal sound is that bright vowels tend to come forward, dark vowels tend to recede, producing a sensation of distance. Furthermore, vowels and consonants integrate timbres with pitches. Clifton sums up that a line of Gregorian chant embod-

17 In *The Improvisation of Musical Dialogue*, Bruce Ellis Benson expresses a similar view, stating that "the work of art provides a space in which to dwell. And that space is not merely for the artist but for others. (...) Performers, listeners, and even composers in effect dwell within the world it creates" (2003:31-32).

18 In *Feeling and Form*, the philosopher Susanne K. Langer provides a related description: "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*. (...) The semblance of this vital, experiential 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" (1953:109).

ies at least five parameters: contour, width, distance, timbre, and rhythmic level (pp. 143-153).

Clifton describes musical surfaces with various kinds of texture. An undifferentiated surface is characterized by absence of movement and absence of contrast in dynamics, such as the beginning of Ligeti's orchestral piece *Atmospheres*, where the particles of sound are absorbed in an amorphous surface, and time seems to be suspended. Another work by Ligeti, the choral piece *Lux Aeterna*, displays a surface with gradual motion and variation of texture, leading to events which stand out and create depth. In a section of Berg's *Lyric suite* for string quartet, the four voices move rapidly in a directionless "flickering turmoil", which creates the impression of a surface in energetic motion (pp. 155-171).

In his paragraph on depth in the musical space, Clifton discusses differences between visual space and musical space, and provides descriptions of experienced distance in the auditory space. He presents illustrative examples, such as the experience of distance evoked by the hunting horns in Wagner's *Tristan and Isolde*, and the trumpet calls in Mahler's *Second Symphony* (pp. 182-186). However, he does not elaborate on the basic spatial features, description of foreground and background, approaching and receding, focus and fringe in the musical space.

Time in motion

Clifton states that the experience of time arises from the experience of motion and change. Events, as lived through by people, define time (pp. 54-55, 114). This implies that knowing, feeling, and willing influence the experience of time. Time is not an abstract continuum flowing by in the physical world. Time is "the experience of human consciousness in contact with change" (p. 56). Music presents or evokes time, it is always coming into being (p. 81, 223).¹⁹ Similar to his 1976 article, Clifton refers to Husserl's description of time-consciousness as a field of presence, which encompasses retention, perception, and protention. While we listen to a tone in a melody, we retain the previous tone in consciousness, and anticipate the next tone. This is the basis for the experience of continuity.

Of particular interest for the practice of phenomenology are Clifton's considerations of continuity and duration. Following Husserl, he points out that continuity is not established by adding separate events. The experience of continuity is primary, permitting us to recognize melody as a coherent succession of tones, which influence each other (p. 95). Similarly, we do not experience duration by adding the durations of every single perceived element. The experience of a field of presence is primary, and the presence of a musical element is perceived as embedded in a duration (p. 100).

The consideration of a single enduring tone, prolonged without changes of dynamics, timbre or vibrato, incites Clifton to devise perceptual variations. One can direct consciousness toward the tone in various ways, focusing on the tone's top edge or its bottom edge, its pitch, its overtone content, its intensity, or its timbre. It is also possible to change temporal focus and listen for the past, the present, or the future of the enduring one. For example, listening with curious anticipation for the continuation of the tone, or desperately hoping that it will stop very soon. Finally, by an act of volition it is possible to focus on something else, relegating the enduring tone to the fringe of consciousness (p. 97). These changes of focus correspond to phenomenological variations proposed by Ihde. Listening to music evokes many kinds of processes related to time; beginning and ending, contrast and continuity, acceleration and deceleration, interruption, insertions, extensions, expansions, contractions and overlaps. (p. 82). Clifton exemplifies these processes with numerous analyses of music, from Bach, Mozart, Beethoven and Chopin to Mahler, Debussy, Bartok, Webern, Boulez and Ligeti (pp. 83-124).

¹⁹ Cf. Ihde's comment on the creation of music, this chapter, p. 8.

Feeling and reflection

Clifton considers feeling to be a necessary constituent of the musical experience. It is his view that feeling is located in the expressiveness of the music itself, it is not a projection or a psychological by-product of the listener. Consequently, he argues for maintaining a critical attitude which focuses exclusively on the expressiveness of the music, and opposes the relevance and value of "unreflective feeling" evoked by spontaneous response to the music (p. 74-75). Clifton specifies very few examples of feeling in music, the energetic motion in a Gavotte by Bach, the grace in a Mozart minuet, and the agony in Coltrane's jazz (pp. 12-14, 19). Nevertheless, he presents advice for including feeling in phenomenological variations. With reference to Dufrenne (1973:425), he suggests the alternation between feeling and reflection:

"The dialectic between feeling and understanding is seen, then, as a process of checks and balances, feeling appealing to and illuminating the path of reflection, while reflection enhances, sustains, and ratifies feeling" (p. 77).

Clifton declares that it is not his primary purpose to describe particular feelings. Instead, he focuses on illuminating "the feeling of possession", which he considers to be the feeling underlying more recognizable feelings (p. 272). He regards a musical work as an entity which addresses the listener, and can deposit its meaning in the person who listens attentively (p. 295). Meaning and value in music appear in the act of conscious listening, which is a "movement of mutual possession" (p. 68, 273). The significance of a piece of music is not a definitive outcome, as the experience never exhausts the musical object completely (p. 5).

Upon hearing particular sounds, the listener faces the choice between rejection and consent. He may judge the sounds to be an intruding disturbance, and refuse to accept the repellant sounds as music (pp. 278-285). Or he may find certain sounds interesting or attractive, and constitute them as meaningful music by exhibiting care towards the sounds. With reference to Heidegger's ideas of care and concern (Heidegger 1962: 83, 227), Clifton states that adequate music listening requires care, consent, and will (p. 277). The listener chooses to believe that the sounds are music and, by an act of will, he assumes his commitment to the music.

Hermeneutical interpretations

Clifton's musical analyses aim primarily at the phenomenological description of space, time and motion in music, and the reflections on the nature of musical experience. However, he includes hermeneutical interpretations in some of his analyses.

Commenting on the descriptions of musical surfaces, Clifton notes that he has found his examples in 20th Century music. He observes that in surface textures, the musical elements lose their individuality. Intervals, melody, harmony, consonance and dissonance become absorbed in an overall background, "so that what one hears in a great deal of contemporary music *is* background brought up close" (p. 168). Here, the general presentation of texture, color and movement is more important than distinction of individual *gestalts*. It is Clifton's view that this kind of musical structure reveals a meaning similar to urban society, where persons are anonymous and can be replaced by other individuals (p. 169, 209).

Clifton provides an intriguing interpretation of the "Crucifixus" section of Beethoven's *Missa Solemnis*.²⁰ He considers the experience of penetration essential in this music. In the listener's temporal experience, the retention of a tranquil mood is suddenly penetrated by the presence of violent death. In spatial experience, the music projects forceful dissonant harmonies toward the listener. The violence of the crucifixion scene is revived in the stabbing, hard-edged sonorities which penetrate the listeners' bodies (pp. 190-194). This is a particularly strong instance of embodied meaning.

20 "Crucifixus" is part of the Credo movement in *Missa Solemnis*. The text is the Niceene Creed.

The play element

In continuation of his 1976 article, Clifton points out that two elements of play, ritualistic and heuristic behavior, are constitutive aspects of music.

Similar to ritual, music is an activity whose continuation is desired. It involves goal-directed action which constitutes meaning, and it permits an experience of achievement or accomplishment. And, similar to ritual, music unfolds as the interplay between spontaneous, immediate rhetorical gestures and structures that confirm expectations. Clifton characterizes this interplay as a dialectic between freedom and control (pp. 207-211).

Heuristic behavior aims at active discovery, the orientation towards grasping an experience which is unknown, but not unknowable. Clifton observes that in music listening, "the "How wonderful!" is coupled with "What is going to happen?" (p. 221). The listening experience raises questions and arouses attentive curiosity. The flow of music can continue in many different ways, and heuristic behavior directs the listener's experience towards hidden possibilities which may or may not unfold in the music (pp. 222-223).

Clifton's achievements: investigations and discovery

Music as Heard applies phenomenological description to a wide and multi-faceted selection of musical examples. The book opens a fruitful perspective by uncovering and comparing the temporal and spatial structures of early music, major-minor tonal music, and 20th Century music. The text provides a multitude of references to phenomenological philosophy, and illuminating reflections on the application of phenomenology in music analysis.

Clifton's style of writing is characterized by spontaneity. He asks open questions, and reintroduces some of his discussions several times. As the book was published posthumously, one may speculate if he had planned to edit the text before publication.²¹ Nevertheless, *Music as Heard* remains a pioneering exploration of applied phenomenology. In his concluding pages, Clifton reminds the reader of the primary motivation of the book: "to provoke the sense of wonder, to uncover the essence beneath the obvious (...) and to contribute to the effort of reuniting music theory with musical experience" (p. 296). This statement sums up Clifton's achievement. His comprehensive knowledge and sincere engagement incites the reader to continued investigation of the listening experience.

2.2.5. Lawrence Ferrara (1984): "Phenomenology as a Tool for Musical Analysis"

In the introduction to his article, published in *The Musical Quarterly* in 1984, Ferrara declares his epistemological position: Objective knowledge is not possible. Any kind of scientific or analytical investigation relies on the researcher's value assumptions and personal decisions. The choice of a particular method determines what questions can be asked, and what kinds of knowledge can be achieved. In order to avoid the dominant restrictions of traditional analytical designs, Ferrara chooses to apply a phenomenological approach (p. 356).

Similar to Ihde and Clifton, Ferrara presents a strategy for a phenomenological investigation of music. However, his project is more modest, and more pragmatic. He does not intend to propose a foundation for music phenomenology. It is his intention to pave the way for applying phenomenology as a tool for musical analysis. The phenomenological description can serve as a guide for the application of other kinds of analyses.

²¹ Reviewers have pointed out that some of Clifton's analyses are not strictly phenomenological, and that his usage of the concepts "time" and "horizon" is not throughout consistent (Tenney 1985, Lochhead 1985/86).

It is Ferrara's goal is to reveal musical meaning, to open up all potential dimensions of meaning that may emerge in a musical work. This goal is related to Ihde's and Clifton's intentions of uncovering unnoticed aspects of the musical experience. However Ferrara's project is more specific. He wants to apply phenomenology to gain access to the "human presence" that imbues music, and can be revealed by the connection between composer and analyst. "That presence is marked by the historical *being there* of the composer and the equally historical *being here* of the analyst" (p. 357, Ferrara's italics).

For Ferrara, it is a distinctive phenomenological tactic that the analyst responds to questions posed by the work. "The interpreter discovers that, in the traditional sense of the terms "subject" and "object", *he is now object*; the music, *as subject*, questions the analyst" (p. 356, Ferrara's italics). This is an interesting and challenging statement. Ferrara refers to the kind of musical experience where a distinction between subject and object appears to be irrelevant, and he shares Clifton's experience of mutual possession²², stating that the phenomenology-based analysis "enables the analyst to be transported into the work. One possesses the work as he is possessed by its unfolding message." (p. 372)

In his subsequent book, *Philosophy and the Analysis of Music*, Ferrara concedes that the analyst cannot be an object (1991:44). However, he maintains the idea that a phenomenological investigation can respond to new questions posed by a musical work.²³ A possible clarification could be that music captures the attention of the listener, and he accepts to maintain and reinforce his attention. The process of opening up to absorb the music and reaching out to grasp its meaning induces the listener to pose new questions about the nature and meaning of the music and his own way of listening.

Ferrara's five-step procedure for phenomenological analysis

It is Ferrara's intention to broaden the scope of applied music theory. He is aware that traditional music theory offers a multitude of methods for analysis of tonal music, and regrets that these methods are not applicable to atonal and electronic music. Ferrara wishes to overcome this deficiency by including phenomenological interpretation in music theory. He chooses Edgar Varèse's *Poème électronique* (1958) for the development of his procedure, which he specifies in five stages (pp. 359-61).

Step 1

Open listenings. No guidelines, no particular questions asked. Each open listening is followed by a reflective description.

Step 2

First, listening for the sound as such. Subsequently, listening for the way the sounds connect in a musical form, the syntactical meanings of the sounds. At this stage, Ferrara is inclined to supplement and support phenomenological listening by means of traditional methods for describing musical syntax and form.

Step 3

Listening for semantic meaning. Asking whether the sounds and their syntax imply any kind of referential meaning.

Step 4

Listening for ontological meaning. Uncovering indications of the composer's "lived time" and its values, outlooks, potentials and realities. Ferrara points out that ontological or semantic meanings may not be forthcoming in all musical works.

²² Ferrara includes Clifton's 1976 article in his references.

²³ Ferrara finds support for his point of view in Hans-Georg Gadamer's *Truth and Method*: "Every sudden idea has the structure of a question. But the sudden realisation of the question is already a breach in the smooth front of popular opinion. Hence we say that a question too 'comes' to us, that it 'arises' or 'presents itself' more that we raise it or present it" (Gadamer 1975:329)

Step 5

Further open listenings, which enable the analyst to embrace all levels and aspects of meaning revealed in the previous listenings, and to integrate them in a reflective description.

In order to apply and develop his procedure, Ferrara performs 13 listenings of Varèse's *Poème électronique*; three open listenings, five for sounds, syntax and form, three for semantic meaning, one for ontological meaning and one final open listening. *Poème électronique* presents a great diversity of material, including electronic and mechanical sounds, instruments and human voices. This diversity permits a richness of observations, descriptions and interpretations. The following describes Ferrara's observations.

Step 1

During the three open listenings, Ferrara experiences a variety of sounds: bells, drills, tapping devices, male and female voices. He becomes aware of distinct kinds of mood, activity and movement, such as a calm temper, frenzied activity, a sense of floating, shrill screams (p. 362).

Step 2

During the following five listenings, he divides the music into sections and proceeds listening for the qualities of the sounds as such. Deliberately avoiding recognition or associations to well-known sound sources, he describes the variety of sounds in a rich, many-faceted language: loud, sizzling / round, rippling, bubbly / shrill, piercing, high friction / scratchy, creaking / gliding, drifting, sustained / steady, rubbing / short, hollow, wooden / interrupting, piercing / hard, crashing sounds (pp. 364-367).

His descriptions encompass a wide range of sound characteristics, including the volumes and textures of sounds, the production of the sounds, the movements and directions of sounds in space, the temporal successions and relations of sounds, and associations of feeling.

Step 3

During three listenings, Ferrara discovers two levels of semantic meanings. First, a level of obvious references such as clocks, an organ, roaring animals, elevators, chewing, voices. On the second level, he describes symbolic meanings of the sounds; the bell tolling and clock ticking symbolize *time*. Sirens, elevators and electronic sounds symbolize *technology*. Voices symbolize *human existence*. Jungle sounds symbolize a *primitive or primordial act*. Organ sounds and chanting symbolize *religion* (pp. 367-369, Ferrara's italics).

Step 4

One single listening for ontological meaning interprets the previous observations and descriptions. *Poème électronique* crystallizes what it means to live in the modern era where human existence, marked by time and underlying primitivism, is surrounded by the sounds of technology.

Step 5

The thirteenth listening is an open listening. Ferrara is aware that he now retains the whole piece in his memory. He experiences each sound in relation to the whole, and can reflect upon the form of the piece, acknowledging the composer's creativity and control of contrast and variety. The opposition between human life and unfeeling technology makes a strong impact.

Ferrara's focus: uncovering meaning

Ferrara's descriptions include feeling, movement, gesture, space, temporal relations and tactile qualities. However, it is conspicuous that he does not thematize or discuss these modes of experience. He takes the experience for granted, contrary to Clifton, who feels obliged to discuss every single act of musical experience as a constituent of music's reality. Ferrara acknowledges that music is already

there in the world, and follows Heidegger's claim that the meaning of phenomenological description lies in interpretation (Heidegger 1962:61). Ferrara directs his interest at uncovering meaning, history and life-world in the music.

2.2.6. Lawrence Ferrara (1991): *Philosophy and the Analysis of Music. Bridges to Musical Sound, Form, and Reference*

In his 1991 book, Ferrara does not develop the phenomenological approach. He declares that his book is not a promotion of the use of phenomenological method in music (p. XVIII). However, he acknowledges the value of phenomenological inquiry for the description of sound in time and for the interpretation of musical meaning. Importantly, he includes the phenomenological approaches as steps in the eclectic method for music analysis which is the core matter of the book. Ferrara dedicates separate chapters to giving accounts of Husserl's and Heidegger's phenomenologies, supplemented with overviews of the history of hermeneutics and research in referential meaning in music. Furthermore, he provides a review of literature on music phenomenology.

Sound, Form and Reference

It is Ferrara's point of departure that listeners experience music as a multiplicity of levels of significance, and that one analytic or phenomenological method cannot explore all possible strata of musical meaning. This is his reason for combining different approaches. He applies phenomenological methods to describe the sound in time, conventional analytic methods to explain musical form, and hermeneutical methods to support the interpretation of feeling, reference and historical background. Ferrara argues that no single method can assure "pure" or "objective" description and insight. Conventional musical analysis subjugates the music to predesignated tasks, and phenomenological description cannot suspend its inherent methodological bias. All methods, analytical as well as hermeneutical, depend on structures of pre-understanding (pp. XIII-XVIII, 34, 45). By giving different approaches equal status, Ferrara aims at avoiding methodological dominance. It is his intention to "support the freedom of the music object to show itself in its multi-dimensional polyphony of sound, form, and reference" (p. 46).

Husserl and Heidegger

Ferrara provides an overview of Husserl's philosophy and its roots in Kant, Hegel and Brentano, and points out some of Husserl's basic phenomenological concepts (pp. 59-63):

- (1) The goal of phenomenology is to provide unbiased and systematic descriptions of the objects of experience. The basis for descriptions is the immediacy of conscious perception.
- (2) Consciousness directs the mind toward the things of experience. It is characterized by intentionality, the act of pointing to the objects of experience. Consciousness is constituted by the objects to which it points and cannot be separated from the objects. The engagement of consciousness implies meaning in the intended objects.
- (3) The constitution of consciousness is tied to the experience of internal time, the field of temporal presence which encompasses retention of the just-past, awareness of the "now", and protention of the upcoming future.

Ferrara acknowledges the value of Husserl's early phenomenology, in particular the second volume of *Logical Investigations* (1901). He appreciates that Husserl brings the subjective aspects of experience "to the forefront for inspection and relative control" (p. 80). But he distances himself from Husserl's later philosophy. He criticizes that, according to Husserl's *Ideas: General Introduction to Pure Phenomenology* (1913), the ego is the basis for all understanding. Ferrara contends that Husserl

cuts off the ego from life. He endorses the alternative view that "man is in the world first; the separation of oneself from others is not prior to being in the world" (p. 80). This is the understanding of the life-world which Heidegger has proposed.

Ferrara underlines the fact that Heidegger is greatly indebted to Husserl's phenomenology. But he emphasizes that Heidegger adds a new dimension to phenomenology, contending that phenomenological description is never pure, it is always an interpretation.²⁴ A description is marked by a pre-understanding based on the individual's cultural and historical context. Ferrara quotes a central statement in Heidegger's *Being and Time* (1962:61-62):

"The meaning of phenomenological description as a method lies in *interpretation* ... The phenomenology of Dasein is a *hermeneutic* in the primordial signification of this word."
(Ferrara p. 105, italics in Heidegger's original text).

"Dasein" is Heidegger's term for human being or existence, which is not merely "being", but "being-there", as the German term indicates. A human being finds itself "thrown" into the world which is already a world with others, with culture and language, and phenomenology is a tool for understanding the potential meanings of being-in-the-world (Ferrara pp. 105,111).

Ferrara concludes that Husserl was wrong in presupposing that "pure description" is possible, and that Heidegger was right in stating that all description is interpretation grounded in pre-understanding or "fore-sight" (Heidegger 1962:191). However, in his quest for the best possible methods for analyzing and understanding music, he acknowledges the value of Husserl as well as Heidegger. Husserl has contributed the method of rigorous and systematic descriptive phenomenology. Heidegger has contributed the hermeneutical phenomenology, which continuously explores and interprets the world (Ferrara pp. 112-116).

Ferrara's modification of the five-step progression

In the 1984 article, Ferrara proposed his five-step progression: Step 1, open listenings. Step 2 a, phenomenological description in listening for the sound as such. Step 2 b, conventional methods for describing sound in form. Step 3, hermeneutical interpretation in listening for referential meanings. Step 4, hermeneutical interpretation in listening for ontological meanings. Step 5, open listenings. Ferrara presented the same progression in a subsequent article about music in general studies (1986), where he sketched a description of a rock album by Moody Blues, *Days of Future Passed*. Here, he maintained that step 2 a, listening for the texture, timbre, and quality of sounds, ought to precede step 2 b, the analysis of musical form. He argued that "the sound as such" is more fundamental than "the sound in form" (1986:125).

In the 1991 book, Ferrara has changed his mind. He divides step 2 into two separate steps, in which "conventional analysis" now precedes listening for "the sound as such". This implies a downgrading of the phenomenological approach. Without further discussion, he now presents his earlier form as a six-step progression (pp. 170-171):

1. Open listenings, permitting the analyst to respond freely to the music.
2. Conventional analysis of the piece, according to a system chosen by the analyst.
3. Phenomenological description of the sound as such, marked by an attempt to suspend (to whatever degree possible) musical syntax and reference.

24 Cf. Ihde's characterization of hermeneutic as a "second phenomenology", this chapter page 9.

4. Semantic report of the meaning of a program or a text, if one is present.
5. Hermeneutical analysis of ontological meaning, if such meaning is forthcoming.
6. Final open listenings, during which any level of meaning – sound, syntax, or reference – can be reported.

In this modified version, Ferrara assigns lower priority to the phenomenological description, and makes reservations regarding the possibility of semantic and hermeneutical analyses. He thus paves the way for giving greater priority to conventional analysis and historical context in his eclectic method.

Ferrara's ten-step eclectic method for sound, form, and reference

In his eclectic method, Ferrara incorporates three approaches to musical analysis, phenomenological, conventional, and hermeneutical, and underlines that it is important to let these approaches function with a large degree of autonomy. "Each system will guide and prescribe the nature of questioning within its province" (p. 180). It is Ferrara's aim that the analyst should be responsive to multiple levels of musical significance. Addressing these multiple levels, it is important to clarify whether analytic questions are directed to sound, form, or reference of the music.

Ferrara states that the analyst must attempt to suspend prejudgements about what a musical work can mean. This is a Husserlian approach. Simultaneously, the analyst must remain open to what the musical work might mean. This is a Heideggerian approach, focusing on interpretation. Finally, Ferrara emphasizes the importance of a meta-critical review, which delineates the strengths and weaknesses of the single analytic components and the overall eclectic method. He describes his method in ten steps:

1. Historical Background

The first step is to place the piece within a historical framework, taking into consideration music history, cultural and political history as well as the composer's overall production, his style and significance.

After step one, Ferrara advises the analyst to focus on the specific piece of music during steps two through seven, suspending potential comparison with other works.

2. Open Listenings

An optional step, permitting the listener/analyst to orient himself in the overall sound, structure and message of the work.

3. Syntax

Collection of syntactical data by implementing a conventional method of analysis. An attempt is made to suspend the collection of phenomenological and hermeneutical data.

4. The Sound-in-Time

A phenomenological description of the sound-in-time according to a Husserlian approach. The analyst suspends syntax and referential meaning from conscious attention as far as possible. He describes coherent temporal units, which may combine into larger temporal structures.

5. Musical and Textual Representation

First level of musical representation, reference found in the meanings of a program or a text.

6. Virtual Feeling

Second level of musical representation, a report of the manner in which the work is expressive of

human feelings. Ferrara makes an effort to emphasize that the analyst must retain a detached attitude concerning music's expressiveness. The analyst's subjective reactions remain a secondary issue. He must give reasons for the report of expressed feelings in his earlier insights in musical syntax and sound-in-time.

7. *Onto-historical world*

The third level of musical representation concerns the onto-historical world of the composer. Ferrara warns against unrelated references in the form of general cultural trends. Similar to in step six, he insists that onto-historical insight must be grounded in observations of syntax and sound-in time in the work under study.

8. *Open Listeners*

In the final open listenings, the analyst responds to the multiplicity of levels of musical significance of the musical work. Steps 3, 4 and 5 consisted in separation of syntax, sound in time, and representation. In steps 6 and 7, separation ceased, as the analyst related the referential dimensions of virtual feeling and onto-historical world to observations of syntax and sound in time.

Now the analyst is prepared to experience how the different levels of musical significance interact in a multilayered dynamic whole. The understanding of this interaction is "the ultimate purpose of the bridging of sound, form and reference" (p. 186).

9. *Performance Guide*

On the basis of his insight in the music, the analyst can now present suggestions and advice for interpretation of the work.

10. *Meta-Critique*

A final discussion and evaluation of the entire analysis and its single steps, examining theoretical presuppositions and the strengths and weaknesses of the different approaches to musical understanding.

Application of the ten-step method

Ferrara has applied his ten-step method in analyses of two works for piano, No. 3 of Bela Bartok's *Improvisations on Hungarian Peasant Songs Op. 20*, composed 1920 (pp. 189-232), and the third movement of David Zinn's *Spanish Sojourn*, published as sheet music 1988 (pp. 235-331). Unfortunately, no commercial recording of the latter work is available.

Ferrara presents an elaborate analysis of the Bartok piece, which clarifies the details, meaning, and overall structure of the music, and demonstrates the utility of the eclectic method.

Step 1 presents a brief overview of Bartok's historical background.

Step 2 reports the results of several open listenings. Ferrara describes the piece as yearning and troubled, growing to a climax of distress and melancholy.

Step 3 is a score analysis of themes, harmony and form. The score indicates that the piece is based on a Hungarian folk song, "See there looming, a black cloud."

Step 4 describes, in great detail, the temporal units of the piece, which combine in four temporal structures which constitute the entire piece of music. This step integrates attentive listening and score verification. Interestingly, the temporal units and structures are not identical with the themes

and sections indicated in step 3. Thus, steps 3 and 4 disclose two different simultaneous musical structures.

Step 5, Representation, presents the full lyrics of the Hungarian folk song. The theme is tragic; the narrator asks a raven to deliver a message to his parents and fiancée that he is ill and will soon die.

Step 6, Virtual Feeling, reports human feelings expressed in the music, with reference to the syntax and sound in time described in steps 3 and 4. Ferrara identifies an opposition between a declarative main theme and a misty and nebulous background. Key clashes create frenzied tension, which culminates in an explosion of dissonance. A sense of restful reconciliation evoked by a transparent structure gives way to gloomy undercurrents in the piano's low register. The closing measures convey an emphatic wailing, which vanishes in vaporous mist. In sum, the piece displays intense, personal pain and deeply felt pathos.

Step 7, Onto-historical world, confirms the tragic signification of the piece. New analytical details support the interpretation that the music represents the transitoriness of human existence. Life succumbs to death.

Step 8 consists of open listenings, which add new structural observations. Accumulated insight enables the analyst to experience how the sound, syntax, and reference continue to coexist as separate strata, yet simultaneously seem to be assimilated into the unified whole of the work.

Step 9, Performance Guide, provides detailed instructions for the pianist's expressive execution of the piece, based on the analyst's analytical observations.

Step 10, Meta-Critique, evaluates the contributions of the different steps to the analysis and interpretation of the music, and concludes that the method's advantage is the potential synthesis of phenomenological and hermeneutical methods with conventional approaches.

Ferrara's achievement and abandonment

The precision and consistency of Ferrara's Bartók analysis is admirable, and its conclusions are convincing. However, the perspective of Ferrara's eclectic method is reduced in comparison with the five-step progression he presented in 1984. In the ten-step eclectic method, Ferrara deliberately downgrades phenomenological exploration in favor of comprehensive and detailed documentation in score-based analyses. It is crucial that he has eliminated "the sound as such" and the ensuing search for any kind of referential meaning that the sounds and their syntax might imply. Instead, he focuses on "the sound in time", which he can verify in the score, and restricts himself to considering referential meaning which is documented in a text.

These are legitimate personal choices. Nevertheless, Ferrara has abandoned his earlier accomplishments. He has abandoned the multi-faceted descriptions of sound and referential meanings in Varese's *Poème électronique*, which interpreted the relationships between sound, culture and the listener's lifeworld. Similarly, he has abandoned the approach to phenomenological description and interpretation of rock music, which he initiated in his article about music in general studies (1986), but apparently did not continue. However, nothing prevents music analysts and music therapists from selecting and applying different steps from Ferrara's methods.

Ferrara has not applied his eclectic method for sound, form and reference in publications after 1991. He has expanded on Qualitative Research and Philosophical Inquiry in two book chapters (2005:79-117 and 119-162).

Complementary contributions to music phenomenology

Ihde, Clifton and Ferrara approach music phenomenology from different viewpoints. Their contributions complement each other.

Don Ihde devises methodical procedures for phenomenological investigation. He discusses the ideas of Husserl and Heidegger, defines their philosophies as first and second phenomenology, and includes their approaches in his philosophy of listening. However, Ihde does not describe any piece of music. Judy Lochhead continues Ihde's work by applying phenomenological methods in music analysis.

Thomas Clifton proposes pioneering ideas concerning the constitution and definition of music. He adopts approaches from Husserl, Heidegger, Merleau-Ponty and Dufrenne in numerous descriptions of music examples, but he does not adhere to a strict phenomenological method. However, Lochhead and Ferrara acknowledge that Clifton has introduced new beginnings, perspectives, and goals in music theory.²⁵

Lawrence Ferrara acknowledges the ideal of unbiased description stated in Husserl's early phenomenology, but he dissociates himself from Husserl's subsequent views, and emphasizes the importance of Heidegger's hermeneutical philosophy. Ferrara proposes a seminal procedure for phenomenological analysis in his description of Varèse's *Poème électronique*, but he later downgrades phenomenology in favor of score-based analysis.

Don Ihde's ideas constitute the basis for investigation of experimental phenomenology described in section four of the present chapter. Lawrence Ferrara's ideas form a basis for phenomenological description of music in music therapy.

2.3 Phenomenologically inspired descriptions of music in music therapy research

A number of music therapy researchers have applied phenomenological approaches to the description of music. In particular, the methods proposed by Ferrara (1984, 1991) have proved fruitful. A few studies mention the writings of Don Ihde and Thomas Clifton, but do not find a use for their ideas. The following section discusses applications of Ferrara's approach in music therapy research.²⁶

2.3.1. Ruud (1987): *Musikk som kommunikasjon og samhandling* [*Music as communication and interaction*]

Even Ruud discusses Ferrara's article in his doctoral dissertation (1987:338-344). He states that listening without any kind of presupposition is not possible. He points out the importance of varying the focus of listening and comparing the outcomes, and he appreciates the startling experience of listening for the sound as such.

The structural, semantic and pragmatic levels

For the description of music therapy improvisations, Ruud proposes to explore a structural, a semantic, and a pragmatic level, which replace Ferrara's syntactical, semantic, and ontological levels. He argues that the structure of relationships between the participants in an improvisation will often be

²⁵ Lochhead (1985/86:364); Ferrara (1991:151,183).

²⁶ For a comparison of these studies with other types of investigation, see Bonde (2005:489-525): Approaches to Researching Music.

more important than musical syntax and form. And he proposes that a discussion of the pragmatic level, that is, the therapeutical effect and meaning of the improvisation, is a suitable replacement for Ferrara's considerations of the music's and the composer's ontology.

2.3.2. Forinash and Gonzalez (1989):

A Phenomenological Perspective of Music Therapy

Michele Forinash and David Gonzalez (1989) apply a modified version of Ferrara's procedure to describe a music therapy session. This is a pioneering article, introducing phenomenology in music therapy in order to develop a qualitative research method that is directly applicable to clinical experiences. The authors present phenomenology as "the study of knowledge gained through appearance or experience" (p. 36), and discuss phenomenological concepts with references to Ihde (1976), Smith (1979), Kaelin (1981), and Ferrara (1984).

Modification of Ferrara's procedure

On the background of personal communication with Ferrara, the authors modify his progression in order to adapt it to the music therapy process, resulting in a seven-step procedure:

1. *Client background*: The psychosocial history of the client and family.
2. *Session*: Description of the therapy session and the evolution of music and interactions.
3. *Syntax*: Analytical description of the music played in the session.
4. *Sound as such*: Description of the qualities of all sounds that appear in the session, including music, sounds of the therapist and client, and environmental sounds.
5. *Semantic*: The therapist's experience of referential meaning of the session.
6. *Ontology*: Awareness of the client's life world, the existential reality of the client in the moment.
7. *Metacritical evaluation*, reviewing strengths and weaknesses of the phenomenological method.

Session description

The session is extraordinary. A client named Sara, 42 years old, is terminally ill with cancer, and Forinash together with the hospice music therapist give musical support to Sara in her last hours of life.

Step 1: Client background

The client's social background is miserable. Her alcoholic husband has committed suicide, and she has been worried about the future of her two children.

Step 2: Session

The therapists sing and play guitars. They vocalise on soft vowels, sing comforting songs, and improvise songs with peaceful images and words. Realizing that Sara is dying, they decide to continue improvising until she stops breathing.

Step 3: Syntax

The precomposed music follows well-known chord progressions. For improvisations, the therapists choose maj7 and sus4 chords.

Step 4: Sound as souch

The sound of Sara's breathing is crucial for the course of the session, and her gradual change from sharp breaths to a soft, relaxed breathing exerts a strong impact on the therapists. The hum of an oxygen machine serves as a reminder of the difference between humanity and machinery.

Step 5: Semantic

Referential meaning appears to the therapists in the form of strong images, including the image of ocean waves evoked by Sara's breathing.

Step 6: Ontology

Forinash senses the transition from life to death as a struggle as well as a resolution, both in Sara and in herself.

Step 7: Metacritical evaluation

It is Forinash's evaluation that the phenomenological approach allows for awareness and full experience of the various components of the therapy process. Summing up, the authors hope that the presented model will encourage further pursuit of alternative methods in music therapy research.

Forinash's Dissertation: A phenomenology of music therapy with the terminally ill (1990).

In her doctoral dissertation, Forinash continues to develop the phenomenological approach. She regards the 1989 article as an extremely useful first step, but feels that the method neglects important aspects of a music therapy session, such as the therapist-client relationship and the presence of the music as a growing and responsive force (1990:27-33).

In her study, Forinash describes ten different therapy sessions with ten terminally ill patients. The sessions include a prominent component of singing. For analyses of the sessions, she does not employ her seven-step adaptation of Ferrara's progression. Instead, she develops a method based on the phenomenological psychology of Amedeo Giorgi. This method enables her to focus on relationship, music, and process as the essential aspects of the sessions.

2.3.3. Amir (1990): A Song Is Born

Dorit Amir (1990) uses Forinash and Gonzalez' seven-step method in her study of two successive music therapy sessions, selected out of ten sessions with Abe, a young man who is quadriplegic as a result of a car accident. The therapist improvises music, while Abe improvises lyrics, sitting in his wheelchair. Abe's issue in the first session is "Freedom of the mind – freedom of the soul – freedom of the body - that cannot be controlled." In the second session, he improvises lyrics about riding in a car, peace of mind, happy places, and a miracle road.

Patient-therapist relationship

The seven-step method serves as a useful framework for Amir, who writes insightful descriptions of the therapy on the basis of observations during the sessions, audio and video recordings, and interviews with the patient and the therapist. She concludes that music therapy for Abe "became a place where he could allow himself to nurture his spirit through discovering his creativity and his beauty" (p. 80). In this study, Amir overcomes Forinash's two reservations mentioned above. She succeeds in describing the patient-therapist relationship as well as the present force of the music.

2.3.4. Kasayka (1991): *To Meet and Match the Moment of Hope*

In her doctoral dissertation, Roseann Kasayka applies phenomenological description in a study of transpersonal elements of the Guided Imagery and Music (GIM) experience. In GIM therapy, the client listens to selected music, lying down in a relaxed state. Guided by the therapist's comments, the client reports imagery, feelings and bodily states evoked by the music.

Peak experience

Kasayka investigates the transpersonal elements evoked by the program "Peak Experience" designed by Helen Bonny.²⁷ This program consists of five music selections:

Beethoven: <i>5th Piano Concerto</i> , 2 nd movement, Adagio un poco mosso	6'36
Vivaldi: <i>Gloria</i> , Et in Terra Pax	5'46
Bach: <i>Toccatà, Adagio & Fugue in C major</i> , Adagio - orchestrated by Ormandy	5'12
Fauré: <i>Requiem</i> , In Paradisum	2'56
Wagner: <i>Lohengrin</i> , Prelude to Act 1	9'50

It is Kasayka's intention to identify the musical elements in this GIM program that are present during moments of transpersonal experience. As transpersonal, she understands "experiences involving an expansion of consciousness beyond customary ego boundaries and beyond ordinary limits of time and space." (p. 5).

On the background of ideas stated by Ihde (1976), Clifton (1983), and Ferrara (1984), Kasayka chooses to apply two forms of phenomenological inquiry. For music analysis, she adopts Ferrara's five-step procedure (1984).²⁸ For analysis of the music therapy session material, she adopts a six-step version of Forinash and Gonzalez' seven-step procedure (1989), omitting step four, "sound as such". Kasayka finds that both methods provide structure, flexibility, and openness for the human presence in the musical experience (p. 28).

Music analysis

Kasayka personally conducts five-step listenings of the five pieces. She gives careful descriptions of her experience in each step, and adds a metacritique (pp. 33-60). Kasayka follows Ferrara's original suggestion (1984:359-360) for step two, "Listening for sound and syntactical meaning". This implies that Kasayka's step two includes a) listening for the sound as such, b) listening for formal structures and implementing traditional methods of analysis.

1. Open listening

Kasayka listens attentively and sensitively. She characterizes the sound, texture, motion, space and mood of the piece and its immediate aesthetic impact.

2. Listening for sound and syntactical meaning

a) Listening for sound: Kasayka preferably reports the bodily impact of sound: the sound "draws", "pulls" or "holds", its nature may be "soft flowing" or "full, but not overpowering".

b) Describing formal structures: She provides detailed descriptions of the musical elements, syntax and formal features of each piece, with reference to the musical score.

27 The Bonny Method of Guided Imagery and Music is described by Ventre (2002:29-35). For introductions to the Peak Experience program, see Bonny (1978:45-48), and Grocke (2002:119-121). Concerning the background of the program, see Grocke (1999:21-25).

28 This chapter, p. 19.

3. Listening for semantic meaning

These listenings focus mainly on the experienced connections of motion, dynamics and emotion. The music may offer journeying, exploration and momentary rest (Beethoven), interweaving and union (Vivaldi), predictability and surprise (Bach). It may represent a dialogue between heaven and earth (Fauré), and it may lift the listener into a space of triumph (Wagner).

4. Listening for ontological meaning

Kasayka is true to Ferrara's idea of looking into the life-world of the composer. For each piece, she makes an account of the composer's history and personal situation and the likely intention of the music. Moreover, she reports Helen Bonny's statements about the function of each piece in the GIM program.

5. Final open listening

Kasayka interprets the music in terms of its potential function in the course of the program, and its particular emotional and spiritual qualities. In her metacritique, she concludes that the method of repeated listenings that reveal new layers of meaning is fruitful and resonant with the GIM process.

Kasayka concludes that Ferrara's method serves the purpose of providing the guide with a deeper knowledge of the music and how it will work in the session (pp. 124-125).

Analysis of the therapy session material

Kasayka analyzes the session material of four case studies (pp. 60-116). The clients were volunteers who had contracted to have at least six GIM sessions with the researcher. Kasayka's research question was: "What types of transpersonal experience occur in a Guided Imagery and Music session when the Peak Experience tape is used?" (pp. 30-32). The reports include six steps:

1. *Historical background*: The client's psycho-social history, and a summary of the progress made in previous GIM sessions.
2. *Session*: Description of the GIM session based on "Peak Experience".
3. *Syntax*: Analysis of the musical material and corresponding imagery material of the session.
4. *Semantic*: The referential component, including possible meanings.
5. *Ontology*: A statement of the life-world of the client in this particular moment.
6. *Metacritique*: Ongoing dialectic regarding the phenomenon of the session.

Kasayka's application of the six-step procedure

Steps 1-2: Historical background and Session

The two first stages provide careful descriptions of the client's personal situation and the decisive factors in the session, including experiences from previous GIM sessions and the motivation for applying the Peak Experience program.

Step 3: Syntax

The *syntax* description is based on an audiotape recording of the session. It consists of a detailed listing of the music, measure by measure, alongside with the distinctive features of the client's imag-

ery experiences and the therapist's additional comments. This is the basis for the following step.

Step 4: Semantic

In the *semantic* section, the therapist considers the interaction of music and imagery, the client's bodily response, the significance of the imagery and the occurrence of transpersonal experience.

Step 5: Ontology

The *ontology* section interprets the meaning of the session in relation to the client's lifeworld.

Step 6: Metacritique

The final *metacritique* discusses the types of transpersonal experience occurring during the session, and their relationship with the music.

Kasayka's analyses of the session material are elaborate and elucidating. She provides detailed descriptions of each piece of music, measure by measure, coordinated with the client's experience of imagery, and the therapist's guiding comments. Subsequently, she interprets the outcome of the session within the framework of the client's lifeworld.

She concludes that the musical sequences of the Peak Experience program "both elicit and support transpersonal experience. They likewise serve to deepen and extend such experiences. The sequences have the potential to assist the client in redefining, refining and transforming the images which form transpersonal experience" (p. 117).

Kasayka's division of the study into two separate investigations ensures clarity and richness in observations, descriptions and interpretations. She has elaborated on the spiritual orientation to the Bonny Method in a book chapter (2002:57).

2.3.5. Grocke (1999): A Phenomenological Study of Pivotal Moments in Guided Imagery and Music Therapy

Denise Grocke's doctoral dissertation presents a study of pivotal moments in Guided Imagery and Music therapy. Grocke explains a pivotal moment as "an intense and memorable GIM experience which stands out as distinctive or unique" (p. 220). Her study is in three parts:

- (1) Interviews with seven clients about their experience of pivotal moments.
- (2) Interviews with the therapists who had facilitated the sessions identified as pivotal.
- (3) Descriptions of the music programs underpinning the pivotal experience.

Interview analyses

For analyzing the interviews in parts one and two, Grocke adopts approaches of phenomenological psychology (Polkinghorne 1989:53-55) in a procedure that progressively distills an interview transcript. The procedure first identifies key statements and meaning units. Next, it distills essence. Finally, it leads to a global description of the experience of pivotal moments (pp. 61-62). Grocke's interview analyses (pp. 69-136) are elaborate and informative. However, an account of phenomenological psychology is beyond the scope of the present text. Grocke has presented her interview protocol in a summary of the study (Forinash and Grocke 2005:329-330).

Music underpinning pivotal moments

For music analysis, Grocke selects four GIM sessions, which display clearly identifiable pivotal moments. Three pivotal experiences are related to a full GIM program:²⁹

29 For detailed descriptions of the Bonny music programs, see Grocke (2002:99-133)

David: Inner Odyssey

Brahms: Symphony No. 3, 1 st mvt, Allegro con brio	10'23
Nielsen: Symphony No. 5, 1 st mvt, Adagio (Excerpt)	9'43
Beethoven: Violin Concerto, 2 nd mvt, Larghetto	10'15
Corelli: Concerto Grosso No. 8 in g minor, Adagio-Allegro-Adagio	3'32

Sarah: Transitions

R. Strauss: Ein Heldenleben (Excerpt from part 6)	8'04
Brahms: Symphony No. 3, 3 rd mvt, Poco allegretto	5'29
Beethoven: Symphony No. 9, 3 rd mvt, Adagio molto e cantabile	14'47
Brahms: Piano Concerto No. 2, 3 rd mvt, Andante piu Adagio	14'29

Bernadette: Emotional Expression 1

Brahms: Piano Concerto No. 2, 1 st mvt, Allegro non troppo	17'52
Brahms: A German Requiem, Part 1, "Selig sind, die da Leid tragen", and Part 5, "Ihr habt nun Traurigkeit"	16'49
Brahms: Symphony No. 4, 2 nd mvt, Andante moderato	12'40

Suzanne:

Suzanne's pivotal experience is related to two music selections:

R. Strauss: Death and Transfiguration (Excerpt)	4'00
J.S. Bach orchestrated by Stokowski: Passacaglia and Fugue in c minor	14'37

Grocke applies two procedures for the analysis of these music selections; the Phenomenological Analysis Model (PAM), a phenomenologically inspired analysis model, which comprises a strong component of score analysis, and the Structural Model of Music Analysis (SMMA), a score-based analysis model, which touches on some phenomenological aspects.

2.5.3.1. Grocke's Phenomenological Analysis Model

Helen Bonny's contributions

As background for her phenomenological descriptions, Grocke chose a framework of pre-understanding, the basis and objectives of Guided Imagery and Music, clarified by Helen Bonny (HB), the originator of the method. In order to establish this framework, Grocke first summarized HB's lecture notes about morphology, musical elements, and choice of music in GIM (pp. 418, 422-423). Subsequently, Grocke conducted interviews with HB, which were taped for documentation. One interview concerned the general characteristics of music chosen for GIM (pp. 418-421). Other interviews concerned the particular features of the GIM programs *Transitions* and *Emotional Expression I*, and the above-mentioned music selections by R. Strauss and J.S. Bach (pp. 424-432). The program *Inner Odyssey* was not included in the interviews.

During the interviews, HB listened to the music in question, commenting on the qualities of the music while it was playing. She did not look at the score while listening, but Grocke afterwards added reference points to the scores. The mentioned documents and interviews are primary sources for the understanding of Bonny's method.

As the two first steps of her music analysis, Grocke conducts *open listening* and *listening for syntactical meaning*, according to the first two steps of Ferrara's five-step procedure (pp. 146-149).

Open listening

In Grocke's music descriptions based on *open listening*, she includes quotes from Bonny's descrip-

tions, marked in italics. This means that Grocke's phenomenological music descriptions represent the integrated outcome of several open listenings by Bonny and Grocke. In these listenings of music by Brahms, Nielsen, Beethoven, Corelli, Richard Strauss and Bach orchestrated by Stokowski, Grocke and Bonny describe particular kinds of perceived qualities (pp. 433-458):

Feelings, moods and expressions:

haunting, plaintive, tranquil, yearning, threatening, reassuring, non-obtrusive, martial, bombastic, pleading, insistent, caring, triumphant, unsettling, eerie, jocular.

Sensuous qualities:

bright, warm, dark, ethereal, rounded, gentle, shimmering, strident.

Movement and bodily actions:

playful, restful, steady, passing back and forth, rocking, marching, running, gathering, leaning, pushing, pulling, panting, interweaving, gathering, drifting, floating, surging, tumbling, pounding, slapping, sawing, scraping.

Space:

ascending, descending, climbing up, going down into a deeper space, grounded, open, inward turning, expanding, a wide container.

Time:

building up, waiting, time stands still, anticipation, prediction, impetus, moving ahead, propelling forward, steady movement, interruption. Bonny: "Changes happening very fast."

These kinds of descriptions are related to the characteristics of music chosen for GIM programs, as pointed out by Helen Bonny; tension and release, expectations, container function, flow and movement, structure and variability, emotional substance, mood, force, dynamic changes, timbre changes, cross-over sensory experience (pp. 418-421, 142-145).

The descriptions display similarities with Ferrara's style of phenomenological description (this chapter p. 20), and similarities with the experiential acts which Clifton considers constitutive of music: feeling, time, space, motion, form, and tone quality (Clifton 1983:22).

Listening for syntactical meaning

In the next step, *listening for syntactical meaning*, Grocke supports her listening for musical elements and syntax with a comprehensive study of the printed score, following Ferrara's suggestion: "At this point in the analysis, traditional methods could be implemented to support and embellish the phenomenological analysis of musical syntax" (1984:360). This leads to the identification of *Music Meaning Units (MMU)* related to characteristic changes in the music, such as themes, tempo, dynamics, texture, or orchestration. Grocke gives each MMU a distinctive heading and describes its particular features, and draws up complete lists of all MMUs, with score excerpts for precise identification (pp. 156, 433-458). The listing provides the basis for a detailed comparison with *Imagery Meaning Units (IMU)* identified in the descriptions of the clients' sessions.

This comparison, together with information from the client interviews in the first part of the study, results in the identification of the precise pivotal moments: David: Beethoven's Violin concerto, slow movement. Sarah: Beethoven's Symphony No. 9, slow movement. Bernadette: Brahms' German Requiem, part 1. Suzanne: The very last part of the fugue by Bach, orchestrated by Stokowski (pp. 163-190).

2.3.5.2. Grocke's Structural Model of Music Analysis (SMMA)

Grocke's final task is to uncover the features of music that underpin pivotal moments. For this purpose, she develops the Structural Model for Music Analysis (SMMA). Upon discussing Bonny's categories of musical elements, Grocke assesses a large number of potential musical components, and proposes a model for the analysis of notated music, comprising 63 components within 15 fields (pp. 149-164, 214-216):

1) Style and Form. 2) Texture. 3) Time. 4) Rhythmic features. 5) Tempo. 6) Tonal features. 7) Melody. 8) Embellishments, ornamentation, and articulation. 9) Harmony. 10) Timbre and quality of instrumentation. 11) Volume. 12) Intensity. 13) Mood. 14) Symbolic / associational. 15) Performance.

The SMMA is not a phenomenological model, but it touches on phenomenological aspects in the observations of the three last fields, mood, symbols, associations, and performance.

The phenomenological analysis had identified the music selections underpinning pivotal moments. The structural analysis subsequently enables Grocke to accomplish her crucial task, to identify features common to all four music selections underpinning pivotal moments (p. 206). She found that the music,

- has a formal structure in which there is repetition.
- is predominantly slow in speed, and tempos are consistent.
- is predictable in melodic, harmonic and rhythmic elements.
- features dialogue between instruments.

Grocke's dissertation is a pioneering work, providing fundamental documentation of Bonny's Method of Guided Imagery and Music, elaborate analyses of relationships between musical units and imagery units in GIM sessions, and a model for structural analysis of music, which may serve as a tool in other studies. Grocke has published a detailed account of the SMMA approach, presenting Sarah's pivotal session as a case example (2007:149-161).

2.3.6. Lee (2000): A Method of Analyzing Improvisations in Music Therapy

Colin Lee's method of analyzing improvisations combines a phenomenological approach with other kinds of analysis, including transcription of the improvisation. He emphasizes the importance of intersubjective evaluation, and recommends the choice of a pertinent improvisation for analysis, as the method is time-consuming. Lee chooses an improvisation from two years of music therapy with Eddie, a HIV positive client who died in 1995.

Lee proposes a progression in nine stages:

1. Holistic listening

Several listenings in order to obtain a sense of the entire improvisation, including open listening, listening for shapes and structures, description and transcription of significant musical elements, and a final open listening.

2. Reactions of therapist to music as process

Including feelings and thoughts immediately after the session, and reflective comments on the client's process.

3. Client listening

The client comments on the taped improvisation. The therapist records and transcribes the conversation.

4. Consultant listening

One or several relevant experts comment on the improvisation. The therapist records and transcribes the conversation.

5. Transcription into notation

Different types of notation are possible, including aural transcription, computer-assisted representation, and diagrams.

6. Segmentation into manageable musical components

e.g. according to changes in texture, themes, or tonality.

7. Verbal description

Concise description of striking or substantial elements.

8. In-depth analysis of segments and comparison of data

This is the culmination of the analysis. A variety of analytical questions are relevant (pp. 157-165).

9. Synthesis

Integration of all obtained data, and clinical conclusions pertinent to the information gathered.

It is Lee's aim to find a balance between musicology and clinical rigor, attempting "to connect two separate yet inherently connected worlds; the personal and the musical" (p. 166). His method is profound and elaborate. The progression displays similarities with Ferrara's eclectic method (this chapter p. 20), in its combination of repeated listening, variable focus, verbal description, analytic scrutiny, and systematic interpretation.

2.3.7. Forinash (2000): On Listening to Edward

In her article "On Listening to Edward. I have to wait for the moment that I'm doing the music to figure out what the meaning is", Michele Forinash describes a practical application of Ferrara's approach in the training of music therapy students' listening skills.³⁰

Edward's desperate cries

For classroom listening with a group of students, Forinash chooses the cassette tape recording of "Edward", a well-known case study published by Nordoff and Robbins (1977:23-36), and reprinted in *Nordic Journal of Music Therapy* (1998).³¹ Edward is a 5 ½ year-old autistic boy, and the tape excerpts provide striking examples of the therapist's response to Edward's violent screaming. In the first and third sessions, the therapist establishes a dramatic and provocative musical interchange, and this strategy eventually leads to expressive, intercommunicative singing and playing in the ninth session.

³⁰ *Nordic Journal of Music Therapy* 2000, 9 (1), 83-96. Forinash's article is part of an article series, "Dialogues on the study of Edward".

³¹ *Nordic Journal of Music Therapy* 1998, 7 (1), 57-64.

Edward's penetrating and desperate cries evoke strong reactions in many listeners, including Forinash, her students, and the present author.

Neutralizing the natural attitude

It is Forinash's intention to teach the incoming music therapy students the importance of listening, and she is aware that the students often come with a certain predisposed way of listening. They have preconceptions about what is good and what is not good in music, and they may come with an idealized image of how to use music in therapy.

Forinash is convinced that it is important to interrupt or neutralize the predispositions of the students. As a remedy against their habitual and idealized ways of listening, she implements a procedure which aims at "bracketing" the students' "natural attitude", suspending their previous beliefs about music and music listening (p. 84).

A procedure for intensive listening

Forinash chooses to let the students listen six times to each tape excerpt. After introducing the case story of Edward, she defines six listening levels, explains what to listen for, and encourages the students to record their responses in the form of notes or drawings. In order to maintain the intensity of Edward, Forinash allows no discussion between the repeated listenings. The six listening levels are as follows:

1. *Open listening*
2. *Listening for structure and syntax*
3. *Listening for sound as such*
4. *Listening for semantic*: The meaning of the session
5. *Listening for ontology*: Edward's life world.
6. *Final open listening*.

Forinash's intention to do something provocative in the classroom pays off. The order of levels seems particularly appropriate for listening to the emotionally disturbing sounds.

At *level 2*, the listening focuses on the therapist's phrasing and choice of musical elements, thus attenuating the impact of Edward's cries.

At *level 3*, the listening focuses on the acoustic features of Edward's voice, thus preparing an understanding of his outbursts as a primordial kind of musical expression. Both listenings serve to modify the "natural attitude" without completely disregarding it.

During the listenings, Forinash observes marked changes in the individual students' engagement from level to level.

Conclusions

A concluding discussion permits comparison of responses, and promotes the understanding of the client's situation, the therapist's strategy, and the outcome of the therapeutic intervention. The students have the opportunity to reflect upon the different levels of listening, and the influence of their own cultural background and world view.

The article reports thought-provoking accounts of the students' and the tutor's observations and responses to Edward's therapy sessions. Forinash's procedure demonstrates the mind-opening effect of the phenomenological approach in classroom listening (pp. 85-88).

2.3.8. Trondalen (2004): *Klingende relasjoner [Vibrant Interplay]*

Gro Trondalen's dissertation is a study of "significant moments" in music therapy improvisations with young people suffering from anorexia nervosa. It was published in Norwegian in 2004, and summa-

ries of her work have appeared in English in the form of articles (2003, 2005) and a book chapter (2007).

Philosophical background for a phenomenologically inspired procedure

Trondalen devotes considerable energy and reflection to developing a procedure for description and analysis of improvisations (2004:41-72). She considers it important to focus on the experiences, events and interpersonal relations in clinical practice before applying theoretical explanations. With reference to Creswell (1998:236) she makes the following demands:

- The researcher must suspend her own preconceived understanding of a phenomenon.
- She must be able to experience an object through her own senses (that is, being conscious of an object), as well as seeing it “as real” outside herself.
- She must be able to describe the individual experience and the meaning ascribed to it in statements that capture the essence of the experience (2004:51).

In her search for a philosophical background for the procedure, Trondalen adheres to Føllesdal's understanding of Husserl, which implies that meaning is a primordial experience (Føllesdal 1969, 1993). She also acknowledges Polkinghorne's emphasis on including description, interpretation, and interpersonal relations (Polkinghorne 1989:45-47), and Merleau-Ponty's fundamental idea that the body is the basis for experience of the world.

Trondalen decides to include phenomenology, hermeneutics³² and bodily experience in her investigations, and finds an adaptation of Ferrara's procedures suitable for this purpose. She discusses Ferrara's 1984 and 1991 methods, compares adaptations by different researchers, and conducts a preliminary test analysis (2004:60-72, 496-497). On the basis of these preparations and considerations, she proposes a nine-step phenomenologically inspired procedure for description and analysis of music therapy improvisations (2004:73-75, 2007:200-204).

Trondalen's nine-step procedure

1. Contextual step

Clarification of the client's personal, social, biological and musical history, and the client's history of treatment.

2. Open listening

- a) Listening to the improvisation as one enduring whole many times, allowing different layers of sensations, feelings and meaning to emerge.
- b) Body listening: The researcher moves to the music in order to be aware of the bodily aspect in the analysis.

3. Structural step

- a) Description of sound and intensity experienced in time, and drawing of a graphic intensity profile.
- b) Structural analysis of the sound and music measured in time (SMMA)³³, illustrated by a score. It is important to notice musical codes and musical relationships between client and therapist at a structural level.

³² Hermeneutics can be considered a “second phenomenology”, as proposed by Ihde (1976:17-23, this chapter p. 9).

³³ Trondalen (2004:495) applies an adapted version of Grocke's Structural Model of Music Analysis (SMMA), described in this chapter p. 34.

4. Semantic step

- a) Description of musical structures in relation to the client's comments, gestures and verbal metaphors, in order to clarify explicit referential meaning in the music.
- b) Focus on codes and symbols in the music which may reveal implicit meaning in the musical interplay between client and therapist. The music may be seen as a metaphor for being in the world.

5. Pragmatic step

A search for a potential effect or outcome of the improvisation in the therapy process.

6. Phenomenological horizontalization

Listing of important issues, musical cues and events in step 3, 4 and 5. In the horizontalization, all elements are assigned equal status.

7. Open listening

- a) Listening again to the improvisation as one enduring whole, allowing every significant element of the improvisation to emerge.
- b) Body listening: The researcher moves to the music, allowing more dimensions of the improvisation to emerge.

8. Phenomenological matrix

A descriptive summary, synthesizing previous information from the analyses into three unit blocks: a) the music. b) the potential meaning of the music. c) a possible effect of the improvisation within the music therapy treatment process.

9. Meta-discussion

A discussion which takes into consideration the descriptive summary in the phenomenological matrix, the client's comments and behavior, the final interview with the client, the therapist's self-reflexive notes, and theoretical and philosophical aspects.

Two clinical cases

Trondalen applied this procedure in the analysis of two cases of anorexia nervosa, Julie, a young woman, 25 years old, and Simen, a young man, 19 years old. For each client, she selected one significant improvisation on the basis of comments by the clients and a concluding interview. She then asked three persons, a scientific adviser, a peer therapist and herself to listen to the recordings and indicate important moments in the music. The "significant moments" selected for description and analysis were the moments indicated by all three listeners (2004:36-38).

Improvisations

In the selected improvisation, Julie sang and played drums, the therapist played piano. The improvisation was the second out of ten, duration 2 minutes and 46 seconds, containing three rather short significant moments, lasting for 9, 25 and 8 seconds.

In Simen's selected improvisation, he played piano for the first time during the therapy process, the therapist played percussion. The improvisation in question was the second improvisation in the seventeenth out of nineteen sessions, duration 13 minutes and 43 seconds, containing three somewhat longer significant moments, lasting for 34, 49 and 44 seconds.

Application of the procedure

The nine-step procedure constituted the basis for detailed descriptions and interpretations. Step 1 described the client's history and background. The open listenings in step 2 included the entire im-

provisation. Steps 3, 4, 5 and 6 focused on the significant moments. Steps 7, 8 and 9 again took the entire improvisation and the client's history and situation into consideration. Trondalen's procedure includes a number of noteworthy features.

Step 1

First, the researcher makes an effort to be conscious of her own possible biases. In step 1, she clarifies her pre-understanding of the client's history and situation before the open listenings in step 2. Again, the "horizontalization" in step 6 is a means of eliminating biases, giving equal value to salient observed features before the open listenings in step 7. Trondalen is aware that a complete neutralization is not possible, because the list of observed features is influenced by previous interpretations (p. 72).

Step 2

Next, the introduction of body listening in step 2 is an important addition. This is motivated by the prevalent bodily aspect of the clients' problems, but body listening may as well be fruitful for understanding improvisations with other kinds of clients.

Steps 3-5

In step 3, the researcher draws an intensity profile of the whole improvisation and separate intensity profiles of each significant moment. These graphic curves are based on the experience of sound in time and the understanding of intensity as a level of activity and assertive expression (p. 70). Together with the score notation, the intensity profiles provide frameworks for the semantic and pragmatic interpretations in steps 4 and 5. This is in accordance with Ferrara's requirement, to base referential and ontological insight on descriptions of musical structure (this chapter p. 24).

Steps 6-9

After the horizontalization and a second round of open listenings in steps 6-7, step 8 presents a final summary of musical structure, semantic meaning and pragmatic effect. Altogether, the phenomenological descriptions provide a many-faceted material for an ample discussion in step 9, related to relevant theories (Julie pp. 246-289, Simen pp. 310-352). Thus, the researcher is true to the phenomenological ideal. She bases the descriptions during steps one through eight on experience, and defers theoretical explanation to step nine. Trondalen has designed and applied an elaborate model for description and analysis of music therapy improvisations.

2.3.9. Bonde (2004) *The Bonny Method of Guided Imagery and Music (BMGIM) with Cancer Survivors*

Lars Ole Bonde's dissertation is a psychosocial study with focus on the influence of BMGIM on mood and quality of life. In his study, Bonde applies a phenomenological approach to the preparation and drawing of musical intensity profiles.

The intensity profile

One of the tools for analyzing the interrelationship of music and imagery in BMGIM is the intensity profile, which is a graphic curve that depicts the varying intensity in a piece of music. In the context of this study, Bonde understands intensity as "a composite phenomenological concept, synonymous with the subjective experience of the music's "power" (p. 140). Several aspects of the musical experience contribute to intensity, such as tension, volume, crescendos, melodic movement and phrasing, mood and texture (p. 252). Bonde bases the intensity profile on,

- (1) Verbal phenomenological description of the music.
- (2) Auditory and visual analysis of the musical form, consulting the score.
- (3) Mood analysis according to Kate Hevner's mood wheel (p. 576)³⁴.
- (4) Analysis of the image potential.

Emotion and narration

Two predecessors have inspired the design of intensity profiles, firstly Helen Bonny's diagrams, which roughly depict emotional effects of GIM programs as plateaus and peaks of a graphic curve (pp. 242-243, Bonny 1978:42, 48). A second inspiration is the graphic curve of the "narrator's model", utilized in narrative theory and journalism to illustrate the unfolding of a story's plot. This curve depicts the psychological tension and release intended by the narrator and experienced by the reader or listener (p. 51). Typical peaks in the curve are "attack", "point of no return", and "climax".

Similar to the narrator's model, the aim of a musical intensity profile is to provide a graphic visualization of the listener's experienced psychological tension and intensity. A GIM client's music-guided "journey" displays similarities with a narrative plot, and the plateaus and peaks of an intensity curve are relevant for clarifying the course of a GIM journey.

Designing an intensity profile

Bonde's prominent example is Brahms' Violin concerto, 2nd movement, duration 9'34, included in the BMGIM program "Mostly Bach" ³⁵ (pp. 248-255). His basis for drawing the intensity profile is the following:

1 - 2. Description and analysis

A detailed overview of the Brahms movement (pp. 563-564) combines phenomenological description, timing of the CD recording, and precise references to the notated score. The description includes emotional expression, observations of motifs, instrumentation, tonality, sound quality and interplay of the instruments. The overall musical form is described as a progression from initial stability through a course of unpredictable changes, back to final stability.

3. Mood

A mood analysis (p. 251) supports the formal analysis. In the first and last sections, Hevner's moods no. III: "dreamy, tender" and IV: "lyrical, tranquil" prevail. In the contrasting middle section, moods no. II: "pathetic, doleful" and VII: "dramatic, passionate" are prominent.

4. Image potential

The analysis of image potential includes intersubjective corroboration based on responses from a group of music therapists in a workshop (p. 252).

The combination of attentive listening, verification by score analysis, and intersubjective cross-checking underpin the reliability of Bonde's approach.

The resulting intensity profile of the Brahms movement (p. 251) provides an overview of the music. It facilitates identification of formal elements, themes, instruments and other musical features, and estimation of the suggested moods. Importantly, the intensity curve identifies the potential emotional peaks of the music.

The intensity profile serves as a guide for listening and for estimating the music's therapeutic potential. The present author's listening experience is consistent with the intensity peaks of the curve. However, individual listening experiences may be variable.

³⁴ Hevner (1936:249, 1937:624)

³⁵ Grocke has described the program "Mostly Bach" (2002:115-117).

2.3.10 Summary of the phenomenological descriptions

One article, Forinash (2000) indicates the value of a phenomenological approach in classroom teaching. The remaining eight studies report phenomenological descriptions related to music therapy sessions.

Ruud (1987) introduces an important modification of Ferrara's approach, replacing Ferrara's syntactical, semantic, and ontological steps with three levels that are more appropriate for describing music therapy practice; the structural, semantic, and pragmatic levels.

Forinash & Gonzalez (1989) adapt Ferrara's procedure in order to describe the background and course of a music therapy session. They conduct a pioneering study that demonstrates the application of a phenomenological approach in qualitative research. Amir (1990) confirms the usefulness of the procedure suggested by Forinash and Gonzalez.

Kasayka (1991) conducts another pioneering study, applying phenomenological description in receptive GIM therapy. For the description of music, she chooses Ferrara's five-step method, and concludes that this progression enhances the therapist's understanding of the music and its clinical potential. Her verbal descriptions are closely related to the tradition for interpreting music in GIM.

For the analysis of session material, she chooses a version of Forinash and Gonzalez' procedure. Her approach permits the description of relationships between the music and the client's imagery. This description constitutes the basis for therapeutic and spiritual interpretation of the session.

Grocke (1999) applies the first two steps of Ferrara's method in her phenomenological description. Her objective is the identification of pivotal moments in GIM sessions. For this purpose, the steps *open listening* and *listening for syntax* are sufficient.

The *open listenings* are very particular, as they include Helen Bonny's comments, taped while the music was playing. The open listenings serve to document Bonny's personal descriptions of music selected for GIM programs.

Grocke's *listening for syntax* represents a further development of Kasayka's analyses of session material. In order to uncover the relationships between the music and the client's experienced imagery, Grocke develops a system for identifying Imagery Meaning Units and Music Meaning Units. This step in the description of music is closely related to score analysis.

Lee (2000) combines a phenomenological approach with other kinds of analysis. The strengths of his method are the precise documentation of musical features, the inclusion of comments on the improvised music and the therapy sessions, and the emphasis on intersubjective validation.

Trondalen (2004) adds new steps to a selection of elements from previous procedures. In her nine-step progression, she emphasizes the importance of eliminating the researcher's own biases. First, an initial evaluation aims at clarifying the researcher's pre-understanding. Subsequently, a phenomenological horizontalization assigns equal value to all elements in the description. Trondalen acknowledges the value of open listenings, and adds body listening and the drawing of intensity profiles to her procedure.

For the purpose of designing intensity profiles of music, Bonde (2004) combines a phenomenological approach with other methods of analysis. Descriptions of experienced musical features, moods and relationships are combined with detailed score analyses, and the image potential of the music is verified by intersubjective validation. The intensity profile permits the identification of emotional peaks in the music, and the estimation of the music's therapeutic potential. The design of intensity profiles adds a new aspect to the phenomenological description of music.

The phenomenological approaches in the summarized studies represent different variations of Ferrara's procedure, modified for use in music therapy; client background / open listening / sound as such / structure / semantics / pragmatic interpretation / open listening / critical evaluation.

All of the procedures are different, but related. Together, they provide an array of elements for phenomenological description that can be selected and combined in future studies.

2.4 Experimental Phenomenology: A project in experimental listening

Background and objective

Don Ihde's book *Experimental Phenomenology* (1977) is an introduction to conducting investigations in visual phenomenology, including practical exercises. His book *Listening and Voice* (1976) introduces methodical approaches to investigations in auditory phenomenology, but provides no exercises or examples. As a contribution to auditory phenomenology, the present author has conducted practical listening experiments which combine approaches from Ihde's two books. This idea was suggested by Michele Forinash (Personal communication, 2010).³⁶

It is the aim of the project to explore the application of phenomenological variations in music listening, in order to add a new operational procedure to the phenomenological investigation of music.

Research questions

What questions and listening tasks are relevant and fruitful for the phenomenological investigation of music?

What kinds of progression and procedure are profitable?

What are the achievements of phenomenological investigation of music?

2.4.1. Don Ihde's method

In *Experimental Phenomenology*, Ihde presents the claim that phenomenological experiments should be conducted according to a set of controls and methods. And in order to understand phenomenology, one has to do phenomenology (pp. 14-15). He describes three levels of investigation (pp. 34-42):

First level

Specify the field of investigation by suspending ordinary belief and taken-for granted theory.

Second level

Investigate the essential features and structures belonging to the experienced object.

Third level

Reflect upon the relationship between what is experienced and the way it is experienced.

First and second levels encompass phenomenological reductions, "methodological devices that clear the field and specify how it is to be approached" (p. 41). It is appropriate to remember that in phenomenological language, the meaning of "reduction" is "to lead back", derived from the word's latin origin. The idea is to lead the inquiry back to "the things themselves", liberated from presuppositions.

³⁶ In a seminar 25 April 2010 in Aalborg University, Forinash introduced Ihde's *Experimental Phenomenology*, and suggested that Ihde's ideas could be applied in the auditory domain.

First level

For level one, specifying the field of investigation, Ihde prescribes three rules of activity:

- Attend to the phenomena of experience as they appear and how they show themselves. Establish a field of purely present experience (p. 35, 38).
- Describe, don't explain. The focus is on describable experience as it shows itself. Do not attempt to give explanations of the phenomena (pp. 34-36).
- Equalize all immediate phenomena. This means that one has to think of all phenomena as "equally real". The aim is to avoid believing that some things are more real or more fundamental than other things. Equalizing phenomena is also called "horizontalization" or "horizontalization" (pp. 36-37).

Second level

At level two, one can carry out the investigation of essential features and structures of the experienced object by performing phenomenological variations, that is, applying different ways of focusing on the object (pp. 39-40).

Third level

For level three, the reflection on the process of experience, Ihde spells out that "*every experiencing has its reference or direction towards what is experienced, and contrarily every experienced phenomenon refers to or reflects a mode of experiencing to which it is present*" (pp. 42-43, italics in original).

There is a correlation between the two sides of experience, one does not exist without the other (Husserl 1970:151). Husserl named the two sides of the correlation. That which is experienced is called *noema*, and the mode of experience is called *noesis*. The correlation itself, the "directedness" of consciousness, is termed *intentionality*.

On the basis of a discussion of Husserl's ideas, Ihde presents the process of experience in schematic form:

(I)noesis -----> noema
3 --- 2 ----- 1

The numbering indicates that the appearance of *noema* comes first. Subsequently, a reflection on the process discloses *noesis*; how *noema* is experienced. Finally, a further reflection reveals the "I" as the bearer of experience.

Ihde illustrates these relationships with a musical example. Listening to a woodwind quintet, the listener can choose to focus on the oboe, even if some other instruments may be louder and more prominent. Thus the oboe stands out as a core phenomenon, the *noema*, and listening for the oboe is the *noetic* activity. This process reveals the "I", which obtains its significance through its encounter with the sound of the oboe and its background (pp. 49-51).

The order in the phenomenological analysis is crucial. Primarily something appears, then the reflexive awareness reveals the correlation between *what* appears and *how* it appears, and this correlation constitutes the experiencing *who*. In other words, the "*who*" or the "*I*" only shows itself in its involvement with its projects. The "*I*" is not located inside the skull. It is constituted again and again in every conscious experience of the world.

Visual phenomena and multi-stability

In *Experimental Phenomenology*, Ihde has chosen to conduct phenomenological explorations of visual phenomena, investigating a number of *multi-stable* visual phenomena. A multi-stable phenomenon can be perceived in two or several alternating appearances, such as the Danish psychologist Rubin's well-known drawing, which can be perceived as a vase or as two faces. Each appearance is only stable for a while, then another gestalt stands out. In a progression of systematic step-by-step investigations, Ihde demonstrates how deliberate variation of perception can reveal or provoke unnoticed appearances of multi-stable drawings. He demonstrates two strategies for variations.

One strategy is the *focusing strategy*.³⁷ Ihde's example is a drawing, Figure 2.1, where lines appear to be curved, even if they in reality are strict and parallel (p. 82-84)

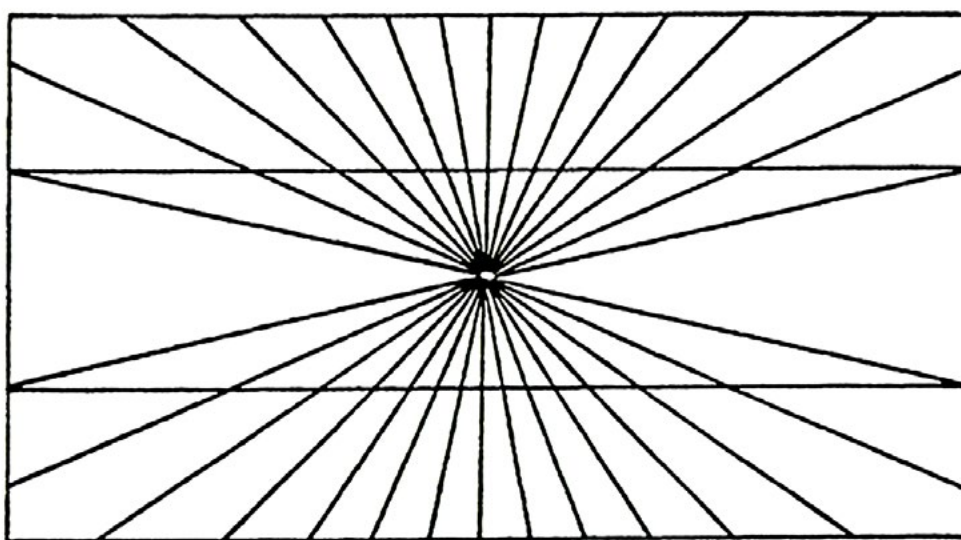


Figure 2.1. Visual multi-stability: The focusing strategy.

(Ihde 1977:82)

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The perceptual experiment consists of focusing on the vertex, where all the diagonal lines converge in the center of the figure, and deliberately push this point back into infinity. By this concentrated focusing, which may call for some exercise, the curved lines will appear straight. The modification of focus is a modification of *noetic shape* (p. 87).

The other strategy is the *hermeneutical strategy*. Ihde's example is another familiar multi-stable drawing, the figure of a cube which can reverse itself into two different appearances, so that the front side becomes the back side and vice versa (Figure 2.2). This reversal seems to occur spontaneously.

³⁷ The term "focusing strategy" is the author's suggestion. Ihde's term is "transcendental strategy", a more philosophical term which indicates that this strategy concerns the conditions of possibility of perception (p. 89)

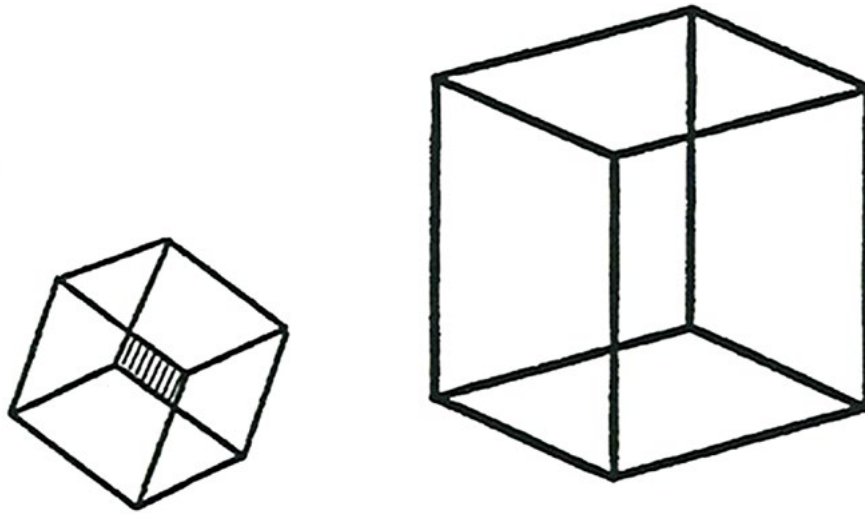


Figure 2.2. Visual multi-stability: The hermeneutical strategy.

(Ihde 1977:96)

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Ihde suggests a third possibility, to suppose that the figure is not a cube, but a two-dimensional drawing of an insect with six legs. In the left part of Figure 2.2, the shaded part in the middle can be seen as the insect's body. Again, it takes an effort to modify one's perception, but it helps to insist that one sees an insect. This is the point. A title, an indication or a story will tend to alter the interpretation of one's perception. Stories and names are used to create a *noetic context* (p. 88). The following section will illuminate both kinds of phenomenological variation, the modification of focus, and the modification of context.

2.4.2. Listening strategies

In order to explore the practicability of experimental phenomenology in music listening, the author has conducted a series of experimental listening sessions according to Ihde's strategies.

It is relevant to apply both the focusing strategy and the hermeneutical strategy to music listening. Ihde conducts his experiments with multi-stable visual figures. In a similar, but more fundamental way, music is multi-stable. It can display multiple appearances depending on the listener's focus and interpretation. It is not difficult to modify the perception of music by a change of focus, title or context. In other words, the musical experience is multivariable.

Some researchers express the same view. Ian Cross states that music has a sort of "floating intentionality", which implies that music can gather meaning from different contexts (2005:30). Similarly, Aksnes and Ruud "believe that music is so *indeterminate* (...) that it can be interpreted in myriad manners" (2008:55, italics in original). Experimental listening can contribute to clarifying the variability of musical experience and musical meaning.³⁸

³⁸ Scherer & Zentner, in a seminal article, propose that an emotion experienced by a listener while listening to music is determined by the interaction of four factors: the musical structure, the musical performance, the listener, and the listening context (2001:365).

Experimental listening is based on performing phenomenological variations. It consists of conducting a long series of repeated listenings, guided by deliberately varied music-focusing strategies and hermeneutical strategies, and clarified by intersubjective inquiry. This progression takes time, and requires commitment and patience.

Experimental listening mixes three types of listening: open, music-focused, and hermeneutical. In an open listening, one listens to the music without any particular focus or cue. A music-focused listening centers on a particular aspect of the music, directed by a specified question, task, or problem. A hermeneutical listening is guided by a cue for interpretation, for example the title of the music, or an association to a context or an activity. To a large extent, the nature of the particular piece of music determines the sequence of open, music-focused, and hermeneutical listenings. Each listening evokes new questions for further investigation of the music,³⁹ and the aim of the successive listenings is "to let the music show itself from itself".

Intensive music listening: A first step towards experimental listening

The background of experimental listening is the procedure of intensive listening, which the author developed on the basis of Thomas Clifton's *Music as Heard*, and practiced for a number of years with groups of music listeners. He has described the procedure in a working paper (Christensen 2007, appendix 2.01).⁴⁰ Intensive listening is not a strict phenomenological method, but the procedure has basic features in common with a phenomenological approach.

The objectives of the procedure are (1) to get a group of listeners to accept unknown and unfamiliar music, (2) to sharpen and educate their attention, and (3) to make them describe the musical experience in their own words.

The groups of listeners are typically high school classes, or groups of university students. The music excerpts are short (1-2 ½ minutes), so that the participants can retain the music immediately in memory. The group listens to the excerpt approximately seven times. The steps of the progression are as follows:

39 This observation coincides with Gadamer's view that a question "comes" to us, that it "arises" or "presents itself", see note 23, this chapter.

40 The approach of intensive listening is discussed by Bonde (2009b:191, 213-214)

A basic model for the practical progression of intensive listening in a class

1. Listen.
2. Listen once more.
Talk together in pairs, describe what you have heard.
3. Listen a third time, listening for something your dialogue partner has told you.
Talk together again.
Short general discussion: The tutor asks all groups, collecting their impressions and descriptions on the whiteboard or a flip chart (it is a good idea to keep the results on paper for later use).
4. The tutor asks one clear and simple question.
Listen and talk together in pairs. Short general discussion.
5. The tutor asks another clear and simple question.
Listen and talk together in pairs. Short general discussion.
6. The tutor asks a third question.
Listen (dialogue may not be necessary at this stage). Short general discussion.
7. The listeners talk together in pairs and formulate questions for the next listening.
Collection of all questions.
- 8...

This progression represents a simple practical introduction to performing phenomenological variations. From a phenomenological point of view, it is relevant to notice the importance of listening twice before describing or judging the music. Two open listenings without comments or reactions eliminates or weakens the “natural attitude”, which might otherwise result in a spontaneous rejection of unfamiliar music.⁴¹

It is important that the music excerpt is short enough to be retained in working memory. This ensures that the listener achieves a certain degree of “ownership” of the music after the second listening, no matter if he or she likes the music or not. The dialogue situation allows spontaneous and informal verbalization of the listening experience and, importantly, implies a certain measure of tolerance and respect for the dialogue partner’s observations and reactions. Usually, all participants have a lot to say in this situation.

Mutual respect is the basis for the third listening, “listen for something your dialogue partner has told you.” This way of listening is an opening towards a phenomenological attitude, listening for unnoticed aspects of the music.

⁴¹ Judy Lochhead, who is a U.S. musicology professor, reported this kind of experience in teaching university students. In spite of her explanations of the developments and structures of twentieth century music, students could still not hear the music as anything other than noise. (Lochhead 1995, p. 35). Lochhead overcame the students’ resistance by showing movies of performances and composers.

The tutor's listing of all comments and observations represents a phenomenological horizontalization, such as described by Creswell; "the researcher lists every significant statement relevant to the topic and gives it equal value" (2007:235). In this way, the tutor expresses accept of all kinds of comments. Even if this accept may not neutralize all sedimented beliefs and negative reactions towards the music, in most cases the path is now clear for step four, investigation of the music guided by a focusing question. This step represents the beginning of phenomenological variations.

The following steps represent further phenomenological variations, which can proceed as far as time and the motivation of the participants allow. In the progression, the tutor makes decisions, choosing between music-focusing and hermeneutical listening. He or she has prepared questions and cues in advance, and can also benefit from new questions arising from the participants' observations and comments. The investigation maintains the dialogue format as long as necessary in order to facilitate unimpeded and informal description. It is rewarding to round off with an open listening.

Intensive listening to an excerpt of music can serve as an introduction to the whole piece. The familiarity with the musical features of the excerpt facilitates continued listening to the same piece of music.

2.4.3. The experimental listening project

The sessions of experimental listening involved two participants who had experiences of intensive listening, and were motivated for further exploration. One had prepared the sessions, the other responded to questions, tasks and cues, and contributed actively to the course of the progression. Similar to intensive listening, experimental listening consists of the alternation of open, music-focused, and hermeneutical listening, but it proceeds much further, applying phenomenological variations in numerous listenings. The outcome is a progressive appropriation of the music, a cumulative description of the music in its entirety and its details (noema), and reflections on the variable process of listening (noesis).

The musical pieces selected for experimental listening were the following:

1. Bela Bartok: An Evening in the Village. No. 1 of Hungarian Sketches for orchestra, Sz 97 (1931). Chicago Symphony Orchestra, cond. Pierre Boulez. DG 445 825-2. Duration 2'47.
2. Anton Webern: Bagatelle for String Quartet op. 9 no. 1. (1913). Emerson String Quartet. DG 445 828-2. Duration 0'30.
3. Coleman Hawkins, tenor saxophone with band: Body and Soul (11 October 1939). RCA Bluebird ND 85717. Duration 3'00.

Reasons for these selections were that the pieces relate to other paragraphs of the present text, and that the performance quality of the three recordings is high. Bartok's piece is included in the GIM program "Present Moments" (Chapter 5). Webern's *Bagatelle* is the object of an analysis by Thomas Clifton (This chapter). Hawkins' saxophone solo is described in *The Musical Timespace* (Chapter 4).

As a dialogue partner in the sessions of experimental listening, the author (EC) invited Lise Christensen Bjerno (LCB), a relative of the author, who is a professional musician, conductor and composer, and who has gained experience as a tutor of intensive listening.

Procedure

1. Preparation

EC conducted a series of preparatory listenings, approximately 15, in order to collect first-hand observations and reactions, possible questions and listening tasks, requests for new ways of listening, possible cues for hermeneutical listening, and problems to be solved or clarified.

2. Listening strategy

EC sketched a preliminary succession of questions and cues. Experience from intensive listening suggests that hermeneutical interpretations as well as music-focused observations will appear in a participant's experience of the music. It is an ongoing task to decide on a favorable sequence of music-focusing and hermeneutical approaches. The initial open listenings will often provide guidelines for these decisions.

3. Experimental listening

LCB and EC conducted a series of listenings, approximately 30, performing phenomenological variations directed by questions, tasks, and cues. The variations alternated between open listening, music-focusing listening, and hermeneutical listening.

In general, EC decided the sequence of questions, tasks and cues. Common consent often occurred, and the progression of observations and comments influenced the nature and order of further listenings. In the dialogue, LCB provided most of the answers and descriptions. EC wrote a continuous report, in some cases including EC's own comments and reflections. The full reports are attached as appendices 2.02 (Bartok), 2.03 (Webern), and 2.04 (Hawkins).

Observations, descriptions and reflections

As a basis for the following observations and descriptions, the author agrees with Clifton's basic assumption that time, space, motion and feeling are necessary constituents of the musical experience. Moreover, he adopts Ihde's distinction between wide, broad and narrow focus, as well as his propositions that silence appears at the horizon of sound, and that the horizon situates the field, which in turn situates the observed event or object.

Further, he acknowledges the conditions for an ongoing investigation proposed by Thøgersen in her discussion of the phenomenological attitude. She states that "we must constantly try to connect different experiences of a phenomenon in a coherent analysis, which continuously clarifies and adjusts the phenomenological description" (2012, in press).

The fields of investigation are characterized as spatial, spatial-temporal, temporal, and hermeneutical. These fields are not strictly delimited, because temporality and spatiality are mutually related in the experience of music.

2.4.3.1. First investigation. Bartok: An Evening in the Village (2'47)

For full descriptions of all listenings, see appendix 2.02.

1. Preparation

EC's 15 listenings of Bartok's piece engendered the following fields of investigation:

Music-focused

Spatial focus

Wide and broad focus: Foreground and background. Solo and accompaniment. Transparency and density. Layers and surfaces of sound. Voices in polyphony. The total space of sound.

Spatial-temporal focus

Wide and broad focus: Movement and sustained sound. Nature and categories of movement. Character of melody. Differences and similarities. Division into sections. Musical form.

Narrow focus: Qualities of single sounds. Timbres. Instruments. Dynamic evolution of a tone. Clarity, vibrato, pizzicato.

Qualities of composite sounds: Fusion and segregation of components. Harmony and other kinds of simultaneity. Compound qualities of orchestration. Expansion of unison in several octaves.

Temporal focus

Wide and broad focus: Continuity, interruptions, pauses. Beginning and ending of a phrase, layer or section. Ensuing silence. Pulse, meter and rhythm. Tempo contrasts.

Narrow focus: Attack – sustain – release. Small tempo variations, rubato. Beginning and ending of a single sound, appearing from and disappearing in silence.

Hermeneutical

Emotional qualities: The listener's feelings (felt emotions) and the emotions experienced to be inherent in the music (expressed emotions). Moods inherent in the music.

Sensory integration and embodiment: Light, shadow and darkness. Color associations. Tactile qualities.

Context-related descriptions: Statements and responses. Song and dance. Similarity with birdsong.

2. Listening strategy

LCB and EC listened to Bartok in two sessions, 17th and 24th August, 2011. The first listenings benefited from the fact that the Bartok score indicates three slightly different titles: "An Evening in the Countryside", "An Evening in the Village", "An Evening with the Szekelys". EC proposed to use these three titles as the context for three hermeneutical listenings (No. 3,4,5). These listenings cleared the way for the subsequent music-focused listenings, which clarified musical form (No. 6,7,8,9,10), and the qualities of single tones (No. 12,13,14). The second session did not follow a predetermined plan. Questions and tasks aimed at bringing up new fields of observations deepened the investigations.

3. Experimental listening

LCB and EC listened 28 times to the Bartok piece.

First session (No. 1-14) : The contexts suggested by three different titles evoked three specific sceneries: A familiar Danish countryside (No. 3), A village scenery from a novel (No. 4), and a theatre-like scene of the Szekely people in exile (No. 5). Subsequently, further imagery emerged: a narrator's voice (No. 7) and a tightrope walker (No. 8).

Wide temporal-spatial focus on form (No. 6-10) and narrow temporal-spatial focus on the single tones (No.12-14) promoted description and appropriation of the piece.

In No.14, listening for the endings of the tones induced a significant change in the way of listening for LCB and EC. This is a parallel to the change of multistability in visual images, as described by Ihde (1977). LCB "saw the music from the back door". EC was overwhelmed by the emptiness succeeding the disappearance of a layer of sound. These are experiences of the horizon of sound, corresponding to Ihde's statement: "The horizon is the limit where presence is "limited" by *absence*." (1976:108)

Second session: A high degree of familiarity facilitated careful description of simple and composite sounds (No. 19-22, 25-26). Listening No.15 suggested an integration of visual and auditory perception. No. 18 yielded new insight in the individual variability of spatial experience. No. 23 and 24 illuminated the experience of surroundability and directionality, and bodily awareness of the music. No. 23 provided a strong experience of the horizon between sound and silence. LCB responded: "I am surrounded by non-sound!". No. 18, 20, 23 and 24 confirmed that it is possible to change focus deliberately as well as involuntarily. No. 25 focused on the attention-attracting power of the single tone. No. 27 yielded awareness of an important field of investigation, musical expression based on small variations of tempo, sound quality and volume.

The sessions engendered the following additional fields of investigation:

Music-focused

Spatial focus: Surroundability and directionality.

Spatial-temporal focus: Interference. Simultaneity of noise and tone. Physical production of sound.

Temporal focus: Flow versus marked rhythm. Syncopation.

Relationship between tones and feeling of underlying meter: pushing / on the beat / laid back

Hermeneutical

Sensory integration and embodiment: Physical impact of sound.
Context-related descriptions: Associations: cultures, landscapes, cartoons, memories.
Narratives and scenes.

Hermeneutical and music-focused

Musical expression based on small variations of tempo, sound quality and volume

2.4.3.2. Second investigation. Webern: Bagatelle for String Quartet op. 9 no. 1 (0'30)

1. Preparation

EC's 14 listenings engendered the following questions and tasks:

General questions

1. Listen for contrasts and similarities. 2. What unfolds?

Music-focused

Spatial focus: Listen for foreground and background.

Spatial-temporal focus: Listen for sections and subdivisions.
Listen for single events versus continuity. Listen for gestalts versus fragments.
Sound qualities: Listen for qualities of the single tones.

Hermeneutical

Emotional qualities: Listen for emotional expression.

Sensory integration and embodiment: Hear the music as movement. Hear the music as voices.
Hear the music as gestures and body movement.

2. Listening strategy

The short duration of the piece (0'30) permitted many listenings. As the music was unfamiliar and had a rather fragmented texture, the session began with four open listenings and continued with hermeneutical tasks, in order to establish meaning and coherence.

3. *Experimental listening*

LCB and EC listened 28 times to the Webern piece. For full descriptions of all listenings, see appendix 2.03. After the open listenings (No. 1-4), hermeneutical tasks (No. 5-8 and 14-16) lead to descriptions of the music as characteristic persons acting on a scene. The task of dividing the music into sections (No. 9-12) contributed to coherence, suggesting an overall form: "gentle / gentle / intense / gentle".

Listening for tone qualities (No. 17-20) supported previous impressions of emotional expression. Listening for space (No. 21-22) and time (No. 23-24) entailed a change from hearing "acting persons" to hearing "absolute music". Further listenings (No. 25-26) explored details of sound production as a technical correlate of emotional expression.

During the final open listening (No. 28), LCB heard all of Webern's six Bagatelles for string quartet for the first time. LCB's comment "Lots of fun!" confirmed that experimental listening of a limited part of the music can serve as an entry to the whole work.

The session engendered the following additional questions and tasks:

Music-focused

Spatial focus: Listen for the space between high and deep tones.
What happens at the top? What happens at the bottom?

Spatial-temporal focus: Listen for qualities of the high tones. Listen for qualities of the deep sounds. Listen for composite tones.
Sound production: what physical surfaces meet to produce the sound, and how do they meet?
How does the music come to an end?

Temporal focus: Listen for rhythm and pulse versus unrelated events.
Listen for coherence versus interruptions, pauses.
Listen for the field of temporal presence: retention – now - protention.

Hermeneutical

Context-related descriptions: Hear the music as persons acting on a scene.

2.4.3.3. Third investigation. Coleman Hawkins: Body and Soul (3'00)

This jazz recording comprises two 32-bar choruses. The descriptions include only the first chorus (duration 1'32), except for open listenings and listening for overall form and instrumentation (No. 1, 2, 3, 4, 5 and 13), which encompass both choruses.

1. Preparation

EC's 14 listenings engendered the following questions and tasks:

Music-focused

Spatial focus

Describe the music as movement

Listen for relationships: Foreground and background. Soloist and accompaniment.
Listen for the background alone. Listen for a particular voice or instrument alone.

Spatial-temporal focus

Listen for the sound as such: Kinds of sound. Sound qualities. Tone bending. Registers

Listen for particular sound sources and instruments
Clear and diffuse qualities. Volume and energy

Describe the music as form: Divide into sections. Characterize sections
Listen for contrasts. Listen for climaxes. Listen for phrasing

Temporal focus

Listen for flow: Coherence. Interruptions, pauses, silences. Tension and relaxation.

Listen for regularity and drive: Pulse and meter. Groove, rhythm group. Has it got swing?
Tempo, tempo variations.

Hermeneutical

Emotional qualities: Listen for mood in the music. Listen for expression and emotion in the music.

What feelings does the music evoke in you?

Sensory integration and embodiment: Describe the music as bodily gestures.

Describe the music as voice. Listen to the phrases as breathing.

Describe the music as speech: "If the melody is speech, what does it say?"

Listen for light and shadow.

Context-related descriptions: Listen without a title. Listen according to the title.

2. Listening strategy

After the first open listenings (No.1-2) it was necessary to discard any preconceived plans for the listening session. The open listenings revealed marked disagreements in LCB's and EC's pre-understanding of the music, probably due to generation and gender differences, and the fact that this recording from 1939 is far below modern recording standards. EC regarded the saxophone solo as an expressive love song, while LCB was annoyed by the soloist's predominant vibrato, and heard the music as outdated, on the verge of provoking laughter. To avoid embarrassing misunderstanding, EC decided to stick to technical focusing questions for some time (No. 6-13)

3. Experimental listening

LCB and EC listened 31 times to Coleman Hawkins' solo. For full descriptions of all listenings, see appendix 2.04.

After identifying the AABA chorus form (No. 3-5), the technical questions (No. 6-13) focused on instrumentation and the groove of the rhythm group, piano, double bass and percussion. Particular issues were the quality of percussion sounds and the flow of the groove, and the question whether the single instruments played "pushing", "on the beat", or "laid back".

After an open listening (No.14), LCB described the sax solo as "lovely, soft, incredibly pleasurable". This agreement with EC's pre-understanding encouraged EC to include hermeneutical questions in the succeeding listenings.

LCB's answer to the question in No. 20: "If the sax solo is speech, what does he say?" confirmed her pre-understanding of an elderly narrator in the countryside in the 1930's. Her interpretations of tone qualities in No. 21-22 were ambiguous: "Supple variety, deep register absolutely fantastic" (No. 21). "Deep tones. Cigar smoke" (No. 22). LCB's reaction to the provocative task in No. 23: "Listen to the sax sound as bodily touch" confirmed the music's expressive qualities: "Total well-being. Lovely, affectionate, warm, gentle, supple. Excess." The final listenings (No. 26-31) aimed at tracking down the temporal qualities of swing, understood as the interplay of small deviations from a regular meter.

The session engendered the following additional questions and tasks:

Music-focused

Spatial-temporal focus: Beginnings and endings of single sounds.

Temporal focus: The temporal relationships between soloist and rhythm group.

The single instrument's relationship to the regular metre: "pushing" / "on the beat" / "laid back".

Hermeneutical

Description of the music as a narrative.

Description of the music's historical and cultural context.

2.4.3.4. The outcome of the listening project

Procedure

The sessions confirmed the utility of the procedure:

1. Preparation

Participant A conducts a series of preparatory listenings, approximately 15, in order to collect possible questions and listening tasks.

2. Listening strategy

Participant A sketches a preliminary plan for the sequence of questions, tasks and cues.

3. Experimental listening

Participants A and B conduct a series of listenings, approximately 30, performing phenomenological variations directed by questions, tasks, and cues. The variations alternate between open listening, music-focused listening, and hermeneutical listening. Participant A continuously modifies the preliminary plan according to the outcome of the listenings.

In the project, the time required was roughly four hours for preparation and four hours for conducting the session, plus one or two working days for transcribing and editing the session notes.

A summary of phenomenological variations

The sessions engendered a considerable number of questions and tasks which can be applied in experimental listening. This is a summary of the findings, categorized according to listening focus:

Music-focused

Spatial focus

Listen for foreground and background. Solo and accompaniment.

Listen for the background alone. Listen for a particular voice or instrument alone.

Listen for layers and surfaces of sound. Voices in polyphony.

Describe the music as movement.

Listen for the space between high and deep tones.

What happens at the top? What happens at the bottom?

Listen for transparency and density.

Listen for the total space of sound.

Listen for surroundability and directionality: When do you hear that the music surrounds you?

When do you hear the music coming from a particular direction?

Spatial-temporal focus

General question:

Listen for contrasts. Listen for climaxes.

Movement, form:

Listen for movement and sustained sound. What kind of movement? What kind of melodies?
Listen for phrasing. Where does a phrase begin, what is its course, where does it end?
Listen for single events versus continuity. Listen for gestalts versus fragments.
Listen for tension and relaxation.

Divide the music into sections. Mark subdivisions if relevant. Characterize the sections.
Describe the overall form. How does the music come to an end?

Sound:

Listen for the sound in itself. What kinds of sound? What sound qualities? What registers?
Clear and diffuse qualities. Volume and energy.

Listen for particular sound sources, instruments, timbres.

Listen for the qualities of the single sounds. Beginnings and endings of single sounds.
The dynamic evolution of a tone. Clarity. Vibrato. Pizzicato. Tremolo. Tone bending.

Listen for the qualities of the high tones. Listen for the qualities of the deep sounds.

Composite sound:

Listen for the qualities of composite sounds. Fusion and segregation of components.
Harmony and other kinds of simultaneity. Compound qualities of orchestration.

Expansion of unison in several octaves. Interference. Simultaneity of noise and tone.

Sound production:

What physical surfaces meet to produce the sound, and how do they meet?

Temporal focus

Flow and continuity

Listen for coherence and continuity versus interruptions, pauses, silences.
Listen for free flow versus marked rhythm.
Listen for events, gestalts and fragments, if there is no rhythm and pulse.

Music with a pulse:

Listen for regularity and drive: pulse, meter and rhythm.
Listen for tempo, tempo contrasts, syncopation.
Listen for small tempo variations, rubato.

What is the relationship between tones and underlying meter:
“pushing” / “on the beat” / “laid back”?
Is the relationship variable?

Music with a groove:

Describe the groove and the rhythm group.
Has the music got swing? If yes, how can you describe it?
What are the relationships between soloist and rhythm group?

What is the single instrument's relationship to the regular meter:
“pushing” / “on the beat” / “laid back”?

Temporal presence and absence

Listen for the beginning and ending of a phrase, layer or section, and the ensuing silence.
Listen for attack – sustain – and release of a single sound.
Does the sound appear from silence and disappear in silence?
Listen for the field of temporal presence: retention – now - protention

Hermeneutical

General question:

What unfolds in this music?

Emotional qualities:

Listen for mood in the music. Listen for expression and emotion in the music.

What feelings does the music evoke in you?

Listen for musical expression based on small variations of tempo, sound quality and volume.

Sensory integration and embodiment:

Hear the music as movement.

Hear the music as voices.

Hear the music as gestures and body movement.

Describe the instrumental music as speech: "If the melody is speech, what does it say?"

Is the instrumental music similar to song or dance?

Listen for light, shadow and darkness. Color associations. Tactile qualities.

What is the physical impact of the sound?

Does the music hit or touch your body?

Does the music fill your body? Does it penetrate your head or your body?

Context-related descriptions:

Listen without a title. Listen according to a title.

What associations and images does the music evoke?

Listen for statements and responses, "call and response".

Hear the music as persons acting on a scene.

Hear the music as a narrative.

Hear the music as the soundtrack of a movie.

Where does this music belong? What kind of place, culture, history?

The aim of the above summary is to provide an array of listening intentions which can be selected, combined, modified, and supplemented in a listening strategy. Some of these intentions may coincide with already existing listening practice in music therapy research.

2.4.4. Discussion of the experimental listening project

Can the experimental listening project be considered an adequate phenomenological investigation?

Guidelines for applying phenomenology stated in the beginning of this chapter were the following:

1. Suspend the natural attitude.
2. Adopt the phenomenological attitude.
3. Perform phenomenological variations.
4. Aim at intersubjective corroboration.
5. Explore time-consciousness.
6. Include the lifeworld as the prerequisite for phenomenological investigation.
7. Regard the body as the origin and enduring basis for phenomenological investigation.

1. Suspend the natural attitude

With regards to suspending the natural attitude, the participants had not planned to include a discussion of their personal biases in the procedure. However, the introductory open listenings gave rise to considerations of the participants' attitude towards the music. Concerning Bartok and Webern, both participants shared the bias that these pieces represented art music of established value. EC had selected the aesthetically most convincing performances.

On the other hand, the open listenings of Coleman Hawkins' saxophone solo revealed marked differences in personal bias. EC listened according to a preconceived belief that the music was an expressive love song. LCB experienced the music as outdated and slightly ridiculous. A discussion of hermeneutical interpretation was postponed, because these viewpoints were so far apart. Subsequently, as a side effect of many music-focused listenings, the participants gradually came to terms with each others' interpretations (Listenings no. 3, 14, 21, 23).

2. Adopt the phenomenological attitude

The phenomenological attitude implies investigation of a) phenomena as they appear to consciousness, b) the way they appear to consciousness, and c) the conditions for appearance in consciousness.

It was the participants' primary intention to meet the first requirement, describing the music as it appeared to consciousness. They agreed with Clifton's approach that listening could be a concern, a project, or a problem (this chapter p. 11). In particular, listening to the fragmented structure of the Webern piece represented a problem to be solved.

The second requirement, investigating the nature of the experience, was met by virtue of discoveries during the sequence of listenings. In these cases, the participants experienced new modes of listening (Bartok no. 14, 20, 22, 23, Webern no. 21, 22, 24, 26, marked with ** in the session reports). Such changes in perception may be akin to the changes in perception of multi-stable visual phenomena described by Ihde (this chapter pp. 44-45).

In a few cases, these experiences led to tentative reflections on the conditions for appearance in consciousness (Bartok no. 18, 23, marked with **** in the reports). The fact that new modes of listening occurred late in a session suggests that the change of mode may be a cumulative effect due to interaction between memory and perception.

3. Perform phenomenological variations

The application of phenomenological variations was continuously implemented in the sessions.

4. Aim at intersubjective corroboration

Complete agreement was not necessary for intersubjective corroboration. The emergence of a multitude of different hermeneutical interpretations was an interesting outcome of the sessions. Moreover,

specific differences could appear in the music-focused listenings, such as spatial visualization in two dimensions versus three dimensions (Bartok no. 18).

The most important outcome of the intersubjective exchange was the progressive appearance of new discoveries. Compared to the preparatory listenings by one participant, the investigations by two participants resulted in much more detailed, far-reaching, and interesting descriptions.

5. Explore time-consciousness

Exploration of time-consciousness was implemented by virtue of variable temporal focusing and the description of wide, broad and narrow fields of sonorous presence.

6. Include the lifeworld as the prerequisite for phenomenological investigation

The lifeworld of the participants was not thematized in the sessions. However, the 11th listening of Bartok gave rise to a long conversation about personal memories and relationships, which is not included in the report. In the hermeneutically directed listenings, references to the participants' memories were inevitable, such as the associations in Bartok listenings no. 3 and 4, and Webern listening no. 16.

Investigations of the onto-historical lifeworld of the composers was not a goal of the investigation. The interpretation in listening no. 5 of the Bartok piece hinted at Bartok's lifeworld, imagining the situation of exiled Hungarians in Transylvania after World War I.

7. Regard the body as the origin and enduring basis for phenomenological investigation

A number of questions and tasks aimed directly at describing the music in the form of body-based experiences, such as song and dance, movement, gesture and voice, mood, emotion and expression, tension and relaxation.

In addition, spontaneous bodily reactions appeared in the session reports. "The first tone enters me directly, a very fine tone, it is like a spearhead, a unicorn's horn" (Bartok no. 1).

"I feel the basses physically as vibrations in the floor" (Bartok no. 16). "I can feel the sound surrounding my shoulders" (Bartok no. 23). "Total well-being. Lovely, affectionate, warm, gentle, supple" (Hawkins no. 23).

Description of the body-based sound production in flutes included hissing and breathing (Bartok no. 12). Description of the sound production in strings included touch, bow strokes, and pressure (Webern no. 25).

A very particular bodily reaction induced by attentive listening was the sensory integration of audition and vision. "I feel my attention as a pressure around the eyes, as if I am observing from the back side of my eyeballs" (Bartok no. 15). This may reveal the participant's particular orientation toward visualization of the musical experience.

Some conclusions

Altogether, the listening project appears to constitute a reasonably adequate phenomenological investigation, which can provide guidelines for further sessions of experimental listening. The application of listening strategies in the sessions suggest the following conclusions:

Repeated phenomenological variations can disclose previously unnoticed features, details, and relationships.

Alternation between open, music-focused and hermeneutical listening can elicit novel observations.

Spatial focus and temporal focus entail different kinds of experience.

It is possible deliberately to alternate between wide, broad and narrow focus, spatially as well as temporally.

Significant changes in the mode of listening can occur, revealing new perspectives of the musical experience.

Listening for the appearance and the disappearance of sound can disclose undetected aspects of the music.

Phenomenological variations promote reflections on the listening experience.

Hermeneutical interpretation of music is multivariable.

2.4.5. Potential applications of experimental listening

Experimental listening requires attention, patience and perseverance. Typical participants are skilled and motivated music listeners, such as musicians, music therapists, educators, and music researchers.

In general, experimental listening can facilitate the appropriation of music, enhance the consciousness of expressive and structural qualities, and promote the discovery of unnoticed features and relationships in the music. The outcome of the sessions suggests that experimental listening can be useful for a number of purposes:

Description and microanalysis of excerpts from music therapy improvisations, such as pivotal moments (Grocke 1999), significant moments (Trondalen 2004), segments which have attracted special attention (Ruud 1990:232), particular moments indicated in consultant listening (Lee 2000:153-154)

Preparation and verification of musical intensity profiles (Trondalen 2004, Bonde 2004).

Uncovering and description of the expressive, structural and formal qualities which render a particular piece of music fruitful in receptive music therapy.

In receptive therapy, musical sound, musical expression, and the course and structure of musical events influence the client's feelings, imagery, and body states. Experimental listening can facilitate a close-up description of the particular features and expressive qualities in a performance that exert a decisive emotional and bodily impact.⁴²

Comparison and evaluation of recordings used in receptive music therapy.

Assessment of musical substance in high-quality recordings compared with MP3 versions of the same music.⁴³

Exploration of the variability of verbal interpretations, image potential and narrative potential in music applied in receptive music therapy.

In sum, experimental listening can serve as a tool for the observation and description of musical features and qualities which are not indicated, or merely roughly indicated, in musical notation or a technologically supported display.

42 For example the intonation and tone quality of the oboe and violin in the recording of Brahms' Violin Concerto included in the GIM program "Mostly Bach". Arthur Grumiaux is the violin soloist. Colin Davis conducts the New Philharmonia Orchestra (Grocke 1999:245, Bonde 2004:251, 563).

43 For a discussion of MP3 properties, see Sterne (2006)

Chapter 3. The Neurosciences and Music

The outcome of four conferences: Venice 2002, Leipzig 2005, Montreal 2008, and Edinburgh 2011.

Research questions

What are the aims, methods and results of the neuroscientific investigations?

What is the ecological validity of the investigations, that is, the relevance for real music ?

What kinds of musical culture are included or implied in the investigations?

What is the potential relevance of neuroscience for music therapy research?

Introduction

This chapter discusses the outcome of four international conferences on The Neurosciences and Music. The conference in Venice 2002 focused on the perceptual components of music and the import of musical training. The conference in Leipzig 2005 included studies of music and language, neurological disorders and music, music performance, and emotion in music. Prominent themes in the conference in Montreal 2008 were rhythms in the brain, music therapy and neuroscience, and musical memory. The conference in Edinburgh 2011 included studies of musical imagery, cultural neuroscience of music, and the role of music in stroke rehabilitation.

The papers published in the proceedings of the three first conferences constitute the basis for a discussion of research; the proceedings of the 2011 conference were not published at the time of writing this chapter. In order to provide an overview of research objectives in the neurosciences and music, the conference papers are summarized in surveys that indicate the aim, procedure and conclusion of each paper, a total of 193 studies.¹

Important themes for the discussion and validation of these studies are the use of musical material as stimulus in experiments, the categories of investigation, and the cultural reference of the studies. The ecological validity of a study, signified by its relevance for music listening in a real-life context, depends on the nature of the stimuli used in the experiment. For the evaluation of ecological validity, the use of synthesized sound, acoustic sounds and real music is reported in a survey of musical material. For estimation of the cultural orientation of the research, a survey summarizes the cultural references of the studies.

Moreover, to facilitate an overview, the categories of investigation are grouped into five fields of research. One field is the investigation of the neural correlates of sound. Another field encompasses culture, development, and training. A third group of studies focuses on deficits, disorders, therapy, and recovery. A fourth field of studies includes attention and memory. Finally, a group of studies investigates embodiment, motion, and emotion.²

Reports of each conference indicate noteworthy papers, critical comments stated at the conference, and an evaluation of the achievements and research problems of the studies.

Brain anatomy

The neuroscience papers are often very technical, and presuppose detailed knowledge of brain anatomy. In order to facilitate the comprehension, a number of illustrations are inserted in the text. Figure 3.1 provides an overview of the surface of the cerebral cortex. For an overview of cortical and subcortical structures, see Figure 7.1.

¹ Appendices 3.01, 3.02 and 3.03.

² Appendices 3.05, 3.06 and 3.07.

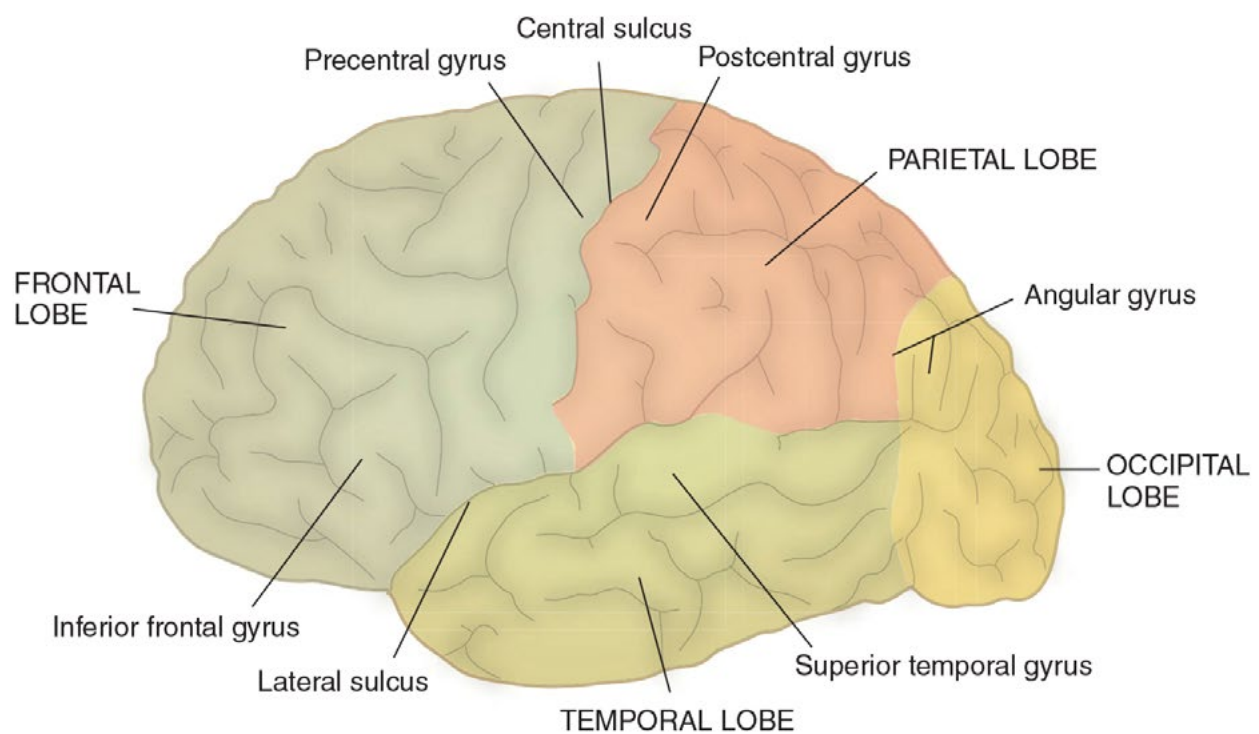


Figure 3.1. The lobes, sulci and gyri of the brain.

The figure shows the surface of the left cerebral hemisphere. The brain lobes are separated by sulci.³ Between the sulci, the surface of the cortex forms rounded gyri.

Four brain lobes can be distinguished. The central sulcus separates the frontal lobe from the parietal lobe. The temporal lobe lies below the lateral sulcus. The occipital lobe is not clearly demarcated on the surface of the cortex.

The superior temporal gyrus includes the auditory cortex and the speech area known as Wernicke's area. The inferior frontal gyrus includes the speech area known as Broca's area.

(Brodal 2010:90)

Current methods in neuroscience

The neuroscience papers refer to current measurement and neuroimaging methods.

The following abbreviations are frequently used:

EEG: Electroencephalography. The recording of electrical activity in the brain, measured by a set of electrodes placed on the scalp.

ERP: Event-Related Potentials measured by EEG. An ERP is the brain response to a specific stimulus, such as a sound or a tone. As the electrical signal is weak, it is necessary to repeat a stimulus many times and calculate the average response.

3 According to medical terminology, the singular and plural forms are sulcus/sulci; gyrus/gyri; nucleus/nuclei.

MMN: Mismatch Negativity in an event-related response, which is measured by EEG. The MMN response is elicited when a rare deviant stimulus occurs in a repeated series of identical standard stimuli, e.g.

aaaaaaaaaaaaaaaaaaaaa

The experimental paradigm is often called the oddball paradigm, the deviant being the oddball. The MMN response is automatic and pre-attentive. It occurs without conscious attention, and participants in experiments can typically watch a silent movie during the experiment.

MEG: Magnetoencephalography. MEG records the very weak magnetic fields produced by the electrical activity in the brain.

PET: Positron Emission Tomography. PET is an imaging technique that produces three-dimensional images of the brain. This technique requires the injection of a slightly radioactive liquid. Activity of the nerve cells in a brain area is correlated with the regional cerebral blood flow (rCBF) which can be registered by PET.

fMRI: functional Magnetic Resonance Imaging. fMRI produces images of the brain due to the contrast between oxygen-rich and oxygen-poor blood, the BOLD: blood oxygen level dependent contrast. Activity in a brain area is correlated with changes in BOLD.

3.1. The Neurosciences and Music I: Mutual Interactions and Implications on Developmental Functions. Conference in Venice 2002

The themes of the 2002 conference were the following:

- I. Cerebral Organization of Music-Related Functions, including roundtable I:
Dissecting the Perceptual Components of Music**
- II. Brain Sciences versus Music, including roundtable II:
A Common High-Level Ground for Scientists and Musicians**
- III. Music and Development, including roundtable III:
Import of Musical Training on Cognition, Behavior, and Skills**

The conference proceedings (*Annals of the New York Academy of Sciences* 2003, Vol. 999) encompass 61 papers. Long papers refer to oral presentations at the conference, short papers refer to poster presentations. Four of the papers describe creative musical projects by composers who were invited guests at the conference. Moreover, the proceedings report introductions to the conference sections, which often present critical remarks concerning the methods and perspectives of neuroscience. Appendix 3.01, provides a survey of the conference papers, which indicates the aim of each study, its musical material and cultural references, its technology and procedure, and the main focus and conclusion of the study.

Robert Zatorre's introduction: Music and the Brain

Robert Zatorre, scientific advisor of the conference, introduces the proceedings with an essay on studying music from a neuroscience perspective (NM I, pp. 4-14). He emphasizes that it is necessary to combine different techniques and interpret studies in the context of information from many other domains (p. 5-6). Furthermore, he acknowledges that the humanistic view of neuroscience may imply "suspicions of a perceived reductionist agenda in science" (p. 4). Zatorre encourages sci-

entists not to ignore critique from humanist communities, and encourages the continued interaction between musicians and scientists. He illustrates the perspectives of neuroscience with studies of musical imagery, absolute pitch, and music and emotion.

Musical imagery

Investigations of musical imagery show that it is possible to probe internal events by objective measurements. The term "musical imagery" denominates the experience of "hearing music in one's mind". In PET studies, Andrea Halpern and Robert Zatorre have found clear similarities between musical imagery and music perception (1996, 1999). Their results indicate that "brain activity elicited during imagery was observed in portions of the auditory cortex and overlapped with the activity elicited by real perception" (p. 7). Zatorre adds that this finding raises interesting questions: How are the neural traces in sensory cortex that correspond to musical imagery activated? And what is the nature of creative processes which recombine known elements into novel patterns?

Absolute pitch

The investigations of absolute pitch reported by Zatorre do not provide clear conclusions about brain mechanisms related to this particular ability (pp. 8-9).

Music and emotion

Concerning music and emotion, Zatorre underscores that emotional responses to music are highly individual, and depend on social and cultural factors, as well as the context of listening. He presents two approaches to studying emotional responses, the use of dissonant music, and the investigation of chills induced by music (pp. 9-12).

First PET study

Zatorre is aware that dissonance, as well as consonance, serves an important role in creating aesthetically pleasant music. However, he presupposes that listeners who have been exposed to the Western tonal idiom to a great extent agree that highly dissonant music tends to be unpleasant (p. 10). In a PET imaging experiment, Anne Blood, Robert Zatorre and colleagues (1999) investigated emotional responses in a group of subjects who had no more than amateur musical training. The set of stimuli set consisted of a tonal melody accompanied by chords in variable degrees of dissonance. The study indicates that exposure to increasing and decreasing consonance is correlated with brain activity in parahippocampal and orbitofrontal regions. These regions are supposed to mediate between emotion, on the one hand, and perceptual and cognitive representations on the other (p. 10).

Second PET study

In another PET imaging experiment, Anne Blood and Robert Zatorre (2001) investigated intensely pleasurable responses to music. The phenomenon in focus was "chills" or "shivers down the spine" elicited by music. "Chills" are experienced as a very positive emotion which encompasses measurable bodily responses, such as changes in heart rate, respiration, and muscle tension.

Participants were musicians with at least 8 years of music training, selected on the basis of frequent, reproducible experiences of chill responses to music. As music preference is highly individual, each test subject selected one piece of music that consistently elicited chills. This piece was used as another subject's emotionally neutral control, so that chills-inducing and neutral musical samples were balanced.

Test results of the PET scanings provided evidence that the subjective experience of chills was correlated with increase in regional cerebral blood flow (rCBF) in a number of brain regions, including the dorsal ⁴ midbrain, ventral striatum (which contains the nucleus accumbens), insula, and the orbitofrontal cortex. Decrease in rCBF during intense chills was observed in portions of the amygdala (pp. 11-12). During the most intensive chills, heart rate, respiration depth, and muscle ten-

⁴ "Dorsal" indicates location toward the back or posterior part of the body. "Ventral" indicates location toward the front or anterior part of the body.

sion increased significantly. The implicated brain areas are known to be related to reward, emotion and arousal, and active in response to other pleasure-inducing stimuli such as chocolate, sex, and drugs.

This experiment is a pioneering study, which combines the use of real music with strict experimental control.⁵

3.1.1. A selection of papers in NM I 2002

The following selection reports noteworthy papers that illustrate findings and research questions that were pertinent at the time of the 2002 conference. To facilitate an overview, the categories of investigation are grouped as follows:

Neural correlates of sound.

Culture, development, and training.

Embodiment, motion, and emotion.

Neural correlates of sound

Pitch

Griffiths (NM I no. 3, pp. 40-49) reports studies on the processing of pitch in different brain regions by means of PET and fMRI. He concludes that (1) spectral and temporal sound features relevant to pitch are encoded in the brain stem; (2) a neural correlate of the conscious perception of pitch exists in areas of auditory cortex distinct from the primary auditory cortex; (3) longer time-scale patterns of pitch are processed in larger networks of the brain (p. 47). This implies that the brain stem responds pre-attentively to sound, and that conscious experience of melodies involves several brain regions. Warren et al. (NM I no. 29, pp. 212-214) find that pitch height and pitch chroma have different representations in the auditory cortex.

Harmony

Koelsch & Friederici (NM I no. 1, pp. 15-28) have studied brain responses to chord sequences representing authentic cadences in major-minor tonal music, by means of EEG and MEG. They conclude that event-related brain potentials (ERP) reflect the violation of a musical sound expectancy (p. 17). This means that listeners accustomed to Western tonality react pre-attentively to unexpected chords.

Timbre

Samson (NM I no. 13, pp. 144-151) reviews studies on timbre processing in the brain. She finds that a number of studies support the involvement of the right auditory temporal areas in timbre processing. However, she points out that the contribution of left temporal areas is also apparent, and that recent investigations suggest that a more distributed neural network is involved in timbre processing (p. 144, 149). This paper invites further research on hemispheric specialization and distributed processing in the brain.

Timing

Thaut (NM I no. 40, pp. 364-373) reports a number of studies on the neural basis of rhythmic timing. Based on MEG and PET studies of finger tapping, he concludes that a widely distributed cortical and subcortical network subserves the motor, sensory, and cognitive aspects of rhythm processing. It is suggested that the cerebellum plays a central role in the temporal organization of cognitive and perceptual processes in music (p. 371).

⁵ The study by Blood and Zatorre (2001) serves as a model for subsequent studies of chill experiences by Salimpoor, Zatorre et al. (2009, 2011), which combine a refined PET technique with fMRI scanning and physiological measurements. Cf. chapter 6.

Sinus tones and musical tones

Two papers contribute to a critical view of the methods of neuroscience. Based on Mismatch Negativity (MMN) studies, Tervaniemi & Huotilainen (NM I no. 2, pp. 29-39) find evidence that complex sounds are automatically represented in the human auditory cortex, and point out that music-sound encoding differs not only from speech sounds, but also from sinus tones. (p. 29, 37).

EEG studies by Trainor et al. (NM I no. 55, pp. 506-513) confirm that violin tones and piano tones evoke cortical responses that are different from the responses of sinus tones (p. 510).

These findings suggest that studies based on sinus tones stimuli are not necessarily relevant for the perception of music.

Parallel pathways

E.G. Jones (NM I no. 30, pp. 218-233) presents an elaborate study of parallel pathways in the monkey auditory system. He suggests that two similar parallel pathways from the brain stem to the cortex exist in the human auditory system. One pathway projects to the core area of the auditory cortex, and transfers information relevant to pitch perception. The other pathway projects to the belt area of the auditory cortex, and conveys information that is more diverse than pitch.⁶ Jones considers the latter pathway particularly important for music perception. He strongly recommends that studies of human auditory processing should focus less on pitch and more on complex sounds of greater biological relevance, including music (p. 218, 231).

Culture, development, and training

Thai and Chinese tonal languages

Sittiprapaporn et al. (NM I no. 26, pp. 199-203) have conducted a mismatch negativity (MMN) study of tonal languages. They have chosen MMN, because they consider this response to be a unique indicator of automatic cerebral processing of acoustic stimuli. The aim of the study was to compare neural responses to consonant-vocal syllables from two tonal languages, Thai and Chinese. The researchers selected two stimuli, both with a falling tone, a Thai "kha", and a Chinese "ta". They prepared two sequences of these stimuli, one with "ta" as standard, and "kha" as deviant, roughly: ta ta ta ta ta ta ta ta kha ta ta ta...; the other with "kha" as standard and "ta" as deviant, roughly: kha kha kha kha kha kha ta kha kha kha...

Nine healthy Thai speakers participated. They listened to randomized sequences of 500 syllables, consisting of 90 % standard and 10 % deviant syllables. While listening, they read a book of their choice in order to ignore the auditory stimulation. The study revealed that spoken words from the subject's native language elicited greater electric sources of the mismatch negativity, corresponding to a pre-attentive response (p. 201). The authors suggest that this finding indicates the presence of a long-term memory trace for spoken words in tonal languages (p. 199).

Familiar and unfamiliar culture

In a fMRI study, Demorest and Morrison (NM I no. 8, pp. 112-117) have investigated Western subjects' responses to music of their native culture and music of an unfamiliar culture. They chose two pieces of real music for their study, carefully matched for instrumental timbre, texture, and tempo; excerpts from A. Scarlatti: *Sonata Terza in C minor for Treble Recorder, Strings and Basso Continuo*, and from a traditional Chinese piece, *Liu Qin Niang*. The participants were all Western, six professional string players and six untrained control subjects. fMRI scans were conducted in order to determine differences in activation responses to Western and Chinese music. Comparison of the two groups showed no such differences. However, for professional musicians, significant activation in the

⁶ E.G. Jones' research is not confined to animal studies. He is the author of the reference work regarding the Thalamus in the human brain (Jones 2007).

For descriptions of the core, belt and parabelt regions of the auditory cortex, see Tramo et al. (NM II no. 15, pp. 148-174); Malmierca & Hackett (2010:31-35); Brodal (2010:249).

right superior temporal gyrus (STG) was noted regardless of the familiarity of the music (p. 113). In contrast, an additional test showed differences in activation responses to English and Chinese language.

The authors conclude that subjects' activation did not differ on the basis of the cultural familiarity of the music, but on the basis of musical expertise. They add that even if they do not regard music as a "universal language", they find that each listener may apply his or her comprehension strategies to all music (p. 114). The authors' meticulous choice of musical stimuli deserves attention. They have published full a report of their study (Morrison, Demorest et al. 2003).

Professional musicians and non-musicians

Münste et al. (NM I no. 11, pp. 131-139) review event-related brain potential (ERP) studies of auditory stimuli processing by professional musicians and non-musicians. Based on measurements of responses to single sinus tones, spatially distributed sound sources, and a real drum sequence, they find qualitative processing differences between musicians and non-musicians. Furthermore, they find specific differences between musicians. In a study of timing abilities, drummers appear to have a more complex representation of the musical time structure than woodwind players. In a study of auditory space perception, conductors appear to have greater sensitivity for peripheral sound sources than pianists (p. 138).

Untrained listeners possess auditory expertise

Bigand (NM I no. 37, pp. 304-312) argues that some studies tend to exaggerate the importance of musical training, and that tests of simple qualities of musical sound are not necessarily relevant for the perception of real music. He reports tests of musical tension in melodies and harmonic sequences, and tests of memorizing Haydn sonata extracts and newly composed dodecaphonic canons. In all four tests, highly trained music students did not perform better than non-musicians. Bigand concludes that in experiments where the participants process musical structures, in contrast to musical tones, untrained listeners exhibit musical abilities which are comparable to the abilities of experts (p. 304). He suggests that the mere exposure to music is sufficient for the development of a sophisticated auditory expertise (p. 311).

Developmental psychology

Trehub (NM I no. 46, pp. 402-413) reviews 93 articles on the developmental psychology of music, and comments critically on prevailing beliefs. Regarding absolute pitch, she points out that recent research offers no support for the view that absolute pitch processing dominates in early life (p. 405). In her own study on adults' recognition of the pitch level of instrumental excerpts from popular TV programs, she finds that adults with minimal musical training remember the pitch level of music heard incidentally, provided that the test context features familiar, ecologically valid materials (p. 406). She argues that at times, naiveté about cultural conventions leads infants to outperform adults on specific music tasks, for example differentiated perception of melodic changes and atypical meters (p. 404). She emphasizes that a developmental approach can provide important insight into many issues in music cognition (p. 402)

Embodiment, motion, and emotion

Musical expression

De Poli (NM I no. 9, pp. 118-123) reports studies of expressive intentions in music performance conducted by his group at the Department of Information Engineering, University of Padua, Italy. Basis for the studies were recordings of 10-20 sec. melodies from Western classical and Afro-american music. Professional musicians played the music according to different expressive intentions in order to make the music sound neutral, bright, dark, hard, soft, heavy, or light. One noteworthy example was a fragment of Mozart's Clarinet Concerto K. 622. Technically speaking, the musicians introduced

micro-deviations in the timing, dynamics, and timbre in order to vary the expressiveness of the performance.

In two experiments, the researchers asked a group of musicians and a group of non-musicians to describe the music performance by indicating values in graduated scales of adjectives.⁷ Mathematical factor analyses of the responses in both experiments indicate that two factors are fundamental for describing a musician's expressiveness: a *kinematics* factor corresponding to tempo and tempo variations, and an *energy* factor corresponding to intensity and attack time (p. 120). On the basis of these factors, the authors have developed mathematical models for adding expressiveness to synthesized music. They have published detailed reports of their investigations (Canazza, De Poli et al. 2001, 2004).

3.1.2. Critical comments stated at the conference NM I 2002

Introductions by prominent researchers preceded each conference section. Several of these introductions included critical comments on current scientific approaches.

Technical limitations

Giuliano Avanzini (NM I, pp. 1-3) pointed out (1) that the technique of averaging many EEG measurements significantly limits the information contained in the recorded response; (2) that individual anatomical variations in brain areas need to be taken into account in brain imaging studies by means of PET and fMRI.

Ecological validity

Carol Krumhansl (NM I, pp. 103-105) emphasized the need to employ experimental materials as close to real music as possible, in order to achieve ecological validity of the experiment. She also recommended the inclusion of materials outside the tradition of Western tonal music.

Cultural bias

Ian Cross (NM I, pp. 106-111) voiced his critical view of neuroscience. He considers the notion of exploring music by examining the neurophysiological correlates of the acoustic signal severely culture specific, permitting only a partial understanding of the neurophysiology of music. He states that the narrow focus on the individual listening experience is predominant only in Western cultural contexts. He also emphasizes that music is a characteristic of communities, involving entrainment of action and interaction.

Cross points out that in some types of music, hand and finger movements can be more important than abstract principles of pitch patterns and harmony. This is the case in African kalimba music, and in blues guitar music. Moreover, the Western preference for euphonious harmonies and timbres is not a universal characteristic of music. An alternative example is the music of Northern Potosi in Bolivia, characterized by a marked preference for severely inharmonic timbres. Cross recommends an ongoing dialogue between cognitive neuroscientists, musicians, musicologists, and ethnomusicologists.

Biologically relevant sounds

Diego Minciaccchi (NM I, pp. 215-217) reported the thought-provoking conclusion by E.G. Jones that analyses of simple sound parameters are of limited use, and ought to be replaced by investigations

⁷ Adjectives in experiment 1: bright, dark, hard, soft, heavy, light. Adjectives in experiment 2: black, oppressive, serious, dismal, massive, rigid, mellow, tender, sweet, airy, gentle, effervescent, vaporous, fresh, abrupt, sharp.

of biologically relevant sounds,⁸ including musical sounds (NM I no. 30, p. 231). Furthermore, he warned against overestimating the localization of brain functions in neuroimaging studies. Finally, he encouraged fruitful discussions between neuroscientists and composers.

In his own paper (NM I, no. 36, pp. 282-301), Minciacchi declares his intention to challenge the classical quest for universals in music (p. 298).

Aesthetic and bodily experience

Curtis Roads (NM I, pp. 302-303), who is a composer and a computer scientist, acknowledged the efforts of neuroscience, but pointed out that aesthetic experience cannot be distilled to a process that is triggered by a specific stimulus. He drew attention to the diversity of musical preference, and to the bodily experience of music.

In his own paper (NM I no. 35, pp. 272-281) he illuminates the perception of microsounds, the sound particles that last only a few milliseconds. He recommends that music should be defined in the broadest possible sense, and encourages studies of the roots of music in the senso-motoric dynamics of the nervous system.

Scientific impoverishment

John Sloboda (NM I, pp. 389-391) encouraged studies of the social, motivational, and emotional factors sustaining musical activity, and research into aesthetic and creative aspects of musical development. He warned against music cognition experiments based on the participant's response to a disembodied brief tone sequence, characterizing this type of research as "methodologically convenient, but scientifically impoverished" (p. 391).

3.1.3. Achievements and problems of research in NM I 2002

The critical comments focused on a number of problems:

- 1) Low ecological validity
- 2) Cultural bias, giving preference to Western tonal music
- 3) Neglect of aesthetic and social factors
- 4) Possible overestimation of the localization of brain functions
- 5) The limitations of experimental techniques

Ecological validity

Appendix 3.05 provides a survey of musical material NM I, which indicates synthesized material, acoustic material, recorded music, and task-defined material applied in the studies.

Sources not indicated

16 out of 61 papers do not report information about the sound sources of applied stimuli.

Sinus tones and acoustic tones

11 papers report the use of sinus tones as stimuli. Only three papers (No. 11, 49, 55) report using tones of acoustic instruments. The singing voice is completely absent in the selection of stimuli. It appears that in many experiments, ecological validity is sacrificed in favor of experimental control. In neuroscience, experimental control is considered an indispensable precondition. However, it remains an unanswered question whether experiments based on very simple stimuli provide information about the perception and cognition of real music.

⁸ Examples of biologically relevant sounds in animals are birdsong, the communication calls of monkeys, and the vocalizations of whales and seals. In humans, biologically relevant sounds include vocal and musical expression and communication.

Synthesized sound

Synthesized sounds are applied as stimuli in 15 studies. To a certain extent, synthesized sounds share characteristics with acoustic sound. The study by Tervaniemi and Huotilainen (no. 2) indicates that the neural responses to synthesized musical sounds differ from the responses to sinus tones. This finding suggests the relevance of using synthesized stimuli. Nevertheless, the properties of synthesized sounds do not equal the expressive qualities of acoustic sounds. The differences between acoustic and synthesized stimuli deserve further investigation.

Real music

Real music is applied in eight studies (no. 8, 9, 18, 41, 46, 48, 57, 58). Two papers report studies of high ecological validity. The fMRI study by Demorest & Morisson (no. 8) is based on real music from European and Indian cultures, and the studies of musical expression reported by De Poli (no. 9) are based on live recordings of musicians.

Khalfa et al. (no. 41) have applied recordings of relaxing music in their study of bodily reactions after stress. In studies by Dalla Bella & Peretz (no. 18) and Drake & El Heni (no. 48), the participants tapped in synchrony with real music. Three studies report children's reactions to recorded music, Trehub (no. 46), Lamont (no. 57), and Platinga & Trainor (no. 58).

One of these eight studies (no. 8) is a brain imaging study. This paper and the PET study of intensely pleasurable responses to music reported in Zatorre's introduction (Blood & Zatorre 2001) prove that it is possible to apply real music as the stimulus in brain imaging experiments.

Cultural references

Appendix 3.07 reports a survey of cultural references NM I.

Western major-minor tonality

The survey indicates that out of 61 papers, 29 focus on Western major-minor tonality, and 23 papers report no cultural affiliation. Seven papers refer to Western popular or traditional music, and seven papers report comparisons of different cultures. This distribution of cultural references indicates a preponderance of Western music in the studies. It remains an open question whether the results obtained in studies of Western tonal music are valid for other types of music.

Cross-cultural studies

Out of the seven papers that compare different cultures, four have applied real music; Alessandro Scarlatti and Liu Qi Niang in the study of cultural familiarity (no. 8), expressive intentions in European and Afro-American music (no. 9), responses to TV tunes by Western and Japanese children (no. 46), and tapping in synchrony to French and Tunisian songs (no. 48).

In addition, Neuhaus (no. 23) has investigated the cortical responses of German, Indian, and Turkish musicians to Europeans and Thai scales and a Turkish makam. Sittiprapaporn (no. 26) has studied the Mismatch Negative responses of native Thai speakers to native and non-native words. Ruzza et al. (no. 60) have examined early vocalizations in Italian and Moroccan infants.

These studies introduce important cultural perspectives in the field of neurosciences and music.

Inclusion of aesthetic and social factors

The first theme of the NM I conference focuses on the cerebral organization of musical functions and the perceptual components of music (papers no. 1-29) This focus is by definition narrow, but necessary for contributing to a basis for reliable research. The second theme, brain sciences versus music, opens important discussions between neuroscientists and creative artists (papers no. 30-44). The third theme, music and development, establishes relevant relationships with developmental psychology (papers no. 45-61).

Localization of brain functions

Overestimation of localization is apparently not the case. Findings in the NM I conference by Griffiths (no. 3), Samson (no. 13), and Thaut (no. 40) indicate the importance of neural networks, as opposed to single locations in the brain.

Limitations of techniques

The low temporal resolution of PET and fMRI brain imaging and the inexact spatial localization of EEG and MEG responses are inherent problems in these techniques. The combination of different techniques contribute to solving some of these problems.

As the fMRI scanner produces considerable noise, a sparse imaging technique can be applied, as described by Griffiths (no. 3, p. 42). Sparse imaging takes advantage of the fact that the blood oxygen level dependent (BOLD) response induced by a stimulus builds up rather slowly, typically in the course of 10 seconds. This implies that the musical stimulus can be presented in quiet, whereupon the scanner is turned on to record the BOLD response.

3.2 The Neurosciences and Music II: From Perception to Performance. Conference in Leipzig 2005

The themes of the 2005 conference were the following:

- I. Ethology / Evolution: Do Animals have Music or Something Else?**
- II. Music and Language**
- III. Mental Representations**
- IV. Developmental Aspects and Impact of Music on Education, including a roundtable on Music therapy**
- V. Neurological Disorders and Music**
- VI. Music Performance**
- VII. Emotion in Music**

A survey of the papers published in the conference proceedings: *Annals of the New York Academy of Sciences* 2005, Vol. 1060, is provided in Appendix 3.02. The survey indicates the aim of each study, its musical material and cultural references, its technology and procedure, and the main focus and conclusion of the study.

Parts III and IV of the 2005 conference continued investigations from the 2002 conference; the neural correlates and the developmental aspects of music. Parts II, V, VI and VII introduced new fields of research; language, neurological disorders, performance, and emotion. In the preface to the conference proceedings, the organizers noted that the field of research in the neurosciences and music had experienced a favorable growth of academic interest.

Composers and cross-cultural researchers were not invited to the 2005 conference. Two new academic communities participated, ethology / evolution scholars, and music therapy researchers.

3.2.1 A selection of papers in NM II 2005

This paragraph summarizes noteworthy papers from the 2005 conference. To facilitate an overview, the categories of investigation are grouped as follows:

Neural correlates of sound.
Culture, development, and training.
Deficits, disorders, therapy, and recovery.
Attention and memory.
Embodiment, motion, and emotion.

Neural correlates of sound

Hemispheric differences

Schönwiesner et al. (NM II no. 9, pp. 89-92) have investigated the responses of the left and the right auditory cortices to novel noise-like stimuli which differ in spectral and temporal complexity. Their fMRI study shows a leftward preference for temporal modulation, which is essential for speech perception, and an equivalent preference on the right side for spectral modulation, which is essential for music perception (p. 92). Their findings agree with a model of hemispheric functional asymmetry proposed by Zatorre & Belin (2001)

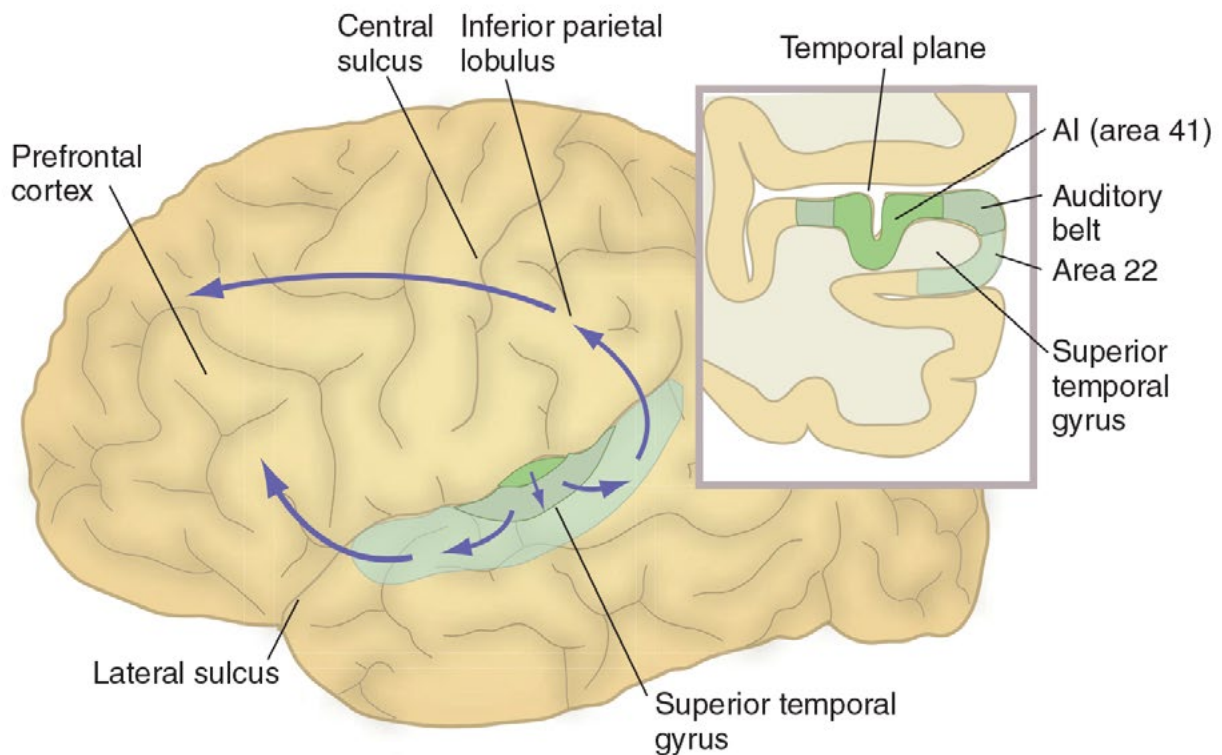


Figure 3.2. The Auditory cortex is situated in the Superior temporal gyrus. The inset shows a section through the temporal lobe.

The figure shows the auditory core area (A I, green), the auditory belt area (grey), and the parabelt area (Area 22, light green).

From the auditory areas, dorsal and ventral pathways project to the prefrontal cortex. The ventral pathway deals with identification of sounds and their meaning. The dorsal pathway deals with sound localization and movements.

(Brodal 210:249)

A distributed neural system

Tramo et al. (NM II no. 15, pp. 148-174) have reviewed literature on studies of pitch perception and the auditory cortex. They present detailed observations in the fields of neurophysiology, neuroanatomy, and the cortical mechanisms of pitch processing. They describe three areas of the auditory cortex, a core area, a belt area, and a parabelt area. The core area contains frequency-selective neurons, and its input consists almost entirely of frequency-specific auditory information. The core area is surrounded by a belt area and a parabelt area, which integrate auditory input with other types of sensory input. The belt and parabelt are characterized as auditory association areas, which are reciprocally connected with the frontal, parietal, and temporal cortices, the basal ganglia, and the cerebellum, to form a widely distributed neural system for music cognition (p. 153).

Performance of rhythm and melody

Ullén et al. (NM II no. 38, pp. 368-376) have investigated whether the temporal structure of movement sequences can be represented and learned independently of their ordinal structure. From a number of studies of non-musicians, using fMRI during finger tapping tasks, the authors conclude that the processing of temporal sequences in voluntarily timed motor tasks is largely independent from the processing of ordinal information (p. 386, 374). This finding suggests that performance of rhythm and melody in piano playing is based on two different neural networks. A further study, investigating piano playing from musical scores, suggests a similar dissociation between brain regions involved in rhythmic and melodic processing (Bengtsson & Ullén 2006).

Culture, development, and training

Brains of musicians and non-musicians

In their study of gray matter brain volume and musical instrument preference, Schneider et al. (NM II no. 40, pp. 387-394) initially tested more than 400 musicians and 50 non-musicians. Listening to a complex sound, some listeners recognized predominantly the fundamental pitch, others predominantly perceived single harmonics of the complex sound (p. 388). This test was the basis for studying a subgroup of 87 listeners.

MRI and MEG studies showed differences in gray matter volume of the pitch-sensitive area of the auditory cortex, the lateral Heschl's gyrus (HG). Fundamental pitch listeners exhibited a larger volume in their left lateral HG. Their preferred instruments were percussive or high-pitched instruments, e.g. drums, guitar, piano, trumpet, or flute. Spectral pitch listeners exhibited a larger volume in their right lateral HG. This group included lower-pitched melodic instruments, e.g. bassoon, saxophone, french horn, cello, organ, and singers (p. 387). This study contributes to a nuanced view of hemispheric specialization.

Child care and the origin of music

Fitch (NM II no. 3, pp. 29-49) has reviewed theories about the evolutionary origin of music, finding support for Darwin's hypothesis of a music-like protolanguage, and the childcare hypothesis, which proposes that the songs in mother-infant communication have a decisive adaptive function. He also points out that the percussive behavior of great apes represents an overlooked homologue to human instrumental music.⁹

Deficits, disorders, therapy, and recovery

Sensitivity to musical expression

Sloboda, Wise, and Peretz (NM II, no. 25, pp. 255-261) have studied the responses to musical ex-

⁹ In an fMRI study of macaque monkeys, Remedios et al. (2009:18010-18015) found that brain regions activated by drumming sounds and by vocalizations overlap in the auditory cortex and the amygdala.

pression in a group of participants diagnosed with amusia, and a control group.

In an earlier study, Peretz et al. (NM I, no. 5, pp. 58-75) assessed amusia or "tone-deafness" by means of a series of tests, the Montreal Battery for the Evaluation of Amusia (MBEA). The test tasks consisted of judging whether two melodies were identical or different. Various types of melodies allowed for assessing the perception of melodic contour, intervals, scale, rhythm, meter, and recognition memory. The MBEA has proved to be a reliable tool for identifying disorders in music recognition in Western listeners.

The original MBEA test material encompassed melodies played in synthesized piano timbre. For the present study, Sloboda, Wise and Peretz developed a new version of the test material. A professional violinist recorded five performances of each melody in the MBEA. These performances varied by emotional intention: happy, very happy, sad, very sad, and neutral. The test consisted of comparing two performances of the same tune, and the test task was to judge whether the emotion conveyed was the same or different. The results of this test showed that the participants diagnosed with amusia performed equally well as the controls (p. 259). This result stood in stark contrast to previous MBEA tests.

The authors conclude that amusic individuals retain the ability to process the variations in articulation, tempo, and timbre, which constitute the basis for emotional expression in music. They consider the emotion test a valuable addition to the Montreal Battery for the Evaluation of Amusia.

Music therapy

At the conference, Luisa Lopez (NM II, pp. 269-270) introduced a round table, which was designed to provide a picture of the efforts of music therapy research to the audience of critical neuroscientists. She pointed out that typical articles on music therapy had not provided reliable evidence, as they were characterized by small samples, lack of a proper control group, and subjective measurement protocols. However, she acknowledged the value of studies analyzed in the Cochrane Review by Gold et al. (2005). This review analyzes the effects of music therapy for people with serious mental illnesses such as schizophrenia. It includes only four studies, which are randomized controlled trials (RCT), and excludes 30 other potential relevant studies according to specific criteria.

In their introduction, the conference organizers voiced their claim for scientific rigor in music therapy research, "to start the validation of evidence-based results of methods where music practice is effectively used in rehabilitation techniques" (NM II, xii).

The conference proceedings included a number of the round table presentations:

Empirical music therapy research

Hillecke et al. (NM II no. 28, pp. 271-282) emphasize the urgent need for the application of empirical research methods to studying the ingredients of music therapy. They point out the lack of theoretical agreement in the field, but they have also observed that the field of outcome studies is growing, and find support for the standpoint that music represents a useful tool in the treatment of different mental and somatic diseases. They present a survey of research strategies, outline a number of problems occurring in music therapy studies, and call attention to a number of meta-analytical studies in the field. Finally, they present a model for the most effective ingredients in music therapy. This model includes five factors; modulation of attention, emotion, cognition, behavior, and communication (p. 271).

Randomized controlled studies in music therapy

In continuation, Nickel, Hillecke et al. (NM II no. 29, pp. 283-293) present three randomized controlled studies based on the Heidelberg model, which describes manualized music therapy concepts for defined patient populations. Their results indicate that music therapy is an effective intervention for patients with chronic pain, children with migraine, and patients suffering from chronic tinnitus (p. 283).

Rhythmic auditory stimulation in rehabilitation

Thaut (NM II no. 31, pp. 303-308) reviews studies related to music therapy and neuroscience. He states that as a stimulus, music engages human behavior and brain function by arousing, guiding, organizing, focusing, and modulating perception, attention, and behavior in the affective, cognitive, and sensorimotor domains. In particular, he focuses on rhythmic entrainment of motor function, which can facilitate the recovery of movement in patients with stroke, Parkinson's disease, cerebral palsy, or traumatic brain injury (p. 304). In a subsequent article, he elaborates on rhythmic auditory stimulation in rehabilitation of movement disorders (Thaut & Abiru 2010).

Attention and memory

Attentive listening

In an fMRI study, Janata et al. (NM II no. 12, pp. 111-124) used a piece of real music, a 15-sec. excerpt from a Schubert piano trio. They asked the participants to perform specific tasks, focusing on either a single instrument or on the entire three-voice polyphony. Their results show that attentively focused listening recruits a network involving prefrontal cortex, cerebellum, basal ganglia, thalamus, and the pre-supplementary motor area (pre-SMA) (p. 114). This observation suggests an important relationship between movement, movement planning, memory, and music. The authors have published a complete report of their study (Janata et al. 2002) ¹⁰

Embodiment, motion, and emotion

Mozart, mood and cognitive abilities

Schellenberg and Hallam (NM II no. 20, pp. 202-209) have retested the "Mozart effect" experiment, which suggested that listening to a Mozart piano sonata produced significant short-term enhancement of spatial-temporal reasoning in college students (Rauscher et al. 1995). Schellenberg and Hallam review attempts to replicate the experiment, which indicate that the effect is real but somewhat ephemeral. Their own experiment included more than eight thousand 10- and 11 year-old children in 207 U.K. schools.

Three different listening stimuli, 10 minutes of contemporary pop music, 10 minutes of a Mozart String Quintet, and 10 minutes of a verbal discussion of the experiment, were broadcast simultaneously on three different BBC radio stations. In each school, the children were randomly divided into three listening groups. After listening, the children completed two tests of spatial abilities, a square completion test and a paper-folding test. Analyzing the data, the authors found that the children who listened to pop music performed better on the paper-folding test than the two other groups. They conclude that a pleasant stimulus can improve a perceiver's emotional state, which can, in turn, affect cognitive performance (p. 202).

Fast emotional responses

Two studies by Bigand et al. (NM II no. 46, pp. 429-437) focus on the timing of emotional experience in music. In their first study, they presented 27 excerpts of classical nonvocal music¹¹ to groups of musically trained and untrained listeners. The excerpts were chosen to illustrate a variety of emotions, and the task was to indicate excerpts that induced similar emotional experiences. The participants were allowed to listen as many times as they wished (p. 432). The critical point of the study was to compare two experimental conditions. In the first condition, the excerpts lasted 25 seconds.

¹⁰ In the published article, the authors emphasize that "the role of the pre-SMA/SMA and premotor circuits in action planning, imagined movements, and attention to temporal patterns is of particular importance to understanding the effect of music on the brain." (Janata et al. 2002:138).

¹¹ The 27 classical excerpts are specified in Bigand et al. (2005:1135-1137).

In the second condition, the excerpts lasted one second.

The results showed that one second of music was enough to induce an emotional experience, and that there was no difference between the responses of musicians and non-musicians. The authors suggest that performance cues are enough to induce emotions in western listeners, even if they merely hear the first tone of a piece. A second study confirmed that excerpts as short as 250 msec may be enough to induce feelings of emotion in listeners (p. 434). The authors argue that the emotional response is not merely subcortical, but requires a cognitive appraisal mediated by the cortex. In their review of literature, they point out the importance of kinematics and energy for musical expression, as proposed by De Poli et al.¹²

Strong experiences of music

Grewe et al. (NM II no. 49, pp. 446-449) have investigated strong experiences of music that can arouse "chills" defined as "goose pimples" or "shivers down the spine". They invited a heterogeneous group to the experiment, comprising 5 professional musicians, 20 amateur musicians, and 13 non-musicians, in order to avoid bias due to social background and education. Every subject listened to seven entire pieces from different styles: Mozart, Bach, Pop music, Film music, Cello-Rockband, Death Metal, and Bossa Nova,¹³ plus 5-10 personally selected pieces known to induce strong emotions. The experimenters asked the subjects to press a mouse button whenever they experienced a chill while listening to music. This permitted identification of the musical events that had triggered chills. Skin conductance response was also measured.

The authors observed that chill experiences are individual, and that strong emotional response to music is related to structural musical elements. Important musical factors seem to be change in loudness, harmonic sequences, the entrance of a voice, and the beginning of a new part (p. 448). The authors hypothesize that the strong response is not a subcortical reflex, but a result of attentive, experienced, and conscious musical enjoyment. The subsequent publication by Grewe et al. (2007) presents a complete report of the experiment.

3.2.2. Critical comments stated at the conference NM II 2002

In comparison with NM I, critical comments were scarce. Diego Minciacchi (NM II, pp. 346-348) noted that the studies of music performance were still in their pioneering stage. Isabelle Peretz and John Sloboda (NM II, pp. 409-411) noted the lack of ecological validity in studies of musical emotion, stating that "studies of the musical brain must generally take place in highly controlled and somewhat culturally impoverished environments, limiting the generality of their findings" (p. 410). They pointed out that no studies had explored emotional responses in complete musical works, and that emotional responses to music were specific to the listening situation.

3.2.3. Achievements and problems of research in NM II 2005

In NM I 2002, the critical comments pointed out five types of problems:

- 1) Low ecological validity.
- 2) Cultural bias, giving preference to Western tonal music.
- 3) Neglect of aesthetic and social factors.
- 4) Possible overestimation of the localization of brain functions.
- 5) The limitations of experimental techniques.

¹² De Poli et al. (NM I no. 9 pp. 118-123), this chapter.

¹³ The pieces are specified in Grewe et al. (2007:777).

To a certain extent, these themes reappear in the NM II conference 2005. The survey in appendix 3.05 permits comparison of musical material in NM I and NM II.

Ecological validity

Sources not indicated

In NM II, seven papers out of 53 do not indicate the sound sources of stimuli.

Sinus tones and acoustic tones

The use of sinus tones has decreased from eleven studies in NM I to three studies in NM II. This may indicate awareness of the limited use of simple stimuli.

However, the use of acoustic tones as stimuli has not increased from NM I to NM II.

Three studies in NM I, and one study in NM II (no. 19) report the use of acoustic instrumental tones. No studies in NM I, and only three studies in NM II apply singing voice (no. 7, 11, and 24).

Similar to NM I, it appears that in a number of studies in NM II, ecological validity is sacrificed in favor of experimental control.

Real music

Sloboda et al. (no. 25) demonstrate the relevance of live music recordings for the study of emotional expression in music. Furthermore, the use of real music is essential in Janata's fMRI study of listening to polyphonic music (no. 12), in the study of fast emotional response to music by Bigand et al. (no. 46), and the study of strong emotional reactions by Grewe et al. (no. 49).

Cultural references

Appendix 3.07 reports a survey of cultural references NM II.

Western major-minor tonality

The survey shows that out of 53 studies, 28 refer to major-minor tonality, and 25 are culturally neutral.

Popular music

Four papers include Western popular music. The study by Schellenberg & Hallam (no. 20) investigates a cultural factor. They find that pop music appears to elicit a slight enhancement of mood and cognitive abilities in schoolchildren, contrary to a Mozart string quintet. The authors name this finding "The Blur Effect".

Otherwise, studies of cultural differences are absent in the 2005 conference. A bias towards Western music is evident.

Inclusion of aesthetic and social factors

The conference plan explicitly aims at including studies of music performance, neurological disorders, music therapy, and the impact of music on education. The inclusion of music therapy in the conference opens a dialogue with another community of researchers.

The discontinuation of a dialogue with composers involves a risk of engendering a cultural gap between the concepts of music prevailing in neuroscience and contemporary concepts of music creation.

Localization of brain functions

A possible over-estimation of the importance of single locations in the brain is not pertinent in the 2005 brain imaging studies. Most of the papers describe networks which integrate several brain areas.

Limitations of techniques

Brain images produced by the fMRI technique display distinctions between activated and non-activated brain regions. These distinctions are based on comparisons of a large number of very small brain areas, defined as voxels. According to statistics theory, the calculations underlying brain imaging have to be corrected for multiple comparisons. In the NM II papers, nine fMRI studies report correction for multiple comparisons (no. 13, 16, 21, 22, 33, 38, 41, 42, 50). Another seven studies do not report corrections (no. 7, 9, 12, 17, 12, 39, 43, 51).¹⁴

3.3 The Neurosciences and Music III: Disorders and Plasticity Conference in Montreal 2008, publication 2009

The themes of the 2008 conference were the following:

- I. Rhythms in the Brain: Basic Science and Clinical Perspectives**
- II. Normal and Impaired Singing**
- III. Music Training and Induced Cortical Plasticity**
- IV. Musical Memory: Music is Memory**
- V. Emotions and Music: Normal and Disordered Development**
- VI. Listening to and Making Music Facilitates Brain Recovery Processes**
- VII. Music, Language, and Motor Programming: A Common Neural Organization?**
- VIII. New Directions: Cochlear Implants**

A survey of the papers published in the conference proceedings: *Annals of the New York Academy of Sciences* 2009, Vol. 1169, is provided in appendix 3.03, pp. The survey indicates the aim of each study, its musical material and cultural references, its technology and procedure, and the main focus and conclusion of the study.

3.3.1. A selection of papers in NM III 2008

This paragraph summarizes noteworthy papers from the 2008 conference. Similar to the papers of the previous conference, the categories of investigation are grouped as follows:

Neural correlates of sound.
Culture, development, and training.
Deficits, disorders, therapy, and recovery.
Attention and memory.
Embodiment, motion, and emotion.

Neural correlates of sound

Auditory brain stem response

Kraus et al. (NM III No. 79, pp. 543-557) report studies of the auditory brain stem response from the Kraus laboratory. They point out that pitch, timbre and timing have distinct subcortical representations. These acoustic properties of the sound are reflected by the auditory brain stem response (ABR), which is considered a reliable and highly replicable far-field potential recorded from surface electrodes placed on the scalp. Their studies suggest that the brain stem processing is not merely a

¹⁴ The reliability of studies based on uncorrected statistics, the limitations of the fMRI technique, and the interpretation of fMRI studies remain topics of discussion (Logan & Rowe 2004, 2008; Logothetis 2008)

passive encoding. Subcortical sensory processes interact dynamically with cortical processes, such as memory, attention, and multisensory integration.

Studies of different populations show that musically trained subjects have enhanced subcortical representations of pitch, timbre, and timing (p. 543). Moreover, auditory sensory processing interacts with visual and motor influences. The authors suggest that music and language experience fundamentally influence subcortical auditory processing, mediated by the extensive circuitry of efferent fibers that descend from the cortex to the cochlea in the ear (p. 554). These findings contribute to explaining the effects of music therapy in persons with developmental disabilities.

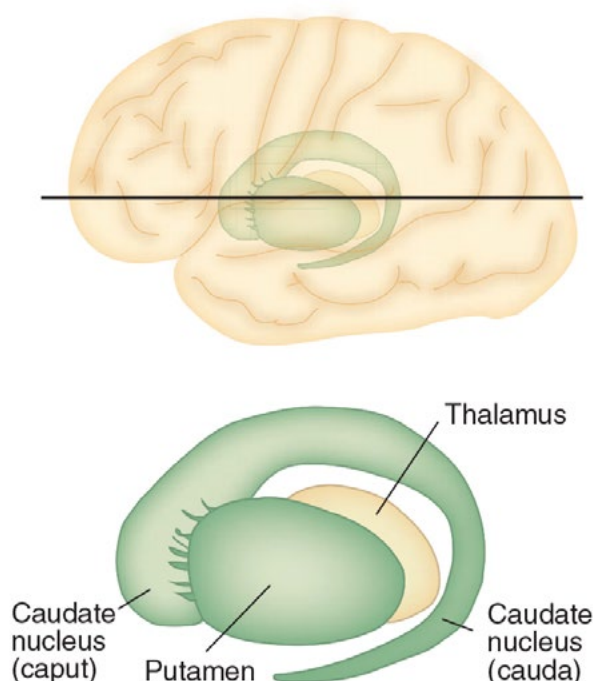


Figure 3.3. The Basal ganglia¹⁵

The Basal ganglia are located in the Basal forebrain near the Thalamus. The Putamen and the Caudate nucleus together form the Dorsal striatum. The Caudate nucleus has a "head" (caput) and a "tail" (cauda). Not shown are the Nucleus accumbens, which is part of the Ventral striatum, and the Globus pallidum. See also Figure 6.4.

(Brodal 2010:325)

A neural loop for timing

Grahn (NM III no. 2, pp. 35-45) has investigated the neural basis of beat perception, using fMRI during tapping and listening tasks. She finds that the basal ganglia are strongly implicated in processing a regular beat, particularly when internal generation of the beat is required. She suggests that a neural loop mediates the timing system engaged by beat perception. This loop connects a part

¹⁵ A ganglion (plural ganglia) is a mass of nerve cell bodies.

of the basal ganglia (the putamen), with the thalamus, pre-SMA, and SMA. Metric simple rhythms, compared to complex and nonmetric rhythms, elicit increased activity in these areas. Moreover, listening to unaccented isochronous rhythms generates internal subjective accents (pp. 35, 41-42). This finding illuminates the familiar observation that we perceive a metric structure in the regular dripping of waterdrops and the ticking of a clock.

Culture, development, and training

Brains of jazz musicians

Chakravarthy and Vuust (NM III no. 6, pp. 70-83) review MRI studies which show differences between the brain structures of musicians and non-musicians, and present their own MRI study of brain morphology in 17 highly skilled jazz/rock musicians. Their results suggest that increased local gray-matter density in motor and auditory areas are correlated to rhythmic ability (p. 81).

Musical expertise

Tervaniemi (NM III no. 18, pp. 151-156) reviews studies which compare the brain functions between musicians and non-musicians and between musicians with different musical backgrounds. MEG studies showed stronger response to piano sounds in musicians than in non-musicians, and showed that trumpeters and violinists had enhanced response to the timbre of their own instrument (p. 153). In an EEG study, Tervaniemi and colleagues compared the responses of musicians and non-musicians to pitch deviations. They conducted two tests, a test of pre-attentive response while the participants were reading a book, and a test of attentive response where the participants were asked to indicate the sounds with deviant frequency. They found superiority in musicians in the attentive task, but observed no difference during the reading condition. The researchers suggest that musical expertise may exert its effects merely at attentive levels of processing and not necessarily at the pre-attentive level. They have published a full report of their study (Tervaniemi et al. 2005).

Effects of training and culture

Wong et al. (NM III no. 19, pp. 157-163) discuss findings that reveal the effect of training and cultural experiences on the auditory pathway. They draw attention to the fact that auditory response and processing begin in the brain stem and continue in the thalamus and the auditory cortex. Their study of the frequency-following response (FFR) in the brain stem showed that musicians exhibit enhanced encoding of linguistic pitch at the level of the brain stem.

Another study, in which violinists and flutists listened to excerpts from Bach Partitas while being scanned with fMRI, showed robust activation of a cerebral network of expertise, when each group heard stimuli played on their own instrument. This network encompasses Brodmann Area 44, auditory association cortex, frontal regions, and precentral gyrus (p. 160).

In the third study, three groups of non-musicians performed recognition and tension judgment tasks, listening to excerpts of Western and Indian melodies. One group was monomusical Western, another group monomusical Indian. Participants in the last group were bimusical, enculturated in Western as well as Indian music. The monomusical groups responded differently to Indian and Western music, the bimusical group did not. The authors conclude that people can acquire sensitivity to complex auditory stimuli associated with multiple cultures simply through exposure and enculturation (p. 162).

Deficits, disorders, therapy, and recovery

Autism spectrum disorders and music listening

Heaton and Allen (NM III no. 45, pp. 318-325) report studies of musical experience in autism spectrum disorders (ASD). They emphasize that it is a misunderstanding that persons with social disabilities must be incapable of a full enjoyment of music. On the contrary, they find that autistic adults

have strong and diverse motivations for listening to music, including mood regulation and the feeling of belonging to a wider community of like-minded individuals. They hypothesize that for people with autism, music provides an opportunity to engage in social-emotional activity without the anxieties associated with interpersonal interactions (p. 322).

Motivations for music listening in ASD adults

Allen et al. (NM III no. 46, pp. 326-331) have conducted a study of 12 high-functioning adults with ASD diagnoses, nine with Asperger's syndrome, three with autism. The researchers used a qualitative approach based on semi-structured interviews which explored the nature of the participants' musical experience. They found two groups which reported a particular musical preference, each including five individuals; a group which primarily listened to classical music, and a group which developed an interest in pop music in their teenage years. Motivations for listening were mood altering, aesthetic pleasure, therapeutic effect, and the feeling of belonging to a community.

The researchers conclude that individuals in their sample use music in several ways similar to typically developing (TD) people, including mood change, self-management for depression, and social affiliation. However, they found a striking difference in the description of music. While TD individuals describe their emotional response to music as valence (happy/sad) and arousal, the ASD individuals used almost no valence terms, but typically described the energizing or calming effect of music (p. 330).

Music therapy and neuroscience

Koelsch (NM III no. 56, pp. 374-384) presents a neuroscientific perspective on music therapy, reviewing 53 studies. He refers to Hillecke's presentation in NM II,¹⁶ and elaborates on six factors which contribute to the effects of music therapy; modulation of attention, emotion, cognition, behavior, communication, and perception.

(1) Music can automatically capture attention, and thus distract from negative experiences, such as pain and anxiety.

(2) Music has an impact on brain structures involved in the modulation of emotions, and an impact on the autonomic nervous system. Koelsch refers to several studies, including the classic PET experiment by Blood and Zatorre (2001), which reported extremely pleasurable experiences during music listening, and his own chapter on functional neuroimaging of emotion with music (Koelsch et al. 2010).

(3) Cognition modulation by music includes memory processes, and processes related to musical syntax and musical meaning. Music listening enhances cognitive recovery after a cerebral stroke.¹⁷

(4) Concerning behavior modulation, Koelsch refers to articles by Schlaug et al. and Altenmüller et al. (below, no. 57-58), and to a growing number of studies which indicate neural overlap between perception and action. In particular, he draws attention to studies of the mirror neuron system,¹⁸ and to the observation that emotion appears to influence perception-action mediation (pp. 379-381).

(5) Regarding communication, he points out that listening to music can elicit attempts to understand the intentions and desires of those who produced the music.

(6) Music training exerts an influence on the perception of acoustic features at the level of the brain stem,¹⁹ and at the level of the cortex (pp. 375-376). This comprehensive article represents an important step towards recognition of the effects of music therapy.

Melodic intonation therapy

¹⁶ Hillecke, NM II No. 28, this chapter.

¹⁷ Särkämö, NM IV, this chapter.

¹⁸ About the mirror neuron system, see also Fadiga et al., NM III No. 66, this chapter, and Overy, NM IV No. 7, this chapter.

¹⁹ About the Auditory brain stem response, see Strait et al., NM III no. 30, and Kraus et al., NM III No. 79, this chapter.

Schlaug et al. (NM III no. 57, pp. 374-384) have studied the changes in brain connections in six patients with large left-hemisphere strokes, who were treated with long-term melodic intonation therapy. These patients suffered from nonfluent aphasia, that is, they could understand the speech of others, but were unable to produce words themselves. The treatment of melodic intonation therapy consisted of 75-80 daily sessions. The sessions were based on melodic intonation, singing words on two pitches to exaggerate the normal melodic content of speech. The therapist also employed rhythmic tapping of each syllable, using the patient's left hand. The idea of the therapy is to create and activate language ability in the patient's right hemisphere to replace the destroyed language functions in the left hemisphere.

The patients were scanned before and after the long-term treatment by means of the diffusion tensor imaging technique (DTI), which produces images of white-matter connections in the brain. Of particular interest was the arcuate fasciculus (AF), a major fiber tract which connects brain areas important for speech, notably the regions known as Broca's area and Wernicke's area. This tract is normally better developed in the left hemisphere, dominant for speech.

The study showed a significant increase in AF fibers in the right hemisphere after treatment. The authors suggest that intense, long-term melodic intonation therapy leads to a remodeling of the right arcuate fasciculus, which may explain the sustained therapy effects in these six patients. They suppose that the regions which play a role in the recovery process are the superior temporal lobe, which is important for auditory feedback control, the premotor regions, important for planning of motor actions, and the primary motor cortex, important for execution of vocal motor actions (p. 385).

Music-supported therapy

Altenmüller et al. (NM III no. 58, pp. 395-405) have studied the effects of music-supported therapy (MST) in patients with motor impairments after stroke. The treatment consisted of motor-skill exercises on a MIDI piano and an 8-pad electronic drum set. The exercises began with one tone, and were systematically increased to songs of 5-8 tones. The instructor played first, and asked the patient to repeat. The patient started playing with the affected arm, later helped by the healthy arm.

32 stroke patients received 15 sessions of MST plus conventional therapy. 30 patients in a control group received conventional therapy only. The study demonstrated a pronounced effect of MST on the recovery of motor functions, and EEG measurements showed profound therapy-related changes (p. 395). The authors suggest that audiomotor coupling is a powerful mechanism for shaping motor functions (p. 403). Auditory feedback enhances the outcome of motor-skill training. The authors have published further details of the study (Schneider et al. 2010).

Neurologic music therapy

Thaut et al. (NM III no. 59, pp. 406-416) have examined the effects of neurologic music therapy (NMT) with brain-injured persons. NMT is taught and practiced according to a training manual by Thaut (1999). It comprises a wide range of treatments, including rhythmic auditory stimulation, instrumental music performance, structuring and cueing functional movements by means of kinematic patterns, vocal intonation, and auditory perception and attention training.

The researchers compared a group of brain-injured patients who received treatment in 30 minute sessions with a group who rested for 30 minutes. The treatment consisted of four sessions on four different days, focusing on emotional adjustment, executive function, attention, and memory. Pre-tests and post-tests by means of established questionnaires showed that the treatment patients improved in executive function, emotional adjustment, and lessening of depression and anxiety (p. 406). The authors add that this is an exploratory study which provides preliminary evidence, as the participants were not randomly assigned to the treatment group or the control group.

Attention and memory

Fast recognition of familiar music

Bigand et al. (NM III no. 33, pp. 234-244) have designed an experiment to evaluate the minimal length of time necessary for participants to make a familiarity judgment of excerpts from classical music. They presented excerpts of 12 very well-known pieces and 12 relatively unknown classical pieces to musically untrained participants. The 24 pieces were cut in a random way into fragments of 250, 350, 550, and 850 sec., linked in a scrambled way, and presented in recognition tests. The experiment showed that familiarity judgments of music can be made on the basis of excerpts as short as 250 msec.

The authors conclude that recognition of familiar music depends on a complex of local features. They sum up these features as the "color of sound", comprising timbre, harmonic style, voicing, and orchestration, and suggest that the color of sound provides a very fast route for accessing musical memory traces (p. 243)

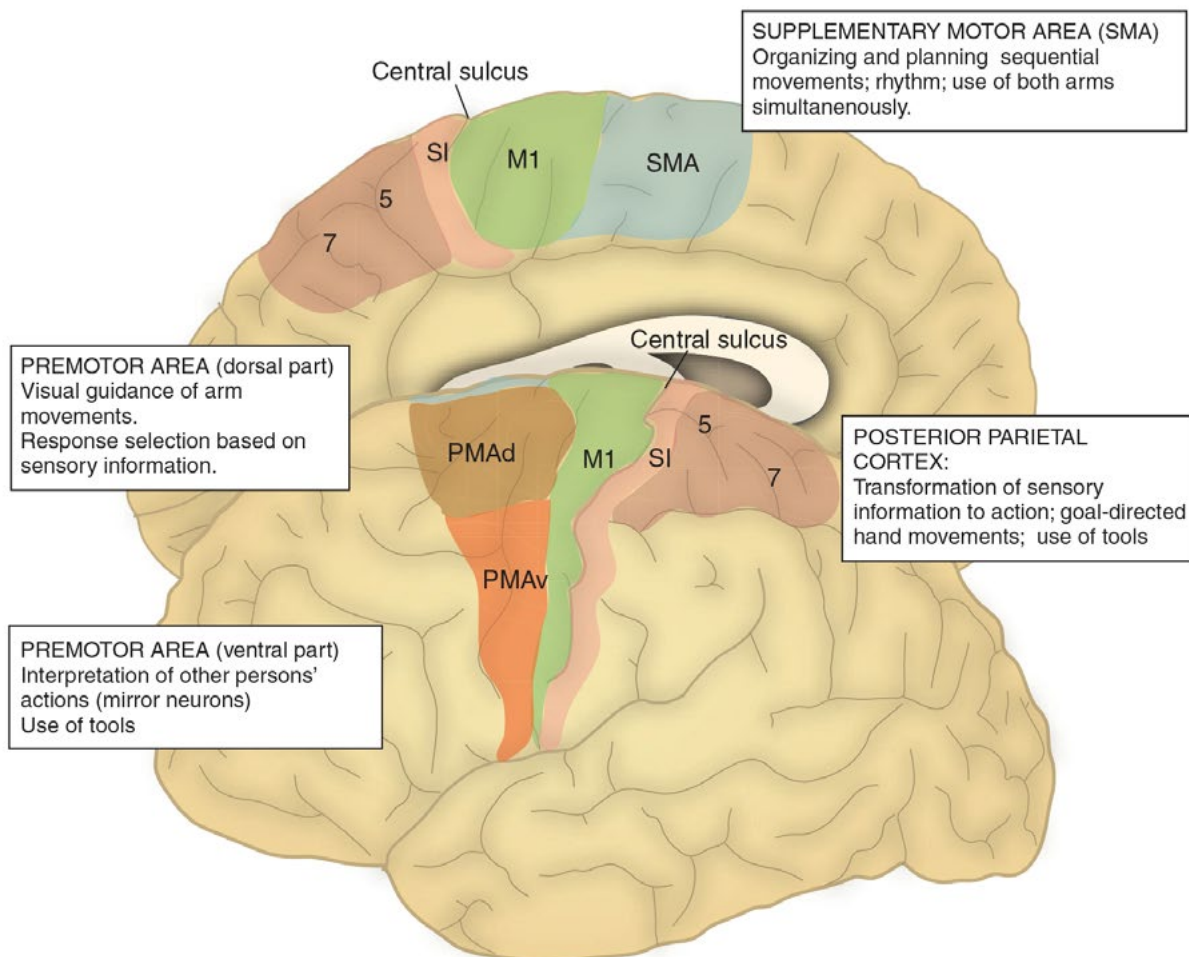


Figure 3.4. Brain areas of special importance for the control of voluntary movements.

The figure shows the surface and the inside of the left cerebral hemisphere.

M1 is the Primary motor cortex, divided from SI, the Somatosensory cortex, by the Central sulcus. Text boxes indicate the functions of the Premotor area, the Supplementary motor area, and areas 5 & 7 of the Posterior parietal cortex. Not shown are areas in the Prefrontal cortex, which are involved in cognitive motor control (selection of goal, choice of movement strategy) (Brodal 2010:314)

Embodiment, motion, and emotion

Sensory-motor processing and mirror neurons

Chen et al. (NM III no. 1, pp. 15-34) present studies of the neural basis for interactions between the auditory and motor systems in the context of musical rhythm perception and production. Based on fMRI studies, they demonstrate that motor sequencing tasks engage the supplementary motor area (SMA), the pre-SMA, the dorsal premotor area (PMAd), and the cerebellum (p. 19). Furthermore, they illuminate how various parts of the premotor cortex are engaged by rhythm. The dorsal premotor area (PMAd) is sensitive to rhythm's metric structure. The ventral premotor area (PMAv) is not, but it is sensitive to the processing of action-related sounds. The mid-premotor area (not shown in figure 3.4) is engaged during both passive listening and tapping (pp. 22-23).

Finally, the authors discuss the role of mirror neurons (pp. 28-29). Monkey studies have shown that the same neurons become active when performing an action, such as grasping a banana, and when observing someone else performing the same action. Similarly, auditory mirror neurons are engaged when the monkey breaks a peanut, and when the monkey hears a peanut being broken. However, the authors assume that the possible role of mirror neurons for auditory-motor integration is still unclear.

Integration of action, music, and language

Fadiga et al. (NM III no. 66, pp. 448-458) review studies of the posterior inferior frontal gyrus (IFG), known as Broca's area. According to classical neuroscience, Broca's area is considered of critical importance for language production. Another area located in the inferior parietal lobule, known as Wernicke's area, is considered important for speech perception. These areas are interconnected with a bundle of association fibers, the arcuate fasciculus (see above, no. 57).

The authors refer to current research, which shows that the posterior IFG is activated for several tasks other than language production, including speech comprehension, action execution and observation, and music execution and listening. These tasks also activate a neighboring area, the ventral premotor cortex (p. 448).

These findings are related to studies which describe the putative human mirror neuron system. This system includes the posterior IFG, the ventral premotor cortex, and the rostral part of the inferior parietal lobule. It becomes activated not only when a person performs an action, but also when he or she sees or hears the same action (Rizzolatti & Craighero 2004). Further studies suggest that it is possible to delineate a network of brain areas shared between listening, producing, and imagining a musical excerpt (p. 454).

In conclusion, the authors propose that the posterior inferior frontal gyrus (Broca's area) might be a center of a brain network encoding hierarchical structures regardless of their use in action, language or music (p. 455).

Bodily impact of music

Grewe et al. (NM III no. 51, pp. 351-354) report a new approach to using chills as indicators of individual emotional peaks. Chills consist of a highly pleasurable feeling response combined with goose bumps and shivers, a bodily reaction that can be measured. The authors point out that it has been a problem in previous studies that individuals experience chills at different points in time and in response to different musical events. In their study, they apply an approach which aims at overcoming this difficulty.

They collected chill samples of 95 listeners in response to seven music pieces of Mozart, Bach, and Puccini. While listening, participants were asked to press a mouse button as long as a chill lasted, and measurements of skin conductance response (SCR) and heart rate (HR) were recorded simultaneously. These data permitted comparison of chill episodes with non-chill episodes of the same participant. Comparisons of 622 chill samples with 622 non-chill samples showed a strong and synchronized relationship between subjective feelings, skin conductance response, and heart

rate (p. 352). The authors conclude that, according to their approach, it is possible to cope with individual responses in a controlled and objective way. They have published an elaborate report of their study (Grewe et al. 2009).

Emotional response to an infant's unhappy cry

Strait et al. (NM III no. 30, pp. 209-213) have investigated auditory brain stem responses (ABR) to affective vocal sounds. A group of non-musicians and a group of musically trained participants listened to an emotionally charged complex vocal sound – an infant's unhappy cry. Differences in brain stem responses suggest that musical experience sharpens subcortical auditory processing, resulting in enhanced perception of vocally expressed emotion (p. 209). The authors attribute this sharpening to a corticofugal system²⁰ incorporating the primary auditory cortex, thalamus, and the auditory brain stem.

3.3.2. Critical comments stated at the conference NM III 2008

Contrary to the previous conferences, the chapter introductions in the proceedings do not include critical comments on methods, cultural and social references, and technology, with one exception. Mari Tervaniemi, in her introduction to the section on Emotions and Music (NM III, p. 295-296) reveals a critical attitude, as she emphasizes the challenge to empirical research in emotions and music, that "each individual listener can build his or her unique mental and emotional scene of any musical piece."²¹ This statement indicates an important approach in neuroscience, the investigation of individual experiences alongside with the general functions of the brain.²²

3.3.3. Achievements and problems of research in NM III 2008

The 2008 conference was oriented towards the concept of plasticity, the possibility of inducing changes in the brain. The conference plan focused on changes in brain function and anatomy due to training and expertise, and changes of deficits and disorders by means of therapeutic interventions.

In the preface to the conference proceedings, the scientific committee pointed out that the 2008 conference highlighted the clinical domain, and that it reflected the consensus that music can serve as a model system to study the plasticity of the brain. Moreover, they report the observation that music neuroscience has established itself as a research area of importance, and that the gap between applied and basic research is being bridged (NM III, pp. 1-2).

Similar to NM I and NM II, the following themes and problematics deserve attention: 1) Ecological validity. 2) Cultural bias. 3) Aesthetic and social factors. 4) Localization of brain functions. 5) The limitations of experimental techniques.

Ecological validity

Appendix 3.05, provides a survey of musical material NM III.

Sources not indicated

Nine papers out of 79 do not indicate the sound sources of stimuli. Four of these papers are studies of tapping and meter (no. 1, 2, 5, and 76). Three papers are studies of memory (no. 36, 37, 38). One

20 A corticofugal system consists of nerve fibers that convey impulses away from the cerebral cortex. See the descending auditory pathway, Chapter 6 and He & Yu (2010:247-268).

21 Cf. Chapter 2, Listening strategies.

22 In his review of bodily responses to music, Donald A. Hodges expresses a related point of view: "Bodily responses are highly idiosyncratic as each person brings a unique self to a music listening situation" (Hodges 2009:127)

paper is a study of subjective appraisal of music (no. 44). One paper is a study of musical syntax processing (no. 72). The lack of information about sound sources raises the question of the validity of the studies. In particular, the nature of the sound source is likely to influence studies of memory and subjective appraisal.

Sinus tones

One MEG study demonstrates different responses to sinus tones and acoustic instrumental tones (no. 18), and one EEG study demonstrates different responses to sinus tones and synthesized piano and violin tones (no. 16). The findings of these studies question the validity of the seven studies based exclusively on sinus tones (no. 4, 8, 15, 22, 28, 64, 74).

Real music

17 papers report the application of recordings of real music. However, none of these are brain imaging studies. In 14 papers, the music is not specified. The music is specified in three papers; Wong et al. (no. 19), a study of auditory brainstem responses (ABR), Bigand et al. (no. 33), a study of familiarity judgments, Grewe et al (no. 51), a study of chills, skin conductance response (SCR), and heart rate (HR).

Cultural references

Appendix 3.07 reports a survey of Cultural references NM III.

Western major-minor tonality

Out of 79 papers, 40 refer to Western major-minor tonal music, primarily classical. 27 papers are culturally neutral.

Popular music

Ten papers include popular music in their studies, but do not specify the pieces. Honing et al. (no. 9) investigate mismatch negativity (MMN) responses to a rhythmic rock pattern. Sevdalis & Keller (no. 73) investigate self-recognition in dance movements to drum and bass, folk and jazz music.

Brattico & Jacobsen (no. 44) provide a comprehensive review of subjective appraisal of music, including pop and rock music. They state that "pop and rock music (...) contain elaborated accompaniment and timbre solutions aiming at engaging listeners' attention and inducing emotions" (NM III, p. 312). However, they do not present a study of pop or rock music.

Cross-cultural studies

Cross-cultural studies are scarce in NM III. One paper (no. 19) focuses explicitly on cultural differences, comparing Western, Indian, and bimusical listeners' judgments of Western classical and Indian classical music.

Two papers investigate tone contours in tonal languages (no. 71, 79). One paper compares Western and Japanese children's identification of TV theme songs (no. 78). Except for these four papers, the bias towards Western major-minor music is significant.

Inclusion of aesthetic, therapeutic and social factors

Therapy and recovery

The overall theme of Disorders and Plasticity in the NM III conference makes room for extensive presentations of music-supported therapy and rehabilitation techniques (no. 57, 58, 59, 62). Koelsch's review of the effects of music therapy (no. 58) provides a substantial introduction to the field.

Embodiment and emotion

In their study of strong experiences of music, Grewe et al. (no. 51) found evidence of music's impact on two physiological variables, skin conductance response and heart rate. Another three papers (no. 53, 55, 56) report the bodily impact of music.

Recognition

Bigand et al. (no. 33) suggest the existence of a very fast route for recognition of voices and music. They have not investigated the anatomical details, but show that excerpts of 250 msec are sufficient for recognition of music²³, and report that an excerpt of 25 msec may permit identification of a speaker's voice.

Localization of brain functions

Networks

Numerous investigations suggest that music activates extensive networks, which integrate subcortical and cortical processes. Some networks function as loops that connect the involved brain regions reciprocally. Wong et al. (no. 19) and Strait et al. (no. 30) uncover networks of expertise. Grahn (no. 2) suggests a neural loop that is engaged by beat perception.

A comparatively new tool for studying neural networks is the Diffusion Tensor Imaging technique (DTI). This technique is applied by Schlaug (no. 57) to produce images of nerve fiber connections in the brain.

Mirror neurons

The interaction of auditory and motor functions and the possible role of a human mirror neuron network are in focus of studies by Chen et al. (no. 1), Koelsch (no. 56), and Fadiga et al. (no. 66).

Auditory brain stem response

Findings show that the brain stem is not a passive relay station; subcortical processing interacts dynamically with cortical processes. Kraus et al. (no. 79) point out that pitch, timbre and timing, which are basic features of music, have distinct measurable subcortical representations. Strait et al. (no. 30) find enhanced auditory brain stem response in musicians.

Reliability of techniques

In two MEG studies, measurements of dipole strengths²⁴ contribute to improving localization of brain activity (no. 5, 38).

3.4. Summary of research in NM I 2002, NM II 2005, and NM III 2008.

A considerable number of research results have been reported in the present chapter. The following list summarizes a number of important achievements in auditory neuroscience, presented in the three conferences 2002, 2005, and 2008. In this list, the emphasis is on investigations related to music listening.

Pitch perception

Griffiths (NM I no. 3), Tramo et al. (NM II no. 15).

²³ In *Ways of Listening*, Eric Clarke reports a similar observation. When you turn on the radio, and involuntarily hear music, you can immediately identify the musical style (Clarke 2005:15-16).

²⁴ Salmelin (2010:124-155) describes the method of dipole modeling in MEG.

Core, belt and parabelt areas of the auditory cortex

Jones (NM I no. 30), Tramo et al. (NM II no. 15).

Hemispheric differences: Spectral and temporal processing

Schönwiesner et al. (NM II no. 9).

Parallel pathways

Jones (NM I no. 30).

Auditory brain stem responses

Wong (NM III no.19), Strait (NM III no. 30), Kraus (NM III no. 79).

Fast responses to complex music

Bigand et al. (NM II no. 46), Bigand et al. (NM III no. 33).

Musical expression

De Poli (NM I no. 9), Sloboda et al. (NM II no. 25).

Chills: Strong emotional experiences

Blood & Zatorre (2001), Grewe et al. (NM II no. 49), Grewe et al. (NM III no. 51).

Mirror neuron systems

Chen et al. (NM III no. 1), Fadiga et al. (NM III no. 66).

Widely distributed neural systems

Janata et al. (NM II no. 12), Tramo et al. (NM II no. 15), Grahn (NM III no. 2).

Many of these findings have been included in the common knowledge of auditory neuroscience, in particular results concerning *pitch*, *areas of the auditory cortex*, *hemispheric differences*, *parallel pathways*, and *chills* (Brodal 2010; Koelsch, Siebel & Fritz, 2010; Altenmüller & Schlaug, 2012). Some investigations are closely related to current trends in neuroscience, such as research on *mirror neuron systems* and *distributed neural systems*.

3.4.1. Research problems

As pointed out in the present chapter, various research problems can be identified in papers presented at the conferences NM I, NM II, and NM III. Themes for discussion are the questions of ecological validity and cultural references.

Ecological validity

The ecological validity of a music listening study indicates its relevance for music listening in a real-life context.

The common use of artificial stimuli in neuroscientific studies raises the question whether the findings of the reported experiments imply validity for acoustic sounds and real music. This question was posed in critical comments in the conference reports, and a number of studies have investigated the differences between responses to artificial and acoustic stimuli.

The survey of musical material in appendix 3.05 gives an overview of musical material presented in the papers at the three conferences. The number of conference papers is as follows: NM I: 61, NM II: 53, NM III: 79, a total of 193 papers. In order to permit comparison of applied material, appendix 3.05 shows a selection of papers that use artificial stimuli, acoustic sounds, and recorded music.

Estimation of ecological validity

Source not indicated

32 papers out of 193 do not indicate the source of the stimulus material. This lack of information obscures the validity of the research in question.

Sinus tones

23 studies apply sinus tones as stimuli. Some of these studies have chosen sinus tones in order to ensure strict experimental control. Other studies investigate differences in neural perception of sinus tones and musical tones. The results of a number of studies show clear differences between perception of sinus tones and perception of musical tones, suggesting that the use of sinus tones as stimuli may reduce the ecological validity of an experiment.

Synthesized material

46 studies apply synthesized material as stimuli. Some of these studies are based on the precise manipulation of sound spectra, which is only possible in synthesized material. Other studies report the use of synthesized instrumental timbres, which approximate the features of acoustic sounds. Nevertheless, the properties of synthesized sounds are not equal to the properties of acoustic sounds. Synthesized sounds do not emulate the minute spectral and temporal variations that are important for the perception and emotional impact of natural sounds. This problem is not discussed in the studies. Thus, the ecological validity of studies based on synthesized sound remains questionable.

Future research can benefit from current investigations which clarify differences between synthesized tones and acoustic tones; research into the modulations and microtemporal evolutions of sound spectra (Malone & Schreiner 2010:125-148), and research into the processing of differences between auditory information from the two ears ²⁵ (Yin & Kuwada 2010:271-302).

Acoustic stimuli

18 studies apply acoustic stimuli.

11 studies apply tones of acoustic instruments, three in NM I, one in NM II, and seven in NM III.

7 studies report the use of singing voice, 0 in NM I, three in NM II, and four in NM III.

The scarcity of acoustic stimuli is apparent. One may speculate whether it is the judgment of neuroscientists that the use of acoustic stimuli implies an unacceptable reduction of experimental control.

Percussion music is totally absent from the conference papers, with the exception of a few drum patterns in tapping studies. The multifaceted timbres and multivariable rhythms of percussive music constitute a rich unexplored field of study. Similarly, the expressive qualities of the singing voice offer a rich material for future studies.

Recorded music

36 studies apply recordings of real music. In 19 papers, the recorded music is specified. Noteworthy papers which apply specified recorded music are the following:

²⁵ The auditory system detects minute differences in timing between the two ears, due to the fact that sound from one side arrives earlier in one of the ears. The auditory system also detects minute differences in sound level between the ears. The technical terms are interaural time disparities (ITD) and interaural level disparities (ILD)

fMRI studies

Two papers report the use of real music in neuroimaging studies, Demorest and Morrison (NM I no. 8), and Janata (NM II no. 12). Together with the PET study by Blood & Zatorre (2001) earlier described in this chapter p. 67, these studies demonstrate that it is possible to combine reliable experimental control with the ecological validity of using real music.

Musical expression

Two papers report investigations of expressive intentions in live music recordings, De Poli (NM I no. 9), and Sloboda et al. (NM II no. 25). This type of investigation is important for the understanding of music perception, the emotional impact of music, and the similarities and differences between acoustic and artificial sounds.

Emotion and recognition

In studies by Bigand et al. (NM II no. 46, NM III no. 33) and Grewe et al. (NM II no. 49, NM III no. 51), the participants listen to live recordings in headphones. These studies yield remarkable results. Bigand et al. demonstrate that emotional response and recognition of complex music occurs within 250 milliseconds. Grewe et al. have investigated the strong emotional responses to music. Their results indicate a strong relationship between subjective feelings, heart rate, and skin conductance response.

Even if these studies of recorded real music are few in number, they set a standard for ecological validity, that is, the relevance for music listening in a real-life situation.

Cultural references

The surveys in appendix 3.07 indicate cultural references in the papers of the conferences 2002, 2005, and 2008. These surveys permit an overview of the cultural orientation of the neurosciences and music. The tables in appendices 3.01, 3.02, and 3.02 provide more detailed information concerning the contents of papers. The tables indicate for each study its aim, musical material, cultural reference, technology and procedure, main focus of interest, and conclusion.

In 76 out of 193 papers, the cultural orientation is neutral or not particularly prominent, e.g. in studies of pitch perception. Out of the remaining 117 studies, 97 papers focus on Western major-minor tonality, in particular classical music and the scales, rhythms, and harmonies of classical music. Three studies include Western non-tonal music, and 11 papers include music from more than one culture. 19 papers deal with Western popular music, and four with Western traditional music.

Western major-minor tonality

Major-minor music is the mainstream in studies of neuroscience and music, prominent in 97 out of 117 studies that imply a cultural reference. It is debatable whether the results of studies of major-minor tonal music can be considered valid for other kinds of music.

Four large fields of music are sparsely represented or absent in neuroscientific studies; Western popular music, Western art music of the 20th and 21st centuries, improvised music, and the music of non-Western cultures.

Inclusion of Western popular music

In spite of its ubiquity, Western popular music is not often in the focus of neuroscience, and very

rarely applied as stimulus material in neuroimaging studies. 19 out of 117 conference papers include popular music. Noteworthy papers which specify popular music are the following:

Western popular music, NM I

Drake & El Heni (NM I no. 48, pp. 429-437) have studied intercultural differences on the basis of French and Tunisian popular songs.

Western popular music, NM II

Schellenberg & Hallam (NM II no. 20, pp. 202-209) have investigated the impact of popular music on schoolchildren's cognitive abilities.

Grewe et al. (NM II no. 49, pp. 446-449) include Pop, Rock, Death Metal, and Bossa Nova in a study of strong emotions that arouse chills.

Western popular music, NM III

Honing et al. (NM III no. 9, pp. 93-96) apply a rhythmic rock pattern in studies of sensitivity to meter in adults and newborn infants.

Sevdalis & Keller (NM III no. 73, pp. 499-502) have investigated body motion related to musical excerpts from drum and bass, folk and jazz music.

In addition to these 5 papers, 14 papers report the inclusion of unspecified popular music.

The scarcity of studies of rock music and other groove-based music genres in the conference proceedings is conspicuous. Future studies of the complex timbres of rock music and the strong bodily impact of techno music and related genres may yield interesting results.²⁶

Additional studies

Only a selection of studies concerning neuroscience and music have been reviewed in the conferences. As a supplement to the conference papers, a number of studies of non-classical music, published elsewhere, can be noted:

Vuust et al. (2005, 2006) have investigated polyrhythms in jazz music.²⁷

Limb & Braun (2008) have conducted an fMRI study of keyboard jazz improvisation.

Witek has investigated the emotional and physiological responses to groove-based music (2009:573-582).

PET studies by Salimpoor et al. (2009, 2011) include various popular genres, specified as jazz, rock, house, trance, post-rock, folk, international, and psychedelic trance. See chapter 6.

The study of polyphonic timbre by Alluri & Toiviainen (2010) is based on musical excerpts of Indian popular music, encompassing genres such as pop, rock, and disco. The fMRI study by Alluri et al. (2012) is based on Astor Piazzolla's tango *Adiós Nonino*.

²⁶ Eric Clarke (2005:55-61) discusses the perceptual and cognitive impact of stability and instability in rock music timbres. Kreutz et al. (2012:460) suggest that the distortions of musical sound in rock music may be essential to its effect on listeners. In the context of music therapy, Von Appen (2007:5-25) provides an informative introduction to the aesthetics of popular music.

²⁷ Cf. the paper presented by Vuust et al. at the Neurosciences and Music IV 2011, this chapter.

Art music of the 20th and 21st Centuries

Creative projects

The conference proceedings NM I 2002 include reports of projects by invited composers.

Rosenboom (NM I no. 34, pp. 263-271) describes a computer-based system that can generate musical structures from direct measurements of EEG.

Minciacchi (NM I no. 36, pp. 282-301) has created systems that convert neurobiological data into structures from which sound objects are generated.

Radulescu (NM I no. 39, pp. 322-363) presents models for creating spectral music based on ring modulation.

Non-tonal music

Two papers include music that is not based on major-minor tonality.

In a study of learning new musical systems, Bigand (NM I no. 37, pp. 304-312) applies newly composed dodecaphonic canons in the style of Anton Webern.

Koelsch (NM III no. 56, pp. 374-384) reports a test of social cognition of music, based on excerpts from piano pieces by Arnold Schoenberg (1874-1951) and Anton Webern (1883-1945).

Musical innovations

Apart from these contributions, musical works of the 20th and 21st centuries are not considered in the Neuroscience and Music (NM) conferences. This omission is remarkable, because art music of the last 100 years has introduced new and challenging approaches to music perception, music cognition, and music-induced emotion.²⁸

Significant musical innovations in the 20th Century include the following:

Charles Ives' multilayered music
Bela Bartok's extended tonality
Igor Stravinsky's patterns of variable meter
Edgar Varèse's use of noise and electronic sound
Henry Cowell's tone clusters
Olivier Messiaen's extended harmony, composite timbres and additive rhythms
John Cage's and numerous other composers' use of percussion
Witold Lutoslawski's use of quarter tones
Iannis Xenakis' use of glissandi
György Ligeti's sound masses and transitions between regularity and irregularity
Luciano Berio's use of musical gestures
Karlheinz Stockhausen's and numerous other composers' development of electronic sound
Krzysztof Penderecki's use of unconventional instrumental techniques
Steve Reich's repetitive musical patterns.

These composers are classics of the 20th Century. In addition, the music of innumerable living composers is currently presented at festivals, played in concert halls, and distributed as recordings. A

²⁸ *The Musical Timespace* presents innovations in 20th Century music by Xenakis, Ligeti, Lutoslawski and Ives. Cf. chapter 4.

future inclusion of the music of living composers and 20th Century classics in neuroscientific studies may lead to interesting new discoveries.²⁹

Music of Non-Western cultures

As reported in the present chapter, NM I 2002 included seven cross-cultural studies. In NM II 2005, music of other cultures was not represented. NM III 2008 included four cross-cultural studies.

Cross-cultural studies, NM I

Demorest and Morrison (NM I no. 8, pp. 112-117). An fMRI study of differences in brain activation due to cultural differences, based on excerpts from A. Scarlatti: *Sonata Terza* and a traditional Chinese piece, *Liu Qin Niang*.

De Poli (NM I no. 9, pp. 118-123) reports studies of expressive intentions in performance of melodies from Western classical and Afro-american music. However, the examples of Afro-american music are not specified.

Neuhaus (NM I no. 23, pp. 184-188) has compared the ERP responses (MMN) of German, Turkish, and Indian musicians to European and Thai scales and a Turkish makam.

Sittiprapaporn et al. (NM no. 26, pp. 199-203) have conducted a MMN study of native Thai speakers' preattentive responses to syllables of two tonal languages, Thai and Chinese.

Trehub (NM I no. 46, pp. 402-413). As part of a comprehensive review, Trehub includes studies of American and Japanese children (pp. 408-409). The studies investigate the children's accuracy at identifying the pitch level of familiar TV and movie signature tunes.

Drake & El Heni (NM I no. 48, pp. 429-437) have tested Tunisian and French adults' ability to tap in synchrony with typical Tunisian and French popular songs.

Ruzza et al. (NM I no. 60, pp. 527-529) explore the differences between early vocalizations in Italian and Moroccan infants.

Cross-cultural studies, NM III

Wong et al. (NM III no. 19, pp. 157-163) have conducted a study of responses to Indian and Western music in groups of listeners who were monomusical, and listeners who were bimusical, enculturated in both cultures.

Nguyen et al. (NM III no. 71, pp. 490-493) have studied French participants' ability to discriminate pitch variation in Mandarin Chinese, which is a tonal language.

Trehub et al. (NM III no. 78, pp. 534-542) have investigated the ability to recognize TV theme songs in Japanese and Canadian children with cochlear implants.

Kraus et al. (NM III no. 79, pp. 543-557) have compared auditory brain stem responses to pitch in speakers of English and Mandarin Chinese (p. 546).

29 Interestingly, in the conference 2000 entitled *The Biological Foundations of Music*, a paper investigated the music of numerous 20th Century composers. This conference was the precursor of the Neurosciences and Music Conferences. In a paper on similarity, invariance, and musical variation, McAdams & Matzkin (2001:62-76) discussed the music of Bartok, Boulez, Ligeti, Messiaen, Penderecki, and Xenakis.

These cross-cultural studies represent the first steps towards a global perspective in the neurosciences and music. There is room for expansion of the perspective, as the selection of Non-Western cultures is delimited to Japan, India, China, Thailand, Turkey, Tunisia, and Morocco.

Universals in music processing?

Studies of major-minor tonal music are predominant in the neurosciences. It remains a topic of discussion whether this predominance promotes or inhibits the understanding of other types of music. Relevant questions concern whether it is possible to identify worldwide music universals, and whether research in major-minor tonal music contributes to the understanding of potential music universals. Scholars disagree on the question of music universals.

Thompson and Balkwill (2010:759-760), in their review of cross-cultural similarities and differences, enumerate a number of likely candidates for musical universals, including,

- A processing advantage for music built on a small number of discrete pitch levels that are spaced unevenly (e.g. the major scale)
- Sensitivity to sensory consonance and dissonance
- A processing advantage for music that contains a regular temporal pattern of stress.

Brown and Jordania (2011:6-15) propose a typology of musical universals, and list 70 putative universals in music cross-culturally. Among the predominant patterns in all musical systems or styles, they state,

- The use of discrete pitches
- Scales have seven or fewer pitches per octave
- Predominance of precise (isometric) rhythms in music

With reference to these scholars, it can be suggested that findings of neuroscience concerning pitch, scales, consonance and dissonance and regular temporal patterns may be valid for a wide range of musics around the world. Other scholars are less certain concerning this assumption.

Stevens and Byron (2009:15-16) point out that consensus on universals in music processing is based, in the main, on studies involving culturally narrow samples. They enumerate a number of musical patterns that await further cross-cultural scrutiny, including,

- The use of discrete pitch levels
- The semitone as the smallest viable interval
- Musical scales with differently sized steps between consecutive tones
- The prevalence of small integer frequency ratios
- A regular beat or periodic pulse.

As candidates for universal qualities in music cognition, Stevens and Byron (2009:20) propose

- Movement perception and its development
- The interplay of tension and relaxation
- Perception-action processes that are the results of tightly coupled sensorimotor systems.

Patel (2008) points out that the Western concept of rhythm, related to periodicity or the alternation

between strong and weak beats, is not a broad notion of rhythm. He indicates that musical forms that are widespread in the world lack one or both of these features. His examples are the Ch'in music of China, Balkan folk music, and drumming patterns from Ghana (2008:97-99, 149-151).

Advances in neuroscience do not presuppose complete agreement on the question of music universals. It can be noted that investigations of movement perception and perception-action processes, as suggested by Stevens and Byron, are currently in the focus of research in the neurosciences and music. Future studies of the music of Non-European cultures and art music from the 20th and 21st Centuries can provide fruitful new insight into music processing in the brain.

3.5. The Neurosciences and Music IV: Learning and Memory Conference 2011 in Edinburgh. A preliminary report

The conference themes were the following:

Workshops: **1. Experimental methods.**
 2. Social / real world methods.

Symposiums: **1. Mechanisms of rhythm and meter learning over the life span.**
 2. Impact of musical experience on cerebral language processing.
 3. Cultural neuroscience of music.
 4. Memory and learning in music performance.
 5. Mind and brain in musical imagery.
 6. Plasticity and malplasticity in health and disease.
 7. The role of music in stroke rehabilitation:
 Neural mechanisms and therapeutic techniques.
 8. Music: A window into the world of autism.
 9. Learning and memory in musical disorders.

The proceedings of the 2011 conference were not published at the time of writing the present chapter. Appendix 3.04 provides a survey of the conference presentations based on the conference abstracts. Appendix 3.06 includes an overview of categories of investigation in NM IV. The following summarizes three presentations which are documented in articles published elsewhere.

Workshop 2: Social / Real World Methods

Shared Affective Motion Experience

Katie Overy and Istvan Molnar-Szakacs (NM IV no. 7) have proposed that music is perceived not only as an auditory signal, but also as intentional, hierarchically organized sequences of expressive motor acts behind the signal (Molnar-Szakacs & Overy 2006; Overy & Molnar-Szakacs 2009). They suggest that the human mirror neuron system (MNS) allows for corepresentation and sharing of a musical experience between agent and listener, and present a model of Shared Affective Motion Experience (SAME).

In accordance with Fadiga et al. (above, NM III no. 66), they identify the MNS as a network consisting of the posterior inferior frontal gyrus, the ventral premotor cortex, and the inferior parietal lobule. They hypothesize that the perceptions of action, language and music share this network, and propose that humans may comprehend all communicative signals in terms of their understanding of the motor action behind that signal, and furthermore, in terms of the intention behind that motor action (2006:238). Referring to a study of empathy by Carr et al. (2003), they suggest that the anterior insula in the brain may serve as a relay from action representation in the MNS to emotion processing

in the limbic system.

The Shared Affective Motion Experience (SAME) model suggests that when we hear music, we hear the presence, or agency, of another person, whose actions we can interpret, imitate, and predict. This experienced presence may include the person's emotional and physical state, technical expertise, social status, and intentions. Musical interplay can promote a powerful sense of shared purpose and togetherness, a narrative of call and response, synchronization, prediction, interruption, and imitation (2009:495). The authors state that imitation, synchronization, and shared experience may be the key elements of successful work in music therapy and special education (2009:499). Moreover, the authors refer to a body of studies which associate the human MNS with a wide range of functions related to social cognition. These studies include imitation and imitation learning, intention understanding, empathy and theory of mind, self-recognition, and the evolution of language. However, they acknowledge that studies of the MNS are still in its early stages.

Not all researchers agree that the MNS is responsible for such a wide range of functions. In their article, "The motor theory of social cognition: a critique", Jacob and Jeannerod (2005) argue that simulating an agent's movements might be sufficient for understanding his motor intention, but not sufficient for understanding his social and communicative intentions. They propose the existence of a purely perceptual system of social perception. This system is supposed to involve three brain areas; the superior temporal sulcus, the amygdala and the orbitofrontal cortex (2005:21-23).

Symposium 3: Cultural Neuroscience of Music

Neural differences between groups of musicians

By means of EEG, Vuust et al. (NM IV no. 17) have studied the neural responses to musical features in different groups of musicians and non-musicians (Vuust et al. 2011, 2012). They have developed a new paradigm for measuring the mismatch negativity (MMN) response to six different types of musical change; pitch, timbre, location, intensity, rhythm, and pitch slide. The MMN response is pre-attentive, automatically elicited in the absence of the subjects' attention towards the stimuli.

The paradigm consists of four-tone "Alberti bass" patterns³⁰ played with piano sounds, alternating between standard sequences and deviant sequences. In the deviant sequences, the third tone is changed. This permits comparison between the event-related potential (ERP) responses to the third tone of the standard sequence and the third tone of the deviant sequence. One example of the paradigm is the following:

standard / rhythm deviant / standard / location deviant / standard / pitch deviant / standard /
timbre deviant / standard / pitch slide deviant / standard / intensity deviant

The new paradigm is more musically interesting than traditional one-tone paradigms, and it permits recording of MMN responses to six different musical deviants within a comparatively short time. The authors point out that they have observed no differences in recorded responses using the new paradigm, compared to the traditional oddball paradigm, which only applies one type of deviant.

Participants in the experiment were 11 non-musicians, 7 classical musicians, 10 jazz musicians, and 14 rock musicians. Their MMN responses were recorded by EEG while they listened to 20-minute blocks of randomized sequences, watching a silent movie. After the EEG recording, the musical skills of the participants were tested by means of a standardized test procedure, the Advanced Measure of Musical Audiation (AMMA).

The MMN findings showed that jazz musicians had larger MMN amplitude than the other groups across the six different sound features. This indicates a greater sensitivity to sound changes in jazz musicians compared to other types of musicians. In particular, the results showed enhanced processing of pitch and pitch slide in jazz musicians. In the AMMA tests, jazz musicians and classi-

30 Alberti bass is a four-tone broken chord accompaniment used in classical keyboard music.

cal musicians scored higher than rock musicians and non-musicians. The authors suggest that the development of musicians' brains is influenced by the type of training, musical genre, and listening experiences.

Symposium 7: The role of music in stroke rehabilitation: Neural mechanisms and therapeutic techniques

Music listening facilitates recovery after stroke

Särkämö et al. (NM IV no. 36) have studied the rehabilitative effects of music listening on the recovering brain (Särkämö et al. 2008; Forsblom et al. 2010, Särkämö 2011). In order to determine whether everyday music listening can facilitate the recovery of cognitive functions and mood after stroke, they designed a randomized, controlled trial. 60 patients with a middle cerebral artery stroke were randomly assigned to a music group, a language group, or a control group.

A clinical neuropsychological assessment was performed three times on all patients, one week after stroke onset, and three months and six months post-stroke. An extensive test and questionnaire battery was used to assess verbal memory, short-term and working memory, language, visuo-spatial cognition, music cognition, executive functions, focused attention, and sustained attention.

All patients received standard treatment for stroke in terms of medical care and rehabilitation. For two months, the music group listened daily to self-selected music, while the language group listened daily to audio books. Of the music selections, 62 % were pop, rock or rhythm and blues, 10 % jazz, 8 % folk music, and 20 % classical or spiritual music. Results showed that patients who listened to their favorite music 1-2 hours a day showed greater improvement in focused attention and verbal memory than patients who listened to audio books or received no listening material. Moreover, the music group also experienced less depressed mood.

Music therapists interviewed all patients before and after the two-month-intervention. Analysis of the interviews showed that music listening was specifically associated with better relaxation, increased motor activity, and improved mood.

The authors attribute the positive effects of music listening to the widespread neural network which is activated by music listening, comprising bilateral frontal, temporal, parietal and subcortical areas related to attention, semantic processing, memory and motor functions. Activation by music listening may have stimulated the creation of new neural connections in the brain. The authors suggest that everyday music listening during early stroke recovery offers a valuable addition to patient care. Särkämö has presented further studies of the stroke patient group in his dissertation (2011).

The proceedings of the Edinburgh Conference were published in the summer of 2012. The proceedings include the papers reported in the survey in appendix 3.04, with a few exceptions. The inclusion of social / real world methods and cultural neuroscience open new perspectives for future research.

3.6 Potential Relationships between Neuroscience and Music Therapy

The scientific approaches in neuroscience and music therapy research do not overlap to a great extent. Whereas neuroscience aims at objective descriptions of neural functions, research in music therapy is oriented towards informing and improving the therapeutic relationship between client and therapist in a clinical setting.³¹ A discussion of scientific ideals in neuroscience and music therapy

31 Abrams (2010:363) has proposed working definitions of music for different perspectives of evidence; "Objective perspective: Music is an aesthetically organized, temporally ordered, physical sound stimulus with specific structural and functional attributes." "Inter-subjective perspective: Music is an aesthetic, context-situated, time-ordered resource; a form of cultural engagement, social capital, and counter-cultural critique; a historical artifact; a sanctioned/authorized ritual promoting social balance and equity."

research is not intended here.³² However, an inquiry into the music types studied in neuroscience and music therapy research has been carried out. The aim was to illuminate to what extent the two research fields share concepts of music and music practice.

Types of Music studied in neuroscience and music therapy research 2002-2008

As indicated in the present chapter, papers from NM I, NM II and NM III report a number of studies that include real vocal music and instrumental music. In these studies, vocal music comprises sung words, syllables and vocalises, TV theme songs, popular songs, and classical vocal compositions. Instrumental music comprises excerpts of classical Western, Chinese, and Indian music, and excerpts from various genres of Western popular music.

In order to permit a comparison, a survey of music types reported in Aalborg University (AAU) doctoral dissertations 2002-2008 has been compiled in appendix 3.08.

The chosen period coincides with the period of the conferences NM I, NM II, and NM III. Even if the AAU dissertations represent only a fraction of music therapy research, this compilation is suggested to subserve an indicative comparison of the two fields of research. The survey comprises 14 dissertations, numbered MT 1-14. These studies present and discuss three main types of music; pre-composed and newly created songs, selections of recorded music, and improvisations.

3.6.1. Songs

Elefant (MT 1) has performed 18 pre-composed songs in her study of song preference in girls with Rett syndrome.³³ In the therapy sessions, the investigator sings and plays the guitar. The live performance permits extensive variation of musical expression by means of tempo, *accelerando*, *ritardando*, *fermata*, pauses, upbeat introductions and syncopation, rhythmic grouping, dynamic variability, and vocal play with sounds.

Aasgaard (MT 3) has investigated the creation, development and use of pre-composed songs and newly created songs in music therapy with children suffering from cancer. Some new songs adopt a specific popular style; heavy rock, blues, rock, reggae, swing, cha-cha, disco.

Gold (MT 4) reports the use of well-known songs to establish secure frameworks in therapy.

Ridder (MT 5) has used a large repertory of familiar Danish songs in musical dialogue with clients suffering from dementia. The songs focus attention and regulate the arousal of the participants.

Baker (MT 6) has applied client-preferred popular songs in voice rehabilitation for people with traumatic brain injury. Her study includes songs by Creedence Clearwater Revival, Pink Floyd, Eric Clapton, U2, Simon and Garfunkel.

Garred (MT 7) reports a spontaneous song which induces joy and laughter in a girl with Rett syndrome.

Rolvjord (MT 13) has sung a number of pre-composed songs with clients, and created a large number of songs on the basis of a client's lyrics.

Comparisons

In music therapy, songs and vocalizations are widely used as important means of communication

³² A comprehensive documentation of research methods is presented in Barbara Wheeler (Ed. 2005) *Music Therapy Research, 2nd Edition*. For a concise introduction, see Wheeler (2009:515-525).

³³ The Rett syndrome is a severe impairment of neural development and communication, which mainly affects females. It is caused by a genetic mutation. Young girls with Rett syndrome are very responsive to music.

and interaction. This is indicated in MT 1, 3, 4, 5, 7, and 13. In the neuroscience papers, studies of the singing voice are scarce, and limited to studies of single sung words or syllables, or studies of infants.

Studies of complete vocal compositions are reported in three papers. Drake & El Heni (NM I no. 48) base their investigation on Tunisian and French popular songs. Grewe et al. (NM II no. 49, NM III no. 51) report strong emotional responses to vocal music.

MT 1

Elefant's use of musical expression can be compared to studies of expressive variation reported by De Poli (NM I no. 9) and Sloboda et al. (no. 25). However, these studies do not include vocal expression.

MT 5

Ridder's use of songs in music therapy with persons suffering from dementia can be related to Schulkind's review of memory for music in dementia (NM III no. 31).

MT 6

Baker's study of voice rehabilitation therapy has traits in common with the study by Schön et al. (NM I no. 24), who investigate a deficit in the retrieval of musical intervals after a brain lesion.

Based on these comparisons, the following neuroscientific studies can be suggested:

- Neuroimaging studies based on complete songs or song phrases.
- Studies of the impact of different voice qualities and singing styles.
- Studies of the impact of variable vocal expression.

3.5.2. Recorded music

Bonde (MT 8) has studied the relationships between the characteristics of selected classical music and the participants' experience in Guided Imagery and Music Therapy. He reports the use of 75 complete movements of classical music, approximate durations between three and ten minutes. The total duration of music in a therapy session was 20-40 minutes.

Schou (MT 14) reports four types of music applied in guided relaxation with music for cardiac patients; Easy listening, Classical, Specially composed relaxing music, and Jazz. The approximate durations of music selections were between two and thirteen minutes. The total duration of music in a relaxation session was approximately 30 minutes.

Comparisons

In receptive music therapy, the client listens to selected music guided by the therapist. A music selection typically consists of entire pieces or movements of music, and the effect of the therapy is dependent upon exposure to music over a period of time.

In the conference proceedings, studies of complete pieces of music are rare. Only the two chill studies by Grewe et al. (NM II no. 49, NM III no. 51) are based on responses to whole pieces. The fMRI studies by Demorest and Morrison (NM I no. 8) and Janata et al. (NM II no. 12) apply short music excerpts of a duration between 15 and 33 seconds. The PET study of intensely pleasurable responses to music by Blood and Zatorre (2001) is based on stimuli of longer duration, 90-second excerpts of the participants' self-selected music.

MT 8

Bonde's study of therapy clients' experience of music includes reports of visual imagery, experienced narratives, and emotional responses to polyphonic music. The study can be related to the fMRI study by Janata et al., based on attentive listening to polyphonic music by Schubert, and the studies of intense responses to music by Blood & Zatorre, and Grewe et al. No counterpart to studies of narrative and visual imagery in GIM is reported in neuroscience.

MT 14

Schou's study investigated three conditions; (1) Guided Relaxation with music, which is a music therapy intervention. (2) Music listening, which is a Music medicine intervention.³⁴ (3) No music listening in a control group. The study can be compared to Forsblom's paper concerning music listening in stroke rehabilitation (NM III, no. 62), and Särkamö's report of the same study (The Neurosciences and Music IV 2011, this chapter).

Based on these comparisons, the following fields of research in neuroscience can be suggested:

- Neuroimaging studies based on complete pieces of music.³⁵
- Studies of psychophysical responses, such as heart rate and skin conductance response, during GIM sessions. Available technology permits measurements which do not disturb the musical experience.

3.5.3. Improvisations

Holck (MT 2) describes active interplay with children with severe functional limitations. The interplay includes vocal sounds, song, glissandi, gesture, movement, jumping, and facial expressions.

Gold (MT 4) reports improvisations which include loud and shifting rhythms, aggressive sounds, voice experiments, games and body movement.

Ridder (MT 5) includes improvised songs and vocal improvisations in her dialogue with clients.

Garred (MT 7) uses improvised drum grooves to establish a moment of eye contact with a girl suffering from autism, and reports the use of syncopation and cross-rhythms to arouse a withdrawn client's interest.

De Backer (MT 9) describes a particular aspect of therapy with psychotic patients; the transition from monotonous or incoherent sensorial play to the creation of musical form and musical symbols in interplay with the therapist.

Kim (MT 10) reports improvisational music therapy with children, using a large selection of instruments.

Nygaard Pedersen (MT 11) reports particular features of improvised interplay; a wall of sound, fragmented sounds, tiny impulses of feelings or sensations, chaos and structure, one-note improvisation.

Comparisons

Musical improvisation is a core activity in music therapy. Musical improvisations are based on the spontaneous interplay between client and therapist, and can include vocal expression, playing on

³⁴ Music therapy is based on the active involvement of a therapist. Music medicine is based on a stimulus-response paradigm. (Trondalen & Bonde 2012:41-42)

³⁵ For a report of a recent study of a complete piece of music, see chapter 6.

melodic and percussive instruments, gestures, body movement, and facial expressions.

In neuroscience, the measurement methods typically require that the participant lies or sits still, and do not permit studies of active interplay and body movement. Thus, until robust portable measurement devices are developed, neuroscientific studies of music therapy improvisations are not probable.

A few studies in the conference proceedings are related to movement and bodily expression. One paper reports a study of facial expression recognition in dementia patients (NM III no. 49). Another paper reports a study of movement to dance music, based on video recording (NM III no. 73).

MT 4 and MT 11

Gold's and Nygaard Pedersen's reports of aggressive sounds and chaos may have traits in common with the study of response to an emotionally charged complex vocal sound (NM III no. 30).

MT 7

Garred's study of a girl suffering from autism can be related to studies of musical experience in autism (NM II no. 33, NM III no. 45, 46, and 47).

Apart from the question of movement or non-movement, a difference between neuroscience and music therapy is apparent. In neuroscience, music is typically regarded as a socially shared system, based on rules and expectations defined by convention and culture. In music therapy, individual expression and action can shape musical improvisation independently of convention and culture. According to a definition proposed by Darnley-Smith and Patey (2003:40), musical improvisations can consist of "any combination of sounds and silence spontaneously created within a framework of beginning and ending." The following fields of research in neuroscience can be suggested:

- Studies of responses to syncopation and cross-rhythms ³⁶
- Studies of gliding and moving tones compared with fixed and static tones ³⁷
- Studies of percussive sound
- Studies of music that combines noise and tone as means of musical expression. ³⁸

3.5.4 Music therapy in rehabilitation

An increasing number of studies report the effect of music therapy and music-supported therapy in rehabilitation. Altenmüller et al. (NM III no. 58, pp. 395-405) have demonstrated the effects of music-supported therapy in patients with motor impairments after stroke. Schlaug et al (NM III no. 57, pp. 374-384) have documented that long-term melodic intonation therapy produces changes in the brain connections of patients suffering from aphasia after a left-hemisphere stroke. Findings by Särkämö (2011) encourage the use of listening to music as a rehabilitative activity in stroke patients. Leins, Spintge & Thaut (2009:526-529) and Hurt-Thaut (2009:508-513) have reviewed the effects of music therapy in neurological rehabilitation. Recently, a study by Daniels Beck (2012) has indicated that Guided Music and Imagery Therapy is an effective short-term treatment for adults suffering from work-related chronic stress. Rehabilitation is a growing field of research that integrates the achievements of music therapy and neuroscience.

36 Vuust et al. (2005) have studied responses to incongruent rhythms in jazz musicians.

37 Griffiths et al. (1994, 1998) report studies of the perception of sound movement.

38 e.g. the sound of the Japanese Shakuhachi flute, which encompasses noise as well as tone.

Chapter 4. The Musical Timespace.

An Investigation of the Listening Dimensions in Music

Introduction

A concise version of *The Musical Timespace* (1996) presents an investigation of the listening dimensions in music and the experience of musical space. The concise version consists of selected excerpts of the original text. Approximately half of the text is included. The original text is maintained, except for minor corrections. Thus, the selection of excerpts does not represent a revised edition of the book. The aim of the shortening is to clarify the investigation of the listening dimensions by omitting parts of the text that appear to be weakly underpinned. Criteria for the omissions are presented in a brief concluding discussion.

The investigation suggests that particular properties of sound constitute the listening dimensions that interact in music perception and musical experience. It is a basic presupposition of the investigation that hearing is not designed for music listening, but for survival in the surrounding world. The essential functions of listening are the identification and localization of sound, and the detection of movement. Basis for the investigation is music that explores the natural continuum of sound, which is not divided into discrete steps.

Abstract

The concise version of *The Musical Timespace* is presented in appendix 4.01, pp. 293-378. The following represents an abstract of the concise version.

1. The Basic Listening Dimensions

The biological basis of listening, pp. 294-298.

Hearing is designed for survival, not for music listening. Hearing permits instant identification and localization of sounds in the surrounding world. Hearing permits detection of movement, which implies the sensation of time. Hearing permits detection of recurrent repetition, which implies the sensation of pulse. Movement and pulse evoke two kinds of temporal experience, related to change and regularity.

The five basic listening dimensions in music, pp. 299-301.

It is proposed that five properties of sound; intensity, timbre, pitch, movement and pulse, constitute the basic listening dimensions in music. Intensity is the prerequisite of sound, and the fundamental dimension of listening. Timbre is the basis for identification of sounds. Pitch is a property of musical sounds. Intensity, timbre and pitch are microtemporal dimensions of sound, perceived instantly. Movement and pulse are macrotemporal dimensions of sound, evoking the experience of time.

The proposed basic dimensions of listening are displayed in the graphic models p. 300 and 356, which reflect that pitch and pulse are related to regularity in sound, and timbre and movement are related to change in sound.

2. States, Events, and Transformations

Descriptions of music which exemplify the basic listening dimensions, pp. 302-316.

The selected pieces of music explore the continuum of natural sound, which is not divided into discrete steps, and which encompasses noise as well as tones. Xenakis' *Metastasis* investigates the continuum of gliding pitch and the perceptive qualities of noisy sounds. Ligeti's *Atmospheres*

explores the continuum of variable sound masses without clearly discernible pitches and durations. This music evokes spatial impressions of foreground and background, distance and proximity, height and depth, transparency and density, stasis and motion. Lutoslawski's *Livre pour orchestre* employs quarter-tones, which create impressions of living streams of sound, moving flexibly and multi-directionally in space. The achievements of the composers are summed up as explorations of timbre, pitch, intensity, movement and pulse, and investigations of the spatial potentials of musical sound.

3. Space, Time, Flow and Memory

Suggestion of memorized representations of the basic listening dimensions, pp. 317-324.

Music is a continuous flow of states, events, and transformations that appear and disappear. The flow of music can be retained in memory. Four basic listening dimensions are represented in memory; *timbre* is represented as a particular quality of sound, *pitch* as a distinct level of pitch height, *movement* as a shape, and *pulse* as tempo. All of these are qualitative potentials of perceived sound. In addition, pitch and pulse possess quantitative properties, which can be counted and measured.

4. Time, Space, and the Environment

Temporal and spatial experience in music, pp. 325-334.

Music evokes three kinds of temporal experience; the time of being, which is related to slow or imperceptible change, the time of movement, which is related to the sensation of change, and the time of pulse, which is related to the sensation of regularity.

The three kinds of time and their interactions are identified in works by Charles Ives, *The Unanswered Question*, and *Central Park in the Dark*. As well as sensations of time, these works evoke impressions of space by means of static transparent sound fields, or slowly changing complex chord colors.

Based on considerations of temporal and spatial qualities in music, the concept of *Musical Timespace* is proposed. In the experience of music, time and space are integrated in a virtual timespace.

5. Microtemporal listening dimensions: Timbre, Harmony and Pitch

Relationships between the microtemporal listening dimensions, pp. 335-343.

Timbre is described as the substance of music, characterized by microtemporal changes of spectral qualities. The microtemporal and spectral properties of musical sound are perceived in two simultaneous dimensions, timbre and pitch. It is proposed that harmony emerges as a secondary listening dimension between timbre and pitch, integrating the properties of timbre and pitch in the particular quality of harmonic color.

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

Relationships between the macrotemporal listening dimensions, pp. 344-356 .

Melody and rhythm are secondary listening dimensions. Melody arises between movement and pitch as a spatial shape of movement. Rhythm arises between movement and pulse as a temporal shape of movement.

A movement from Ligeti's *Second string quartet* exemplifies interactions between movement time and pulse time, and transitions between temporal regularity and irregularity. Coleman Hawkins' saxophone solo *Body and Soul* exemplifies the shaping of melody and rhythm.

Change and regularity constitute the fundamental basis of the listening dimensions.

7. Density and Color of the Soundspace

A flow of timbral-harmonic colors, pp. 357-360.

Ligeti's harpsichord piece *Continuum* displays rhythmic structures, melodic lines, and harmonic colors, which emerge in a continuous stream of sound. This music demonstrates that the secondary listening dimensions rhythm, melody and harmony can be evoked in a flow of timbre, pitch and pulse.

8. The final model of listening dimensions in music

Micromodulation of sound, pp. 361-367.

Micromodulation is described as the interaction of pulsation and a timbral spectrum. Vibrato, tremolo, and flutter-tongue are various forms of micromodulation.

The inclusion of micromodulation completes the model of listening dimensions. The five basic listening dimensions are intensity, timbre, pitch, movement, and pulse. The four secondary listening dimensions are melody, rhythm, harmony, and micromodulation. The model is reproduced in figure 4.1.

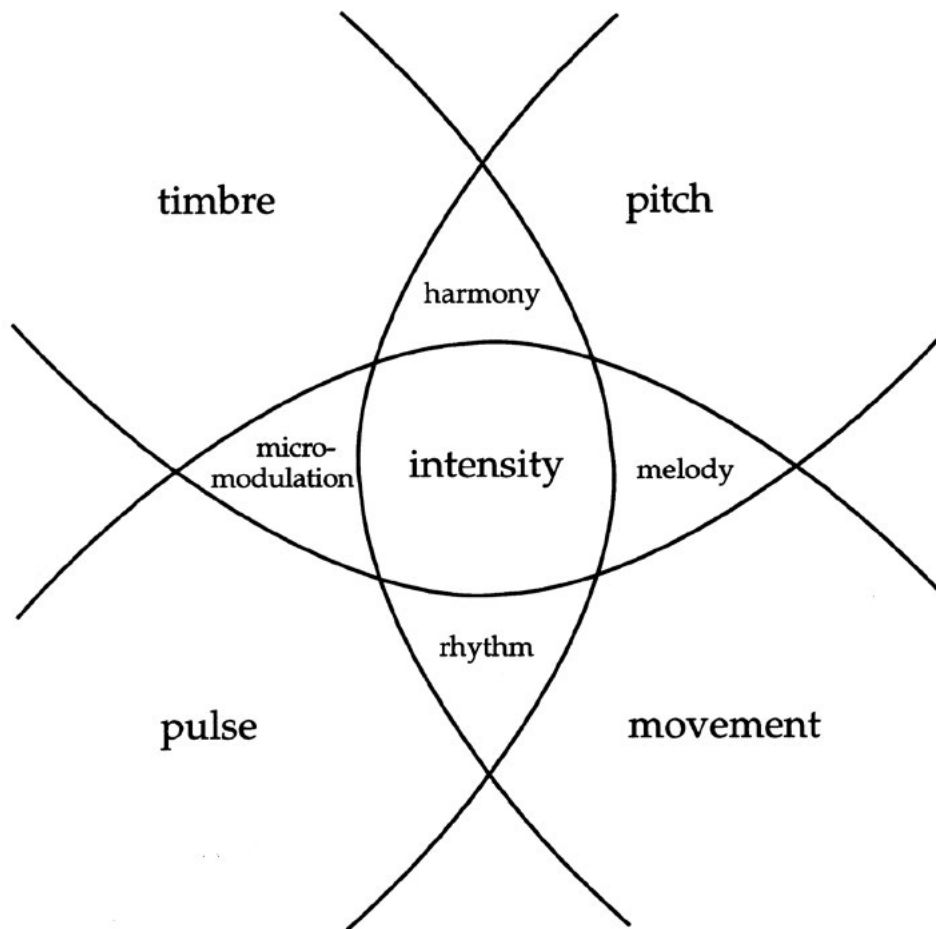


Figure 4.1. The basic and the secondary listening dimensions in music

Discussion

In order to clarify the investigation of listening dimensions in music and the experience of musical space, only half of the original text in *The Musical Timespace* is maintained in the concise version. The remaining parts of the text are omitted according to the following criteria;

- (1) Excluded is a model of listening dimensions that incorporates space as one of the dimensions. This version of the model is discarded, because space is not one dimension among other dimensions. The experienced musical timespace is multidimensional, evoked by the interactions of the nine listening dimensions.
- (2) Excluded are descriptions of pitch as a predominantly spatial dimension, ranging from low to high sounds. This is a consequence of (1). Pitch contributes to the experience of space, but so do other dimensions in the model. It is an oversimplification to assign spatiality specifically to one single dimension.
- (3) Excluded are descriptions of music based on the presupposition that pitch is predominantly a spatial dimension. This is a consequence of (2).
- (4) Excluded are a number of detailed descriptions of musical structures, which are not necessary for the investigation of listening dimensions.

It is suggested that the concise version of *The Musical Timespace* represents an investigation of music listening that is clearer and more tenable than the original text. However, certain limitations of the investigation can be noted.

It is an obvious limitation that the human voice is not included in the musical examples. The investigation is oriented towards similarities between musical sounds and sounds of the surrounding world, but does not take vocal communication and expression into account. Further investigations are needed to clarify whether the proposed listening dimensions encompass the features of the human voice. Likewise, the bodily aspects of musical communication are not taken into consideration.

In the present form, the excerpts do not represent a full-fledged presentation of the listening dimensions and their interactions. In particular, argumentation and examples that underpin the proposal of rhythm as a temporal shape of movement are needed. Furthermore, the relationships between working memory, short-time memory and long-time memory of music deserve clarification. Finally, descriptions of the spatial features of music are presented in various parts of the investigation. A comprehensive and coherent exposition of the features and totality of the musical timespace is desirable.

Relations to Phenomenology

The descriptions of music in *The Musical Timespace* represent preliminary attempts at phenomenological description. The descriptions are informative, but do not meet the requirements of a phenomenological investigation, as outlined in a previous chapter.¹ In particular, the descriptions could benefit from integrating Husserl's exploration of time-consciousness.

It can be suggested that experimental listening may serve as a tool for more thorough phenomenological descriptions, as exemplified in the investigation of Coleman Hawkins' saxophone solo *Body and Soul*.² Experimental listening permits investigation of the temporal and spatial properties of music, and exploration of the interactions between listening dimensions. Importantly, experimental listening includes intersubjective validation.

The descriptions of the virtual musical space coincide with descriptions in phenomenology. As indicated in the chapter on music phenomenology, Merleau-Ponty reports "that other space through

¹ Chapter 2, pp. 3-6.

² Chapter 2, pp. 54-55, and appendix 2.04., 191.

which, a moment ago, the music was being unfolded" (2002:257-258). Thomas Clifton states that "the spaces formed by music are actually inhabited by my being there, in the space-time world of that piece" (1983:138). Don Ihde reports that in his experience of music, "auditory space surrounds me and may, in the striking sound of a symphony, fill my being" (2007:214)

The observations by phenomenologists suggest that the spatial experience of music can be intersubjectively validated. However, it can be supposed that the experience of a virtual musical space is closely related to attentive listening, and does not occur in more casual listening. Furthermore, the experience of spatiality in music may be highly individually variable and context-dependent. The investigations in experimental listening show that it is possible deliberately to modify the spatial and temporal focus of listening.

Relations to Neuroscience

Fields of exploration common to the investigation of listening dimensions and the findings of neuroscience can be noted.

Identification and location of sound

Rees and Palmer, in their introduction to the auditory brain (2010:1) point out that hearing is important for survival, and that essential processes of hearing serve the distinction and identification of sounds, and the location of sound sources.

Experience of auditory space

Young (2010:94) describes two stages of representation in auditory perception. The first representation occurs in the cochlear nucleus. It depicts the spectrotemporal properties of sound. The second representation occurs in the inferior colliculus. It includes information from both ears, and contains spatial information alongside spectrotemporal information.³ Due to the processing of auditory information in the brain stem, the experience of auditory space is an integral component of listening.

Movement

Findings of neuroscience indicate close interactions between auditory and motor systems in the brain (Griffiths et al. 1994, 1998; Janata et al. 2002; Zatorre et al. 2007). Listening to music appears to trigger activations of the premotor areas of the brain (Chen et al. NM III:15-34; Fadiga et al. NM III:448-458).⁴ Stevens and Byron (2009:20) propose that "one universal process in music cognition might be movement perception and its development."⁵

Pulse

The regularity of musical pulse is in the focus of studies of meter and rhythm (Thaut NM I:364-373; Vuust 2005; Chen et al. 2008). Grahn (NM III:35-45) suggests that the basal ganglia are particularly important for the perception and production of regular beat.

Pitch, timbre and timing

Kraus et al. (NM III:543-557) have investigated the auditory brain stem responses to the acoustic properties of sound. Their findings indicate that pitch, timbre, and timing have distinct representations in the brain stem.

It can be concluded that it is possible to find support in neuroscience for the investigations of musical space and the basic listening dimensions in music.

³ The stages of processing in the auditory pathway are described in chapter 6, pp. 125-129.

⁴ NM = The proceedings of the Neuroscience and Music conferences, see Chapter 3.

⁵ The composer Roger Sessions states a similar view; "the essential medium of music (...) is *time*, made living for us through its expressive essence, *movement*." (1941:105)

Chapter 5. Present Moments:

A New Program for Guided Imagery and Music Therapy Based on Art Music of the 20th and 21st Centuries.

Research questions

Is it possible to create a GIM program on the basis of art music from the 20th and 21st Centuries?
What are the criteria for music selections included in such a program?

Introduction

"What is 'music' to one person's ears is often offensive to another's."

Many music listeners will agree with this statement by neuroscientist Robert Zatorre (2005:315). Some of these music listeners may feel profound disappointment when they realize that the kind of music they value highly is disliked strongly by other listeners.

Contemporary art music is disliked by many devoted lovers of major-minor based classical music, and only to a limited extent utilized in music therapy. In continuation of the investigations of 20th Century music carried out in *The Musical Timespace*, it was the author's intention to assess whether art music composed during the last hundred years might be accepted or rejected in receptive music therapy. In order to pursue this objective, he proposed a collaboration with an experienced GIM therapist, aimed at creating a new GIM program.

Background

The Bonny Method of Guided Imagery and Music (BMGIM) is an established method in receptive music therapy. In a BMGIM session, the client listens to selected pieces of music in a relaxed state, and relates his or her experience during the listening in dialogue with the therapist. The session is often described as a journey, and the client as a traveler. The method is amply documented and underpinned by research.¹

The core of BMGIM consists of eighteen music programs created by Helen Bonny² between 1973 and 1989. These programs contain selections of classical music from the baroque to early 20th Century. The majority of music selections belong to the classic and romantic repertory, but Bonny's programs also include music by Debussy, Ravel, Holst, Copland, Shostakovich, and Nielsen (Grocke 2002:99-133).

Helen Bonny encouraged the development of additional GIM programs, as expressed in an interview in May 2000 (Cohen 2003-2004:20). Bonny's followers have created a large number of programs (Bruscia 2002:313), which are listed by Bruscia and Grocke (2002:555-591) and Bonde (2009a). Some of these programs include music by 20th century composers, notably selections suggested by Joanna Booth, James Borling, Kenneth Bruscia, Marilyn Clark, Martin Lawes, Ian Leslie, Even Ruud, Ruth Skaggs and Sierra Searns. However, with some exceptions, these 20th Century selections adhere to the musical forms and structures established in the tradition of classical and romantic art music.

1 The basic references for GIM are *Journal of the Association for Music and Imagery*; Bonny (2002) *Music and Consciousness*; Bruscia & Grocke (Eds., 2002) *Guided Imagery and Music*; Bonde (2009a) *GIM Music Programs. Annotated List*. Bonde (2010) *Guided Imagery and Music. A Bibliography*.

2 Helen Lindquist Bonny was born in 1921, and died in 2010.

5.1. Creating a new GIM Program

Method, participants, and progression

The investigation was conducted between November 2009 and August 2010 as a collaborative research project, implying an ongoing process of planning, selection, evaluation, testing, and reflection (Stige 2005:410). Primary GIM trainer Ellen Thomasen (ET) and musicologist Erik Christensen (EC) selected and evaluated the music. Music therapist Helle Mumm (HM) participated in GIM test sessions, and professor Lars Ole Bonde (LOB) contributed ongoing advice and feedback. The project progressed in four steps; encouragement and agreement, test of a pilot program, music selection, and test of the final program.

Encouragement and agreement

Listening to the GIM program *Atonement* by the British GIM therapist Martin Lawes provided an important incentive for the project. Lawes had presented his program at two GIM conferences (Lawes 2006, 2009), and he kindly placed the music selection at the project group's disposal. In his description, Lawes indicates that *Atonement* is an advanced working program for participants open to challenging music. The program includes 20th Century music by Tormis, Birtwistle, Seldin, Henze and Gorecki. In particular, one piece differs from the traditional GIM music selections, the British composer Harrison Birtwistle's 18-minute-long, extremely energetic "Panic" (1995) for alto saxophone, jazz drummer, wind, brass and percussion.

Listening to this music selection encouraged EC and ET to initiate the project. Some weeks later, ET guided EC and HM in GIM-sessions based on *Atonement*. The outcome of the sessions confirmed the relevance of including unconventional music in a GIM program for experienced participants.³ Another test session, in which EC traveled to Kenneth Bruscia's program *Faith*, guided by ET, provided further encouragement. This program encompasses 20th Century music by Pärt, Ives, Alwyn and Messiaen, and a symphony movement by Saint-Saëns (Bruscia & Grocke 2002:570).

In January 2010, EC and ET listened to selected music pieces in order to assess their applicability for GIM. ET agreed that one piece might serve as the core piece of a GIM program. This was the 10-minute-long "Garden of Love's Sleep", the sixth movement of Olivier Messiaen's *Turangalîla Symphony* (1948). This movement is characterized by a repeated melody in strings unfolding extremely slowly, accompanied by counterpoints of flute and clarinet, gentle metal percussion and live birdsongs in the piano.

Testing a pilot program

After listening to a variety of new music, EC assembled a pilot program, consisting of;

- | | |
|---|-------|
| 1. Arvo Pärt: Da Pacem Domine (2004) for choir | 5'30 |
| 2. Olivier Messiaen: The Ascension (1933) for orchestra, second movement | 6'10 |
| 3. Sofia Gubaidulina: Seven Words on the Cross (1982)
for cello, Russian accordeon and strings, third movement | 4'00 |
| 4. Bela Bartok: Elegy from Concerto for Orchestra (1943) | 7'45 |
| 5. Olivier Messiaen: Garden of Love's Sleep (1948) | 10'30 |

Criteria for selecting these pieces were musical space and polyphony, richness of sound, performance quality, religious features and existential issues of death and resurrection.

ET familiarized herself with the music of the pilot program. Subsequently, in order to assess its potential qualities for GIM, she traveled to the program in a GIM-session guided by LOB in April 2010.

³ HM has described her experience of the Atonement session in an interview by EC 16 July, 2010 (Unpublished manuscript in Danish).

On the background of this experience, ET concluded that some of the pieces were not ideal candidates for a program. She found the expressivity of Messiaen's *Ascension* and Bartok's *Elegy* too dominant. The sound of Gubaidulina's piece appeared to be too distant, and some transitions between pieces implied disturbing contrasts. Nevertheless, she found two pieces suitable for inclusion in a GIM program; Pärt's *Da Pacem Domine* and Messiaen's *Garden of Love's Sleep*. She pointed out that the nature of Pärt's choral work appeared to be too static for a starting piece. Thus, the ensuing task consisted in finding pieces which could fit and match Pärt and Messiaen in a program.

Music selection

Preliminary music selection

Continuing the search for appropriate music, EC listened to approximately 400 pieces by various composers in May and June 2010. As a rule, 1-4 minutes of listening provided sufficient basis for rejection or preliminary accept. He selected 35 pieces for further consideration by ET, preferably orchestral and choral music, and a few pieces of chamber music. Similar to the selection of the pilot program, criteria for inclusion were polyphony, musical space, richness of timbres, and performance quality. According to ET's experience of the test program, criteria for exclusion were sudden disturbances, too strong dissonance, and excessive expression or dynamics. The selected composers were:

Bela Bartok (4 pieces), John Corigliano (1), Ernesto Halffter (1), Alan Hovhaness (4), Magnus Lindberg (2), Witold Lutoslawski (2), Olivier Messiaen (3), Per Nørgård (6), Christopher Rouse (1), Toru Takemitsu (5), John Tavener (5), Veljo Tormis (1).

Final music selection

From the 35 pieces, compiled on CDs, ET carried out the final selection during May-June 2010. The selection to be tested in GIM sessions consisted of;

1. Bela Bartok: <i>An Evening in the Village</i> (1931)	2'50
2. John Corigliano: <i>Voyage</i> for Flute and String Orchestra (1983)	8'00
3. Olivier Messiaen: <i>Garden of Love's Sleep</i> (1948)	10'30
4. John Tavener: <i>Lament from "The Repentant Thief"</i> (1990)	2'15
5. Arvo Pärt: <i>Da Pacem Domine</i> for mixed chorus (2004)	5'30
6. Veljo Tormis: <i>Wee Winkie Mouse (Lullaby)</i> , for mixed chorus (1970)	2'45

ET described the process in an interview with EC:

"I had no conscious intention of creating a program for a specific purpose. The program grew gradually out of the available pieces, focusing on Messiaen's *Garden of Love's Sleep* as the core piece. It had to be placed in the middle, but to which side of the middle?

I listened again and again for pieces that could fit with Messiaen and Pärt's choral piece. I had the idea of moving gradually towards Messiaen, and was very concerned about the transitions between pieces. After listening many times for sound and instrumentation, I realized that Corigliano's *Voyage* for flute and strings constituted a fine introduction to Messiaen.

I knew that a direct shift from Messiaen to Pärt would not be favorable. I needed a piece to create the transition, and chose Tavener's short *Lament* for clarinet, strings, handbells and timpani. In the Messiaen piece, one has entered a magic, enchanted universe. It is extremely delightful and easy to be there. There is a lot of support, and at the same time excitement and freedom to move around. It is a piece for "being here and now". Its ending remains open, and there is a need for a piece that facilitates a gradual return.

Tavener serves as the link between Messiaen and Pärt. The luminous tones of the hand-

bells draw a thread backwards to the gentle metal percussion in Messiaen, and the shadowy sounds of the strings point towards Pärt's gliding and dark choral setting. Pärt's *Da Pacem Domine* is unbelievably spatial and containing, it is calm and holding, evokes bodily feelings, and creates contact to the spiritual realm. It is a piece that embraces light and darkness, freedom and breath, hope and devotion, intensity and centering.

Having decided the succession Corigliano – Messiaen – Tavener – Pärt, I knew this should be a program that carries the traveler into a relatively quiet energy of being. The traveler can enter a universe which is rich and abundant, where time ceases to exist, and you are weightless.

After listening a number of times to Bartok's piece, which depicts a scene in a village, I chose it as the initial music. It begins very slowly with a single clarinet tone, like breathing, continues in a friendly manner and begins to dance. Then it gradually gains breadth and depth, and manifests itself in strong unison in the end: "We are here, and on our way."

I listened a lot for the consistency of the wind instruments in the first four pieces, clarinet, oboe, and flute. It was no preconceived idea, it grew out of the listening process. And I was very aware of tonalities and modalities and sound in the transitions between the pieces, taking care to avoid too strong gaps and differences. After Pärt, the Tormis choral piece begins half a tone higher, giving you a slight lift. Tormis is a kind of extender which helps the traveler to return after Pärt. And it can be repeated if desirable. It is a lullaby in looping repetitions which can continue forever and ever."⁴

Testing the new program

During June and July 2010, the first tests of the new program were carried out. In GIM sessions based on the new program, ET guided EC, HM, and LOB, and LOB guided ET.⁵ In consequence of this experience, ET decided to name the program *Present Moments*, stating that "the traveler experiences time in the *Kairos* dimension, while *Chronos* sets the frame within which any kind of event may happen.⁶ Time appears to stand still, yet everything is moving and vibrating, the birds 'speak', the waves lap, the wind carries you to places where you can really feel and sense yourself AND the music." ET guided two more test sessions, one with an experienced GIM therapist, and one with an unexperienced non-clinical volunteer. As a result of the test sessions, she concluded that the program was well suited for clinical GIM therapy with appropriate clients. ET recalls that,

"The first test sessions, in which I guided EC and HM, suggested that the program had a potential appropriate for GIM therapy. My own subsequent journey in a guided GIM-session corroborated this potential. The music exerted a strong bodily and kinaesthetic impact, and the session induced feelings of focusing and centering, which relieved personal tensions and worries.

Additional test sessions confirmed that all travelers remained in an altered state of consciousness, and that every music selection evoked imagery which was appropriate for interpretation in a therapy context; visual imagery as well as emotions and bodily sensations.

My subsequent inclusion of *Present Moments* in clinical GIM therapy indicated that the program could contribute to self-accept and alleviation of stress, induce relief of excessive cognitive control, and promote reconciliation and resolution of conflicts.

Summing up further clinical experience, the program appears to facilitate centering and grounding, feelings of accomplishment and belonging, sensations of bodily presence, appreciation of a quiet space with sparse activity, alleviation of anxiety, accept of one's personal life

⁴ ET interviewed by EC, 23 July, 2010.

⁵ HM has described her experience of this session in an interview by EC 16 July, 2010 (Unpublished manuscript in Danish). ET's transcription of EC's GIM session is reproduced as appendix 5.01.

⁶ In ancient Greek, Chronos indicates quantitative, measurable time. Kairos indicates qualitative time, characterized by the lived experience of significant events.

situation, and creative investigation of one's inner potential,

In several of the music pieces, the slow motion may be a challenge to a traveller who feels insecure, deprived of stimulating events. Another challenge is the ambiguity entailed by the multiple sound layers in the Messiaen piece, which may engender surprising or overwhelming imagery. This GIM program is not recommended in therapy for individuals characterized by a fragile sense of self.”⁷

5.2. Present Moments: Description of the final GIM program

1. Bela Bartok: An Evening in the Village (1931) Chicago Symphony Orchestra / Pierre Boulez	2'50
2. John Corigliano: Voyage for Flute and String Orchestra (1983) Paul Edmund-Davies, flute. The Orchestra of Flanders / Rudolf Werthen	8'00
3. Olivier Messiaen: Garden of Love's Sleep (1948) Berlin Philharmonic Orchestra / Kent Nagano	10'30
4. John Tavener: Lament from "The Repentant Thief" for clarinet, strings, handbells and timpani (1990) Andrew Marriner, clarinet. London Symphony Orchestra / Michael Tilson Thomas	2'15
5. Arvo Pärt: Da Pacem Domine for mixed chorus (2004) Estonian Philharmonic Chamber Choir / Paul Hillier	5'30
6. Veljo Tormis: Wee Winkie Mouse (Lullaby), for mixed chorus (1970) Holst Singers / Stephen Layton	2'45

In order to benefit from the full sonorous and spatial qualities of the music in the GIM session, it is necessary to play the music from CDs on a sound system of good quality. MP3 and other reductive playback systems should be avoided.

Theme: The aim of the program is to offer the traveler an experience of centered presence and gentle bodily energy. A high degree of coherence facilitating introspection and slowly unfolding visual imagery enhances deep body imagery and kinaesthetic sensations.

Each piece has its distinct mood enabling the traveler to move effortlessly backwards and forwards in time and space. The music has a gentle flow yet with a clear potential for transformation.

Notes on music selections:

Bartok: Begins in an idyllic evening mood. Woodwind instruments play a floating theme on a background of strings, alternating with a lively dance in staccato flutes. In its last appearance, the theme manifests itself in unison woodwinds, indicating an enhanced presence. The music is Bartok's adaptation of a pentatonic folk tune from the Szekely people, exiled Hungarians living in Romania.

Corigliano: A solo flute accompanied by lush harmonies of strings. The overall mood is calm and soothing, at times animated by passages of growth and increased expectation. The flute extends the musical space to a soaring high register and a voice-like depth.

The music is an instrumental version of the composer's choral work that represented a setting of Baudelaire's poem *Invitation to the Voyage*, echoing the quality of the repeated refrain: "There, there is nothing else but grace and measure, richness, quietness and pleasure."

⁷ ET Interviewed by EC, 28 June 2012.

Messiaen: A love song, thus described by the composer: “The two lovers are immersed in the sleep of love. A landscape has emanated from them. This garden is full of light and shade, of plants and new flowers, of brightly coloured and melodious birds. Time flows on, forgotten, the lovers are outside time, let us not wake them.” The music is the sixth movement of Messiaen’s *Turangalila Symphony*. Its recurring theme is closely related to the love theme of Wagner’s opera *Tristan and Isolde*.

Tavener: An immobile drone of deep strings maintains a dark mood. A solo clarinet plays a plaintive melody, enhanced by a nimbus of high strings and the fragile sound of handbells. The music is the first of two laments from Tavener’s *The Repentant Thief*, referring to one of the thieves crucified alongside Jesus on Golgatha.

Pärt: Human voices emerge in a four-part setting of a prayer: “Give peace, O Lord, in our time, because there is no one else who will fight for us if not You, our God.” A transparent musical space embraces light and darkness, freedom and breath, hope and devotion, intensity and centering.

Tormis: A quiet lullaby sung by women on a background of humming voices. The looping repetitions could apparently continue forever. The song is inspired by folklore of the Livonian people in the Baltic region.

5.2.1. Dissemination of the new GIM program

At the 9th European GIM Conference in Spain in September 2010, ET and EC presented the research project in a poster, which included mandalas drawn in the initial test GIM sessions. In January 2011, ET and EC introduced *Present Moments* in a seminar on receptive music therapy in Denmark. Subsequently, a number of GIM therapists have reported their experience of the program in clinical settings and training courses.⁸ A workshop on the program is planned for the GIM conference in Sweden, September 2012.

Julie Exner (Denmark) points out that *Present Moments* invites the client to endure the presence in a quiet space, as an alternative to GIM programs which imply direction and progression.

Denise Grocke (Australia) reports from a GIM training workshop that the participants in general considered *Present Moments* to be a working program for use with experienced travelers.

Florence Holligan (Australia) has noted the potential holding quality of the program.

Kenneth Bruscia (USA) hears an existential choice in the alternation between winds and other instruments in the first two pieces: “Do I want to reflect upon things, or do I want to live in the moment?”

5.3. Present Moments: Criteria for inclusion and exclusion of music

Positive criteria

In order to uncover the common features of the music selections, EC carried out further listenings of the new program in July and August 2010, and consulted the score of each piece of music. In accordance with recommendations by Bruscia (2001) and Abrams (2002:328-335), he listened to the program;

- 1) in a guided GIM session in an altered state of consciousness, focusing on the music.⁹
- 2) in an alert state, focusing on the imagery potential of the music.
- 3) in an alert state, listening for the mood, structure, and prominent features of the music.¹⁰

⁸ Personal communication to ET.

⁹ An unpublished manuscript in Danish reports EC’s verbal description of the music during the session 18 July 2010, transcribed from the audio recording. The guide was GIM trainee Lene Ravn.

¹⁰ A detailed phenomenological description of Bartok: *An Evening in the Village* is reported in appendix 2.02, p. 172.

Repeated listening and score reading indicate that all pieces share the following common features, which can be considered criteria for inclusion;

- Polyphony
- Musical space
- Continuity
- Movement and variability
- Repetitions and similarities
- Gentle flow and predominant quiet mood
- Melody and harmony related to modality or tonality
- Good performance quality

Negative criteria

In the preliminary music selection, EC listened to 400 pieces of music, and excluded music that displayed sudden disturbances, too strong dissonance, and excessive expression or dynamics.

In the final music selection, ET listened to 35 pieces, and selected six pieces as preferable for GIM. In August 2010, ET and EC listened again to the music that had not been selected, in order to clarify the criteria for exclusion. Discussions of the music indicated that ET's criteria for exclusion were the following:

- The music insists too much on itself
- Too strong expression or dynamics
- Sudden disturbances
- Potential irritation
- Incessant tension
- No place to dwell

Exclusion and inclusion

The difference between listening to music in a GIM session and listening to music in an alert state give reasons for ET's exclusion criteria. In the GIM session, music is not heard for its own sake. In GIM, music functions as a "co-therapist" (Skaggs 1992:77-83, Bonde 2007, Summer 2009:55, 62). Thus, it is not the music's role to insist too much on itself.¹¹ Furthermore, the music in GIM is supposed to function as a 'container' for the client's imagery and emotional experience (Bonny 1989/2002:134, Grocke 2002b:92). Thus, sudden or violent events that may disturb the client's altered state of consciousness are not desirable.

The criteria for inclusion in *Present Moments* listed above appear to be in agreement with Helen Bonny's characteristics of the music chosen for GIM programs. Bonny specified the characteristics in an interview with Denise Grocke (1999:416-421). Grocke (2002b:92-95) summarizes that according to Bonny, the music in a GIM program;

- 1) creates tension and release, expectation and suspense
- 2) is a fluid and flexible container, which allows a wide space for exploring emotion
- 3) stimulates flow and movement of the imagery experience
- 4) displays a certain amount of variability
- 5) conveys an appropriate mood

For a concise summary of the description, see Chapter 2, pp. 50-52.

¹¹ Ruth Skaggs explains that "the symbolic, ambiguous nature of music is always pointing toward something not quite clear. This leaves an opening for the client to create his own clarity and meaning. Even when one meaning is derived, there is always the potential for another lying in wait" (Skaggs 1992:80-81)

- 6) shares essential features of classical music;
 - multiple layers
 - predictable structure with appropriate variability
 - dynamic change
 - ambiguity and suggestibility
 - access to the composer's creative imagination

Finally, Bonny has emphasized that the performance quality is important for inclusion in a GIM program.

Preliminary conclusion

This project in collaborative research has confirmed that it is possible to design a clinically functional GIM program on the basis of 20th and 21st Century art music. The criteria for inclusion of music in the program *Present Moments* coincide to a large extent with the criteria for GIM programs based on classical music, as originally proposed by Helen Bonny.

It might be an obvious conclusion that the characteristics underscored by Bonny are universal and indispensable criteria for inclusion of music in a GIM program. However, the design of one new GIM program does not provide sufficient basis for drawing a definitive conclusion. Further research, including a comparative study of new GIM programs, will be needed to elucidate this question.

Inclusion or exclusion in a GIM program depends on an assessment of the music's therapeutic potential. This assessment does not equate an evaluation of the music's aesthetic quality. In the preliminary music selection, EC excluded hundreds of musical works that offered intense aesthetic experience. Many of these works were excluded, because the music "insisted too much on itself."

5.4. GIM experience and music phenomenology. Possible relationships

Similarities between the client's experience of music in a GIM session and the experience of music in phenomenology suggest perspectives for future investigations. Three themes appear to be relevant; the bodily experience of music, the listening attitude, and the multidimensionality of the musical experience.

Body listening

In a GIM session, listening is a bodily experience. In phenomenology, Thomas Clifton ascribes musical meaning to primordial bodily knowledge (1983:45-46, 70). Don Ihde states that "to listen is to be dramatically engaged in a body listening that 'participates' in the movement of the music" (1976:155-156). Merleau-Ponty emphasizes that bodily experience constitutes the basis for phenomenological investigation.¹²

Mutual possession

In the GIM experience, the traveler may adopt changing attitudes towards the music. He or she may observe the music, or be the object of the music's impact, or feel being one with the music. Clifton describes the latter kind of experience as mutual possession: "I possess the music, and it possesses me" (Clifton 1976:76). Don Ihde describes the double nature of music listening; at the same time, music seems to penetrate the listener's body and surround it (Ihde 1976:76-78). Merleau-Ponty reports that music appears to unfold in a particular kind of space (2002:257-258). Clifton describes that he, as listener, inhabits the spaces formed by music (1983:138).

Multivariable experience

Music employed in GIM is polyphonic. The multiple relationships within the polyphonic musical structure constitute a basis for the vivid emergence of imagery and narrative in GIM sessions (Bonde 1997c, 2004b; Aksnes & Ruud 2006, 2008). As suggested by the experimental listening of Bartok's *An Evening in the Village*,¹³ experimental phenomenological listening can contribute to uncovering the internal musical relationships that are important in music selected for GIM.

¹² Cf. chapter 2.

¹³ Chapter 2, pp. 50-52, and appendix 2.02, p. 172.

Chapter 6.

Subcortical and Cortical Processing of Sound and Music in the Brain

Introduction

The specific regions of the brain are integrated in extended functional systems. Two neuroscience scholars, Gerald Edelman and Antonio Damasio, have proposed comprehensive theoretical accounts of these brain systems. Their ideas contribute to a global understanding of the interaction of sensory and motor systems, emotion, memory and consciousness. Gerald Edelman, in collaboration with his younger colleague Giulio Tononi, has summed up his ideas in *A Universe of Consciousness. How Matter Becomes Imagination* (2000).¹ Antonio Damasio has gathered his neuroscientific insight in *Self Comes to Mind. Constructing the Conscious Brain* (2010).²

6.1 Gerald Edelman & Giulio Tononi: A Universe of Consciousness

Integration and differentiation are fundamental concepts in Edelman & Tononi's understanding of the brain. Billions of neurons with differentiated functions are integrated in large-scale dynamic networks. The authors point out three fundamental types of anatomical connections in the brain; reentrant connectivity, parallel loops, and diffuse projections.

Reentrant connectivity

The first anatomical arrangement is the thalamocortical system, a large, three-dimensional network of millions of neuronal groups linked in circuits, which connect most parts of the cortex with the thalamus, and different parts of the cortex with each other. The thalamus consists of two egg-shaped structures situated above the brainstem. They function as relay stations which forward most kinds of sensory information to the cortex. The crucial quality of the thalamocortical system is reentry, which is a continuous process of signaling back and forth between the connected groups of neurons (pp. 42-45, 70-75). The reentry process implies that any change in one part of the network may elicit rapid responses everywhere else in the network. Roughly, the back of the network is engaged in perception, and the front engaged in action and planning (p. 42).

The authors argue that conscious processes are typically based on these highly differentiated neural patterns in the thalamocortical system, characterized by "the rapid integration of the activity of distributed brain regions" (p. 70). They add that the conscious processes are dependent on an activating system in the brain stem (p. 54).

Parallel loops

The second anatomical system consists of long parallel loops which leave the cortex, enter one of the cortical appendages, and go back to the cortex. The cortical appendages are the cerebellum, the basal ganglia, and the hippocampus, three structures which subserve the cortex in the performance of specific functions.

The cerebellum consists of two lobes connected with the brain stem. An important function of the cerebellum is to modulate the activity of the motor cortex, in order to ensure smooth and accurate performance of movements. The cerebellum contributes to emotional and cognitive functions as

1 Edelman and Tononi's *A Universe of Consciousness* (2000) is preceded by several publications by Edelman, notably *Neural Darwinism* (1987), *The Remembered Present* (1990), and *Bright Air, Brilliant Fire* (1992). In a more recent overview of the neurology of consciousness, Laureys and Tononi (2009:375-412) recapitulate the main ideas of the 2000 publication, emphasizing the importance of the thalamocortical system and the widely distributed reentrant neural networks, and downplaying the role of brain stem areas as generators of consciousness.

2 Damasio's *Self Comes to Mind* is preceded by three books, *Descartes' Error* (1994), *The Feeling of What Happens* (1999), and *Looking for Spinoza* (2003). Damasio indicates that *Self Comes to Mind* presents an updated account of his ideas (2010:185, 322).

well. A loop passes from the cortex through the brain stem to the cerebellum, and projects back to the cortex via the thalamus.

The basal ganglia encompass a group of large nuclei situated close to the thalamus. They are connected with different cortex areas by different loops, and assist these areas in their specific tasks. One loop is involved in motor control, another loop in regulation of mood and emotion. The loops are organized in parallel, and do not interact with each other. A loop arises in one cortex area, arrives in an area of the basal ganglia, and projects via the thalamus back to the same cortex area.³

The hippocampus is an arch-shaped continuation of the temporal cortex. The hippocampus and nearby areas constitute the hippocampal formation, which is connected by loops to cortical and subcortical areas, in particular association areas of the cortex. An important function of the hippocampal formation is the consolidation of memory traces in relevant distributed parts of the cortex. The loops permit a continuous interchange of information between the hippocampus and cortex areas.

The authors underscore that the loop architecture is radically different from the reentrant thalamocortical network. In the loops, information travels in one direction, and the function of the loop is to execute a subservice to the cortex with speed and precision (pp. 45-46, 184).

Diffuse projections

The third kind of anatomical arrangement is a diffuse set of connections which originate in the brain stem and hypothalamus and spread to most parts of the brain. The function of these widespread connections is to distribute neurotransmitters, which modulate the activity of the neurons.

Neurotransmitters are produced by specific nuclei in the brain stem, basal forebrain, and hypothalamus. Significant neurotransmitters are dopamine, serotonin, norepinephrine, acetylcholine, and histamine. The authors denominate the diffuse projections of neurotransmitters *value systems*, because they can transmit information about the state and well-being of the whole organism, as well as emotional responses to occurring events, such as novel and unpleasant stimuli.

One example is norepinephrine (also named noradrenaline), which is produced in a small group of approximately 15.000 neurons in the brain stem, called the locus coeruleus. These neurons receive sensory information and respond by distributing norepinephrine to virtually all parts of the central nervous system, including the cortex, cerebellum, basal ganglia, hippocampus, and hypothalamus. Neurons in the locus coeruleus respond to novel and exciting stimuli, and an effect of norepinephrine is to influence arousal and shifts of behavior. Edelman and Tononi underscore the potential impact of the value systems on conscious experience, cognition, learning, and memory (pp. 43-48, 88-92).

Reentry and mapping

According to the authors, reentry is the unique feature of higher brains in animals and humans. Reentry is an ongoing interchange of signals between widely dispersed, reciprocally connected areas of the brain, "an interchange that continually coordinates the activities of these areas' maps to each other in space and time" (p. 48). Reentry is not feedback, but interchange of information across multiple simultaneous paths. Reentry leads to rapid synchronization and desynchronization of groups of functionally specialized neurons, permitting the integration of perceptual and motor processes and the activity of local and global mappings. A global mapping is a dynamic structure, which integrates multiple reentrant motor and sensory processes, and permits continuous adjustment of brain functions and the body's activity. The authors argue that perception is closely connected to action, continuously influenced and altered by motor activity and rehearsal (pp. 85-86, 95-96).

Memory is not a representation, but a result of the interaction of numerous brain systems, which have been modified by signals from the world, the body, and the brain itself. "The dynamic changes linking one set of circuits to another within the enormously varied neuroanatomical repertoires of the brain allow it to *create* a memory" (p. 98). The consolidation of the changes in neural connections that support memory is influenced by the value systems.

3 Brodal (2010:332-333) describes four different loops between the basal ganglia and the cortex.

Perception and memory

Perception is not merely a reflection of input from the world and the sensory organs. Perception of the environment is a result of the interaction between signals from the outside and intrinsic signals in the activated connections of neurons. Sensory information interacts with memory in the form of neural structures that have been influenced and stabilized by previous experience. To a certain degree, perception involves construction in the brain and comparison with memory (pp. 137-138, 160).⁴

Functional clusters and dynamic cores

Edelman and Tononi propose the existence of functional clusters, which are integrated subsets of neural elements which interact strongly among themselves by means of reentrant connections, but less strongly with other structures in the brain. A functional cluster is supposed to be temporarily integrated and active in a cognitive task over a period of hundreds of milliseconds. The authors suggest that the rapid synchronization of large populations of neurons, which can be measured by EEG and MEG, indicates the creation of functional clusters. However, they are aware that more research in this field is needed (pp. 120-124).⁵

In order to contribute to conscious experience, it is essential that the integrated functional cluster is highly complex and differentiated, corresponding to "a conscious state selected out of billions of possible states" (p. 125). The authors denominate such an integrated and differentiated cluster "a dynamic core". A dynamic core is not localized in a single place in the brain. It is a process of spatially distributed interactions which may change its composition rapidly. These reentrant interactions occur primarily in the thalamocortical system, but they may involve other brain regions (pp. 139-144).

Primary consciousness and higher-order consciousness

The authors sum up their hypothesis that "the neural processes underlying conscious experience constitute a large and changing functional cluster, the dynamic core, which includes a large number of distributed neuronal groups and has high complexity" (p. 164). They distinguish between primary and higher-order consciousness.

Primary consciousness is the ability to generate a unified mental scene for the purpose of guiding present behavior. It occurs in human brains and in animals with similar brain structures, and is based on reentrant processes. Primary consciousness requires perceptual categorization, concepts, memory, and value responses. Concepts are not words, but mappings of recognizable activities, for example forward motion. Positive and negative values are added to perception and memory by the diffusely projecting value systems, which distribute neurotransmitters to many brain regions. An integrated mental scene depends on the interaction between perception of sensory stimuli and memory of previous experience. Consequently, the authors characterize primary consciousness as "remembered present." Primary consciousness is supported by functions on three levels in the brain; the value systems in the brain stem, the value-related limbic system, which forms a circle around the brain stem, and the thalamocortical circuits characterized by reentrant connectivity (pp. 78, 102-109).

Higher-order consciousness is a characteristic of humans. It presupposes the existence of primary consciousness and is accompanied by a sense of self and the ability to assemble past and future scenes (p. 102). The self is constructed from social and affective relationships, entailing the development of a self-conscious agent. The concepts of past and future emerge from semantic capabilities.

4 In *The Embodied Mind* (1991), Varela, Thompson and Rosch propose a related view concerning the pathway of visual perception from the eye via the thalamus to the cortex. They state that merely 20% of the information transmitted through the thalamus to the visual cortex comes from the eye, while 80% comes "not from the retina but from the dense interconnectivity of other regions of the brain" (1991:95). Similarly, Brodal indicates that considerable selection and suppression of signals take place in the sensory pathways (2010:164).

5 Brodal confirms that "each cortical area establishes association connections with many other areas; (...) Together, the many areas of the cortex are extensively connected, forming complex networks specialized for specific tasks" (2010:497-498).

Higher-order consciousness is based on semantic capability, the ability to refer to objects and express feelings by symbolic means. The authors propose that in evolution, semantics developed before language in the form of gestures and sounds conveying meaning. Subsequently, verbal syntax may have emerged from a "protosyntax" related to gestures and pointing actions. The evolutionary development of symbolic gestures and speech has served expressive functions as well as referential functions, and is closely linked to value systems. Fully developed higher-order consciousness is strongly dependent on language and memory systems mediated by language (pp. 193-197).

6.2 Antonio Damasio: Self Comes to Mind. Constructing the Conscious Brain

Similar to Edelman and Tononi, Damasio proposes a model of the working brain and its connections on the cortical and subcortical levels. He characterizes his project as a framework of hypotheses. Damasio's understanding of conscious experience displays similarities with Edelman and Tononi's model, but also an important difference. Damasio includes the brain stem as an integrated basis of consciousness. He proposes that the key brain structures crucial for consciousness are sectors of the upper brain stem, nuclei in the thalamus, and widespread regions of the cortex.

Mapping

It is a fundamental concept in Damasio's framework that the brain maps the surrounding world as well as its own activity. Maps are momentary neural patterns which represent objects and events in the external world and the body, or represent other patterns processed in the brain. These momentary patterns are experienced as images in the mind. In Damasio's terminology, an experienced image may be auditory, tactile or visceral as well as visual (p. 18, 70-71).

The construction of maps of the outside world is closely connected to interaction with objects in the world. Similar to Edelman and Tononi, Damasio underscores the connection between perception and action, and states that perception involves both information from the senses and active contributions from inside the brain (pp. 63-65).

Contributions of the thalamus and the cortex to consciousness

Damasio agrees with Edelman and Tononi that reentrant connectivity between the thalamus and regions of the cortex is a requirement for the processing of images in the conscious mind. He refers to reentry as massive recursive cross-signalling amplified by corticothalamic interlocking. Furthermore, he points out the cooperation between the primary sensory cortices, nuclei in the thalamus, and large areas of associative cortices. Ensembles of neurons that work together appear to synchronize their activity momentarily. This synchronization can be measured by EEG as oscillations in the gamma range, approximately 40 Hz (pp. 75, 86-88, 248).

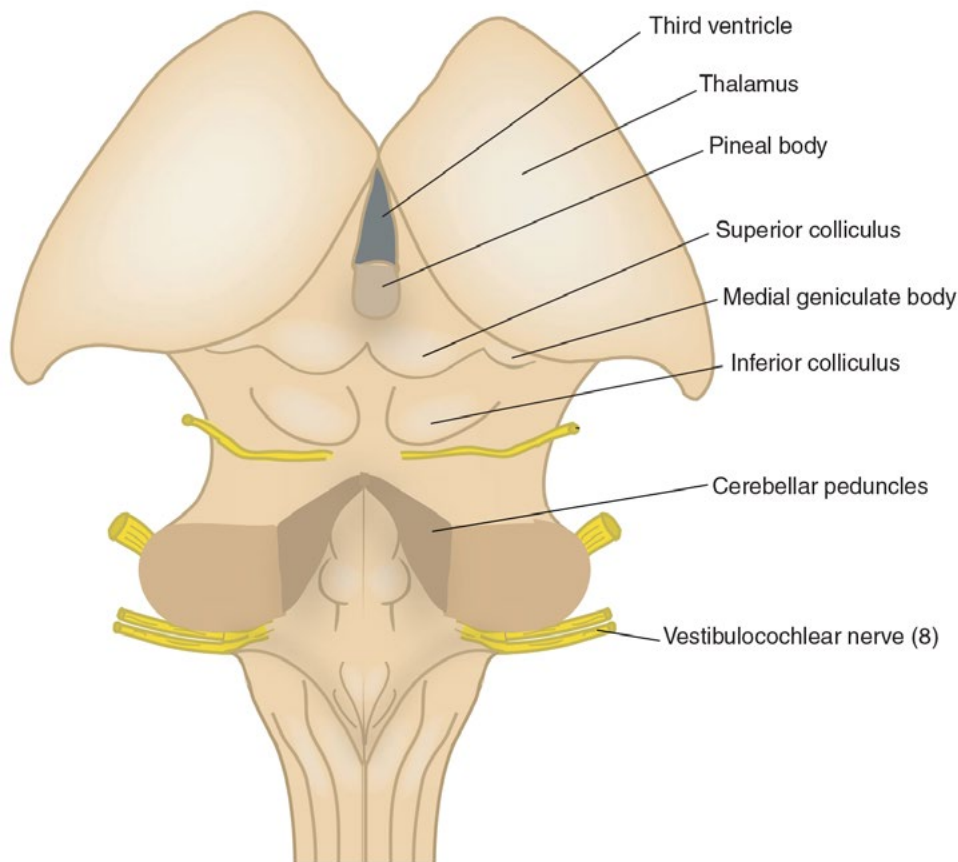


Figure 6.1. The brain stem.

The Inferior colliculus and the Superior colliculus are located in the upper part of the brain stem, close to the Medial geniculate body in the lower part of the Thalamus. The vestibulocochlear nerve connects the brain stem with the ear. The figure also shows other cranial nerves (yellow).

The pineal body is a gland.⁶ The third ventricle is a fluid-filled cavity. The cerebellar peduncles connect the brain stem with the cerebellum, which is cut off in the figure.

(Brodal 2010:86)

Contributions of the brain stem to consciousness

Damasio argues that "brains begin building conscious minds not at the level of the cerebral cortex but rather at the level of the brain stem" (p. 22). He finds evidence that subcortical structures can create coarse maps, in particular the geniculate bodies in the lower thalamus and the neighboring superior colliculus in the upper brain stem. Deep layers of the superior colliculus create maps related to visual, auditory and somatic information, and the superior colliculus displays gamma-range oscillations, similar to oscillations ascribed to synchronization in the cortex (pp. 68, 83-86, 326).

A special kind of evidence for the contribution of the brain stem to the conscious mind comes from the study of children born without the cerebral cortex as consequence of a trauma during the pregnancy period. This deficit is known as hydranencephaly. Such a child possesses an intact brain

⁶ The pineal gland produces the hormone melatonin, related to the regulation of sleep.

stem and hypothalamus, but its skull is filled with fluid in the place of the cortex. These children can survive if provided sufficient care, they can orient head and eyes, they respond to light, sound, music and human voices, and they display expressions of emotions.⁷ Damasio concludes from these findings that functions in the brain stem support a modest kind of conscious mind. Related findings indicate that patients with damage to the visual cortices retain a vague visual orientation supported by the superior colliculus, known as blindsight (pp. 80-85).

Emotion and Feeling

Damasio distinguishes between emotions and feelings. Emotions are complex programs of actions carried out in the body. Feelings of emotions are perceptions of emotions mapped in the brain. Damasio states that all feelings of emotions can be considered variations of the primordial feelings which arise in the brain stem.

Primordial feelings arise continuously and spontaneously, reflecting the internal state of the body as variations of pleasure and pain or relaxation and tension. Particular nuclei in the brain stem respond to the body signals and transmit them to the thalamus and insular cortex (pp. 78-80, 97-98, 109-111).⁸ Further structures that produce emotional responses are the amygdala, the ventromedial prefrontal cortex, and nuclei in the basal forebrain (p. 255). Damasio points out that the insular cortex and a closely connected area, the anterior cingulate cortex, are the important cortical regions involved in the processing of feelings (pp. 117-118). He briefly refers to the neurotransmitters and their relations to value, pain and pleasure, reward and punishment (pp. 47, 193, 209).⁹

Memory

Damasio agrees with Edelman and Tononi's view of the brain functions underlying memory. Memories are not stored as representations, but as dispositions, which are procedures for reactivating and assembling aspects of past perception (p. 141). These procedures require the synchronized activation of distributed brain regions. Damasio proposes that the interaction of two fundamentally different types of brain systems is necessary. He denominates one type "the image space", consisting of the areas which can map sensory and motor information: the visual cortex, the auditory cortex, the sensorimotor cortices, and nuclei in the upper brain stem.

Damasio denominates the other type of brain areas "the dispositional space". It encompasses most of the remaining brain, including the extensive association cortices in the temporal, parietal, and frontal lobes, as well as the thalamus and basal ganglia. It is Damasio's hypothesis that synchronized activation of circuits in the dispositional space sends signals to the image space, which reconstructs approximate maps of the original objects, events, and interactions in the areas where they were first mapped (pp. 130-153).¹⁰

Consciousness and Self

Damasio presents an extended framework of hypotheses concerning the nature of consciousness and the self. His basic proposition is the following:

7 Björn Merker has published an elaborate study of consciousness without a cerebral cortex (2007:63-81).

8 Damasio explains that the Solitary Nucleus, also called Nucleus Tractus Solitarius (NTS) and the Parabrachial Nucleus (PBN) in the brain stem receive a complete range of signals from the interior of the body. These nuclei respond by regulating body functions, and transmitting signals from the body via the thalamus to the insular cortex (p. 78, 118). The NTS and PBN are closely connected to other nuclei in the brain stem, situated in the Periaqueductal Gray (PAG), which trigger numerous emotional responses, including laughter and crying, and reactions in situations of fear (p. 80).

9 In his earlier publication *The Feeling of What Happens*, Damasio discussed the production and impact of neurotransmitters (1999:246-253). Parvizi and Damasio (2001:144-147) discuss the interactions between nuclei that produce neurotransmitters and other nuclei in the brain stem and the basal forebrain. See also chapter seven.

10 Studies of auditory imagery for music are reported by Halpern & Zatorre (1999); Zatorre & Halpern (2005). Auditory imagery for music is "the tune that runs through your head", that is, music retrieved deliberately or involuntarily from memory. Halpern & Zatorre find that recall of memorized melodies activates the same brain areas as perception of melodies.

"Consciousness is a state of mind in which there is knowledge of one's own existence and of the existence of surroundings" (p. 157, italics in the original).

Consciousness has content, it is always about something. It contains an aspect of feeling and includes a self process. The self is not a constant entity. The self is a dynamic process which is generated in the mind's processing of images, and evokes feelings of knowing, and feelings of ownership and agency. Damasio characterizes the self not as an observer, but as an informer, an imaged protagonist of the mental events, which is constructed from moment to moment in the form of "self pulses" (pp. 166, 181, 212-213). The idea of self pulses corresponds to the view that the self is continuously modified. The degree of presence of a self in the mind varies with the circumstances. However, Damasio insists that even if the feeling of self may be subtle, its presence is a necessary constituent of the conscious mind (p. 169-171).

Protoself, core self, and autobiographical self

The self is built in three stages, the protoself, the core self, and the autobiographical self. The simplest stage is the protoself, which consists of a collection of images that describe the ongoing state of the organism and generate primordial feelings, which are spontaneous feelings of the body. Contributors to the protoself are brain stem nuclei, the hypothalamus, the insular cortex, and the somatosensory cortices (pp. 180-181, 190-193).

Damasio characterizes the core self as "a self in the proper sense". It is generated in pulses, as moment-to-moment modifications of the protoself caused by the interaction between the organism and an object. "The relation between organism and object is described in a narrative sequence of images, some of which are feelings" (p. 181). The assumed contributors to establishing the core self are the superior colliculi, which can generate integrated mappings of sensory information, the associative nuclei in the thalamus, which coordinate the activity of brain areas, the basal ganglia, the insular cortex, the primary sensory cortices, and the sensorimotor cortices (pp. 207-09).

The autobiographical self is the result of a multitude of core self pulses, produced by the interaction between the protoself and previous recordings of lived experience, or anticipations of the future (p. 181). The autobiographical self reconstructs, modifies and rearranges lived experiences, and the recalled events may adopt new emotional qualities in the process. Damasio's hypothesis of the autobiographical self's mechanism is the following: "(a) past memories, individually or in sets, are retrieved and treated as singular objects (biographical objects); (b) objects are delivered to the protoself; (c) core self pulses are generated; (d) core self pulses are held transiently in a coherent pattern" (p. 213). Characteristically, Damasio maintains that the brain stem nuclei and the protoself are active participants in the creation of the autobiographical self (pp. 243-247).

The next indispensable participant is the thalamus, which coordinates cortical activity and the flow of information from the body to the cortex (pp. 215, 247-248). Finally, the brain areas in the "image space" interact with the extended regions of association cortices in the "dispositional space." In his discussion of these areas, Damasio argues that the posteromedial cortices, which are situated near the midline of the brain, play a central coordinating role (pp. 215-229). In short, cooperation of the brain stem, the thalamus, and the cortex is necessary for the creation of the autobiographical self.

According to his concepts of the self, Damasio has named two kinds of consciousness, the core consciousness, which is the sense of the "here and now", and the extended or autobiographical consciousness, which includes personhood, the lived past and the anticipated future (pp. 168-169).

Damasio and Edelman: Similarities and differences

Damasio and Edelman & Tononi agree that the temporary reentrant connectivity of functional neuron clusters distributed over different brain areas is essential for consciousness. Moreover, they agree that values and feelings are indispensable components of consciousness; that perception is closely

related to action; and that perception involves contributions from the brain as well as sensory input.

The main difference is that Edelman & Tononi apply a top-down view, while Damasio applies a bottom-up view. Moreover, Damasio acknowledges introspection as a relevant approach to understanding consciousness (p. 15), while Edelman & Tononi reject introspection (p. 217).¹¹

Edelman & Tononi's primary interest is the "higher-order" consciousness, mediated by the thalamocortical connections, and its close relation to language. In Damasio's discussion of consciousness, he gives lower priority to language, and higher priority to visual, auditory and tactile images. Damasio maintains that the relations to the lived body, mediated by brain stem nuclei, are integrated in all levels of consciousness.

6.3 The auditory pathways¹²

Two pathways are simultaneously active in auditory perception and cognition. The ascending pathway conveys auditory information from the ear's cochlea to the auditory cortex. The descending pathway, which is also named the corticofugal system, projects in the opposite direction from the auditory cortex to the ear.

The functions of the ascending pathway are well-known. The studies of the descending pathway are gaining increasing interest, as these top-down connections modify the upward flow of information at all levels. The cortex sends information back to the ear, which promotes the selection of relevant sounds and the suppression of irrelevant sounds (Rees & Palmer 2010:2; He & Yu 2010: 264; Brodal 2010:250).

6.3.1. The ascending auditory pathway

(Figure 6.2, see also the illustration of the brain stem Figure 6.1)

The cochlea

The cochlea in the ear transmits auditory signals to the cochlear nucleus in the brain stem. The signals are tonotopically organized, that is, they reflect the precise ordering of frequencies in the cochlea, from high to low frequencies.

The brain stem

In the brain stem, auditory information is processed at four levels: (1) the cochlear nucleus, (2) the superior olive, (3) the lateral lemniscus, and (4) the inferior colliculus. At each of these levels, the nuclei are subdivided in several areas, which perform different functions.

(1) Division of the pathway: From the cochlear nucleus, one branch of nerve fibers projects to the lateral lemniscus. Another branch projects to the superior olive.

(2) Localization of sound: Nuclei in the superior olive compare auditory information from the two ears. Comparison of differences in sound level and timing permit the localization of sound sources.

(3) Further processing: The lateral lemniscus contains two different functional systems. One system processes temporal information with high precision. The other system is important for sound localization, and for discriminating between a direct sound and its reverberation.¹³

11 Edelman & Tononi (2000:217) equate introspection with phenomenology. This is a badly informed view, cf. chapter 2.

12 Main references for this paragraph are Rees & Palmer (Eds. 2010) *The Oxford Handbook of Auditory Science: The Auditory Brain*, and Brodal (2010) *The Central Nervous System. Structure and Function*. The functions and interconnections of the auditory system are highly complex and differentiated. This paragraph presents a simplified overview.

13 Klug & Grothe (2010:184-185)

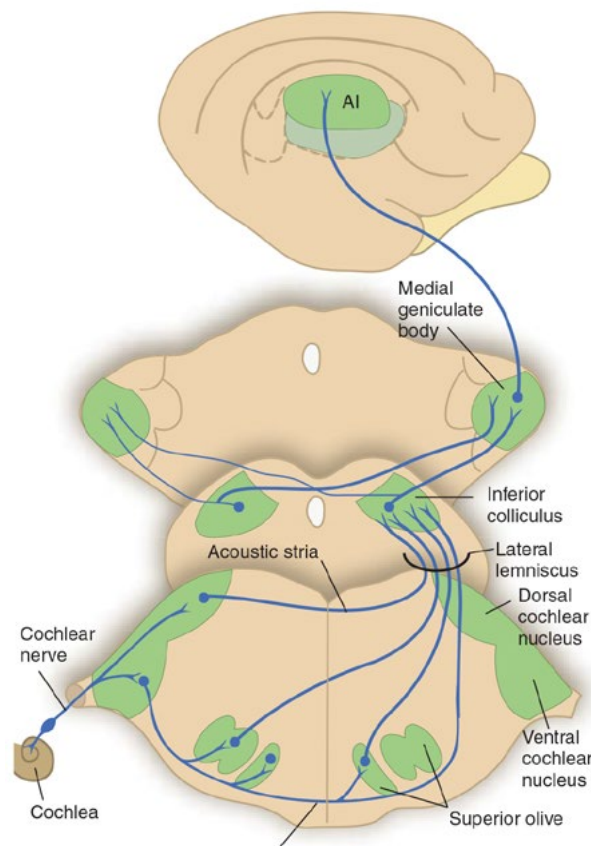


Figure 6.2. The ascending auditory pathway

The figure shows the cochlea, the cochlear nerve, and the levels of auditory processing.

Levels in the brain stem: (1) the cochlear nucleus, dorsal and ventral part; (2) the superior olive; (3) the lateral lemniscus; (4) the inferior colliculus. In the thalamus: (5) the medial geniculate body. In the cortex: (6) A I, the core area of the auditory cortex. See also Figure 3.2.

(Brodal 2010:248)

(4) Integration and differentiation: The inferior colliculus (IC) collects information from all lower auditory nuclei. The IC contains several areas with different functions. It projects to the medial geniculate body (MGB) in the thalamus.

One area of the inferior colliculus displays a sharply tuned response¹⁴ to auditory input. It projects to the MGB in a tonotopic manner, that is, the frequencies are ordered precisely from high to low frequencies. Another area of the IC displays a more broadly tuned response to auditory information. It contributes to multisensory integration. It projects to the MGB and to the superior colliculus, which integrates auditory and visual information.

Studies by Kraus et al. (NM III 2008, pp. 543-557) indicate that pitch, timbre and timing have distinct representations in the brain stem. These representations can be measured by electrodes on the scalp (p. 545).

¹⁴ Sharply tuned neurons respond to a narrow frequency range. Broadly tuned neurons respond to a wider frequency range.

Damasio points out the multisensory integration carried out by the inferior and the superior colliculi. (2010:84, 244).¹⁵

The thalamus

The medial geniculate body (MGB) in the thalamus conveys all auditory information from the brain stem to the cortex. It contains several nuclei. One nucleus projects tonotopically organized information to the core area of the auditory cortex. Another nucleus projects more broadly tuned information to the belt area of the auditory cortex. A third nucleus, which also projects to the belt area, is sensitive to auditory, visual and somatic stimuli.

The auditory cortex

The auditory cortex is located in the superior temporal gyrus of the temporal lobe, see Figure 3.2. It displays a complex organization, which can roughly be divided into a core area surrounded by a belt area and a parabelt area.

The core area is tonotopically organized, and responds strongly to sharply tuned sounds, such as tones.¹⁶ The belt area responds better to spectrally complex sounds. It contributes to multisensory integration. The parabelt area adjoins the belt area. It has extended connections with other brain areas. Tramo et al. (NM II 2005, pp. 148-174) characterize the belt and parabelt areas as auditory association areas, which are integrated in a widely distributed system for music cognition.¹⁷

Zatorre and Belin (2001:946) have found evidence for a hemispheric specialization of the auditory cortices. The right hemisphere gives priority to spectral processing, including tones, and the left hemisphere gives priority to rapid temporal processing, including language.¹⁸

It appears that one route in the ascending pathway is throughout tonotopically organized, characterized by sharply tuned neurons which respond to narrow frequency information. Other routes are characterized by more broadly tuned neurons, which respond better to complex sounds.

The "what" and "where" pathways (Figure 3.2)

From the auditory belt area, functionally specialized pathways, a ventral and a dorsal stream, reach the prefrontal cortex and the parietal cortex. The ventral stream is characterized as a "what" pathway, dealing with object information, which subserves the identification and meaning of sounds. The dorsal stream is characterized as a "where" pathway, dealing with spatial information, which subserves the localization of sounds and the detection of movement (Rauschecker & Tian 2003:44-48).¹⁹ The pathways are reciprocally connected.

15 Damasio underscores the role of the superior colliculus for sensory integration. Malmierca & Hackett point out the role of the lateral cortex of the inferior colliculus for sensory integration (2010:27).

16 The precise location of pitch perception remains a topic for discussion. Wang & Bendor (2010:161-164) and Griffiths (NM I 2002, p. 47) propose the existence of a pitch perception area close to, but distinct from the core auditory cortex.

17 Chapter 3, p. 76.

18 A recent meta-analysis of 58 studies confirms the high speech sensitivity in the left auditory cortex, and indicates specific areas sensitive to spectral and temporal variation in both auditory cortices (Samson, Belin et al. 2011)

19 Warren et al. (2005:637-641) and Zatorre et al. (2007:549, 557) propose that the dorsal pathway serves general transformations of acoustic information into motor representations. In a recent article, Rauschecker (2012:1-4) agrees that the dorsal pathway, alongside with its role in spatial processing, also plays a more general role in sensorimotor integration and control.

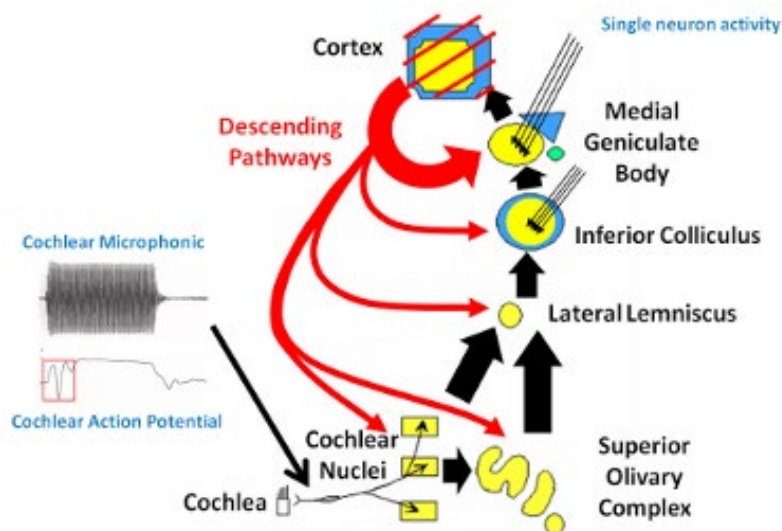


Figure 6.3. Schematic diagram of the ascending auditory pathway (black arrows) and the descending auditory pathway (red arrows).

Similar to Figure 6.2, the diagram shows the levels of auditory processing: (1) the cochlear nuclei, (2) the superior olivary complex, (3) the lateral lemniscus, (4) the inferior colliculus, (5) the medial geniculate body in the thalamus, (6) the auditory cortex.

(Courtesy of the MRC Institute of Hearing Research)

6.3.2. The descending auditory pathway

The descending pathway reaches all levels of auditory processing from the cortex to the cochlea. It performs important functions, modifying the upward flow of information and influencing the neural processing at lower levels. Direct projections descend from the auditory cortex to all levels of the auditory system (Figure 6.3). Three systems are active, a tonotopic system related to the core area, a diffuse or non-tonotopic system related to the belt area, and a multisensory system, related to widespread areas of the auditory association cortex.

The thalamus

Each area in the auditory cortex project to several nuclei in the thalamus. Some projections form reciprocal loops between the thalamus and the cortex. It is hypothesized that such loops may function as a dynamic filter for auditory attention, which permits focusing on a particular sound source or speaker (He & Yu 2010:264-265).

The inferior colliculus

The tonotopic, the diffuse, and the polysensory systems interconnect the auditory cortex with the IC. The functional roles of the three systems are not precisely understood.

The superior olive and the cochlea

The superior olive consists of many nuclei. The complex functions of this system exert impact on the hair cells in the cochleas. This impact may result in the amplification of particular frequency ranges, and contribute to the focusing on a sound source in a noisy environment.

Brief summary of the auditory functions

The overview indicates that the auditory system is integrated and highly differentiated. It processes spectral and temporal information with great precision. The processing is not linear, but mediated and modified by neural connections on several levels. The auditory system deals with tonotopically organized information as well as non-tonotopical and multisensory information, and interacts with multiple other brain systems. Important functions of the auditory system are the identification and localization of sounds, and the response to movement indicated by sound.

6.4 Music listening activates extended networks in the brain

Recent reference works and review articles report that music listening involves extended networks in the brain.²⁰ Altenmüller & Schlaug summarize that a typical musical experience involves attention, multisensory integration and motor preparation mediated by frontal and parietal brain areas, as well as timing and motor coordination supported by the basal ganglia and cerebellum. Simultaneously, emotional responses elicited by music are related to nuclei in the brain stem, the nucleus accumbens, hippocampus, amygdala, insula, and the cingulate gyrus. Moreover, music exerts an impact on bodily functions, such as heart rate, respiration, and perspiration (Altenmüller & Schlaug 2012:12-17). Important networks related to music concern motor planning, rhythm and regularity, and pleasure and reward.

Motor planning and preparation (See Figures 3.2 and 3.4)

A number of studies indicate that music listening activates brain areas related to motor planning and preparation, even if no motor action is carried out.

In their review of auditory-motor interactions, Zatorre, Chen and Penhune (2007:549-553) discuss the ventral and dorsal pathways, which are suggested to support object identification and spatial processing. They highlight research concerning the dorsal stream, and propose that the dorsal stream plays a role not only in spatial processing, but also a more general role, transforming acoustic information into motor representations.²¹ The dorsal pathway connects reciprocally the planum temporale in the auditory cortex with the premotor cortex, motor cortex, and prefrontal areas. Furthermore, the authors report that "hearing music in the mind" activates the supplementary motor area and premotor areas.

Bremmer et al. (2001:290-291) have found polymodal cortical areas that are activated by visual, tactile, and auditory motion stimuli. They suggest that polymodal processing involves the posterior parietal and premotor cortices.

Schönwiesner et al. (2007:2075) have studied the detection of acoustic changes by means of fMRI and EEG. They find that a pre-attentive process in the auditory system encompasses three stages: (1) initial detection in the core auditory cortex (2) detailed analysis in the posterior superior temporal gyrus and planum temporale (3) judgment of sufficient novelty for allocation of attentional resources in the mid-ventrolateral prefrontal cortex.

Chen, Penhune, and Zatorre further discuss the auditory-motor interactions in an elaborate review (NM III 2009, pp. 15-34).

20 Useful references are review articles by Zatorre (2005), Koelsch & Siebel (2005), Zatorre et al. (2007), Warren (2008), Levitin & Tirovolas (2009). Furthermore, chapters from Hallam, Cross & Thaut (Eds. 2009) *The Oxford Handbook of Music Psychology*; Juslin & Sloboda (Eds. 2010) *Handbook of Music and Emotion*; MacDonald, Kreutz & Mitchell (Eds. 2012) *Music, Health and Wellbeing*.

21 Zatorre indicates the importance of studies by Griffiths & Warren (2002:348-352) and Warren et al. (2005:637-640).

Rhythm and regularity

Zatorre, Chen and Penhune (2007:550) indicate that listening to rhythm often involves the basal ganglia, cerebellum, the dorsal premotor cortex, and the supplementary motor area. In a subsequent study, the same authors interpret the involvement of the motor areas during passive listening as motor planning (Chen, Penhune and Zatorre 2008:2844).

Grahn (NM III 2009, pp. 35-45) has reviewed studies of the role of the basal ganglia in beat perception. She finds that the basal ganglia are strongly involved in processing a regular beat. In particular, the basal ganglia appear to be linked to internal generation of the beat.²² Grahn proposes that rhythms with a beat involve a circuit connecting the putamen, which is part of the basal ganglia, and premotor and supplementary motor cortices.²³

Janata and Grafton (2003) have conducted a meta-analysis of 34 PET and fMRI studies concerning sequencing and music. Their analysis indicates that a core circuit consisting of the sensorimotor cortex, the premotor cortex, the supplementary motor area, and the cerebellum underlies sequenced behaviors (2003:686). They call attention to the deviations from a strictly regular beat, which characterize an expressive musical performance, and refer to Bruno Repp, who has studied this topic in a number of experiments.

Repp (1999:529) has suggested a sensorimotor feedback mechanism that is sensitive to timing deviations. Münte et al. (NM I 2002, pp. 131-139) have found differences between drummers and nonmusicians in the pre-attentive processing of temporally deviant beats. Similarly, Vuust et al. (2005) indicate differences between jazz musicians and nonmusicians in their pre-attentive responses to incongruent rhythm.

Reward and pleasure

The classic study by Blood and Zatorre (2001), reported in chapter 3, p. 67 showed that intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. These regions include the ventral striatum in the basal ganglia (which contains the nucleus accumbens), the insula, and the orbitofrontal cortex.

Menon & Levitin (2003, 2005) have investigated responses to pleasurable music in an fMRI study based on excerpts of classical music by Bach, Beethoven, Elgar, Mozart, Rossini, Johann Strauss, and Tchaikovsky. Similar to Blood and Zatorre, they found that the experience of pleasant music activated a network which included the nucleus accumbens in the striatum, the ventral tegmental area (VTA) in the brain stem, the hypothalamus, the insula and the orbitofrontal cortex. As the VTA is a brain stem area that projects the neurotransmitter dopamine to the nucleus accumbens, they suggested that dopamine release was connected to the experience of reward and pleasure.

In continuation of these studies, Salimpoor et al. (2009, 2011) have investigated the possible relationship between dopamine release and pleasurable musical experience. They focused on chills as an indicator of strong pleasurable response, because it is possible to compare the subjective experience of chills with simultaneous objective measurements of bodily response to the music. Prominent bodily responses are changes in skin conductance response (SCR), which is related to sweat production, and changes in heart rate (HR). Both of these responses reflect arousal of the autonomic nervous system.

22 A study by Patel et al. (2009:827-830) suggests that, similar to humans, certain birds may be able to synchronize their body to a musical beat. This ability appears to be related to auditory-motor circuits in the brain, including the basal ganglia. Patel reports and discusses his study in NM III 2009, pp. 459-469.

23 Edelman & Tononi underscore that the functional connections between the basal ganglia and the cortex are one-directional loops, different from reentrant connections (2000:183-185)

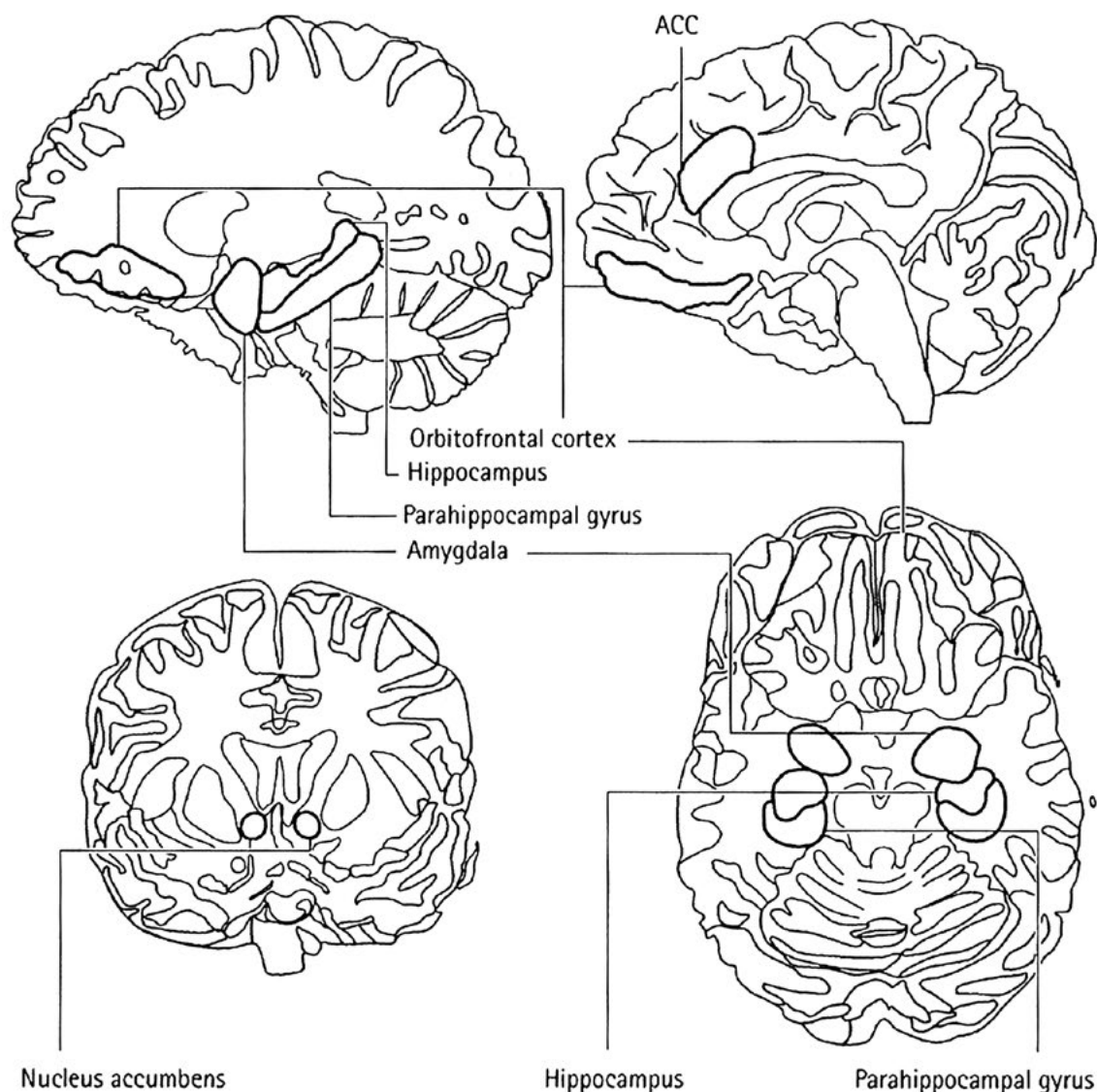


Figure 6.4. Brain areas involved in emotional processes.

The figure shows some brain structures that are involved in the generation of emotion; the amygdala, the nucleus accumbens, the anterior cingulate cortex (ACC), the hippocampus, the orbitofrontal cortex, and the parahippocampal gyrus.

Traditionally, these structures are named limbic or paralimbic.²⁴

(Koelsch et al. 2010:315)

²⁴ the notion of a "limbic system" is outdated, but still in use (Brodal 2010:462)

In their first study (2009), Salimpoor et al. aimed at finding correlations between subjective experience and objective physiological responses. Out of a group of 200 volunteers, they selected 28 persons who reported repeated experience of chills when listening to music. As the experimenters were aware that emotional response to music is highly individual, they asked the participants to bring pieces of music which they knew would evoke chills. The self-selected music included classical, jazz, rock, folk, and trance music, with a majority of classical music. From these pieces, three-minute chill-evoking passages were excerpted. Additionally, according to a procedure designed by the researchers, the participants selected music that they found emotionally neutral.

In the experiments, the participants were asked to press and hold buttons while listening to the music; one button for neutral, one for low pleasure, one for high pleasure, and one for chills. Simultaneously, their physiological responses were measured.²⁵ Exact timing of button presses and physiological measurements permitted synchronized registration of subjective experience and objective measurements. The participants listened to chill-evoking and emotionally neutral pieces in random order.

The data showed a strong positive correlation between subjective ratings of pleasure and autonomic nervous system arousal. Participants who did not experience pleasure showed no significant increases in emotional arousal.

On the basis of this study, the researchers designed a new experiment (Salimpoor et al. 2011:257-264). The experiment aimed at detecting release of dopamine in the brain during listening to pleasurable music. Out of the 28 participants in the first study, the researchers selected eight persons who had most reliably experienced chills during their peak pleasure responses to music. These eight persons were asked to listen to their self-selected pieces and the emotionally neutral pieces again, once during a PET scanning, and once during an fMRI scanning. During the scanings, physiological variables were measured, similarly to the first experiment.

Both kinds of scanning produce images of the brain. PET scanings permit the detection of dopamine release in particular areas of the basal ganglia after the injection of a slightly radioactive liquid in the blood.²⁶ However, PET scanning does not afford precise timing of the dopamine release related to the music. For this reason, the music listening was repeated during an fMRI scanning, which secured better timing.

This complicated procedure led to the desired results. The researchers found evidence for dopamine release during listening to pleasurable music in two anatomically distinct areas of the basal ganglia. The *nucleus accumbens* was more involved during the peak emotional response. The timing of the dopamine release in the *caudate* was different. The caudate was more involved during the anticipation of the peak response (2011:257, 260).

These results confirm that music listening involves brain areas related to reward and pleasure, and add considerable precision and control to the study of Blood and Zatorre (2001). The indication of different neural responses to anticipation and peak emotional experience shed light on prominent driving forces in music listening; the process of expectation and fulfilment, and the process of tension and release.

²⁵ The measurements included five variables. Skin conductance response, skin surface temperature, heart rate, and blood volume pulse was measured at the fingertips. Respiration was measured at the chest.

²⁶ The technical explanation is as follows: This experiment uses a synthetic radioactive molecule named [¹¹C]raclopride. The scanning investigates dopamine release in the *striatum*, which is a region of the basal ganglia. The striatum includes two areas that are of particular interest, the *nucleus accumbens*, and the *caudate*. Salimpoor et al. explain that it is possible "to estimate dopamine release specifically in the striatum on the basis of the competition between endogenous dopamine and [¹¹C]raclopride for binding to dopamine D2 receptors." (2011:257)

Real music activates large-scale brain networks

Vinoo Alluri, Petri Toivainen and colleagues (2012:3677-3689) have launched an ambitious project. In an fMRI study, the brains of the participants were scanned while they listened to a whole 8-minute piece of music, the tango *Adiós Nonino* by Astor Piazzolla. This tango is an extraordinary piece of music. It was recorded in a live concert by Piazzolla and his tango nuevo band, which comprised two bandoneons, piano, guitar, cello, and double bass.²⁷ The recorded music offers a rich display of timbre, pitch, rhythm, volume, and polyphonic interplay. Remarkable are the changes from rhythmic drive to floating timing, the extreme accelerandos and ritardandos, a very large range of pitch, the use of glissando, and considerable variation in loudness, timbre contrasts, and musical expression. In order to capture the features of this complex music, the researchers have developed a novel procedure.

First, the short-term and long-term features of the music were extracted by means of the Music Information Retrieval toolbox (Lartillot & Toivainen 2007). The short-term features encompass timbral properties of the music, including spectral centroid, spectral spread, spectral roll-off, roughness and spectral flux. The long-term feature encapsulate tonality and rhythm, and include pulse clarity, fluctuation, mode and key clarity.

Next, a principal component analysis (PCA) was performed in order to reduce the number of features, resulting in nine components; Fullness, Brightness, Timbral Complexity, Rhythmic Complexity, Key Clarity, Pulse Clarity, Event Synchronicity, Activity and Dissonance.

Third, excerpts of the Piazzolla piece that represented these nine components were presented to a group of 21 musicians. In a controlled procedure, the participants were asked to rate the musical properties of the excerpts. An analysis of the participants' ratings showed significant correlations between the rating scales of Fullness, Brightness, Timbral complexity, Key Clarity, Pulse Clarity and Activity and the respective acoustic components. These six acoustic components were used for further analysis in the fMRI study (p. 3680).

Eleven participants with formal musical training participated in the study. Five played mainly classical music, two played folk and jazz, and four played mainly pop/rock music. In the experiment, the whole-brain activity of each participant was recorded by fMRI while listening to the 8-minute piece of music. Subsequently, correlations between acoustic components and brain activity were calculated. First-level analysis showed correlations at an individual level, second-level analysis pooled the individual results to obtain group maps for each acoustic component (p. 3684).

The results of the study provided a number of new findings in comparison with previous studies. Timbral feature processing involved cognitive areas of the cerebellum and areas related to the default mode network (DMN), which is a network that constantly monitors the sensory environment. Processing of musical pulse recruited limbic and reward areas. Processing of tonality involved cognitive and emotion-related brain regions. In sum, the study "revealed the large-scale cognitive, motor and limbic brain circuitry dedicated to acoustic feature processing during listening to a naturalistic stimulus" (pp. 3677, 3685, 3687). The authors suggest that further studies may call for an expansion of the acoustic feature set.

The procedures of this experiment represent a considerable step forward in neuroimaging, permitting the investigation of neural responses to real music in controlled studies of high ecological validity. Even if the procedure and research design may be subject to further testing and refinement, this study paves the way for future investigations in neuroscience.

27 The recording is commercially available. Astor Piazzolla: The Lausanne Concert November 4, 1989. CD Radio Suisse Romande M2-36165 R1.

Chapter 7. Embodiment

Introduction

"The body is our general medium for having a world."

This statement in Merleau-Ponty's *Phenomenology of Perception* (2002:169) summarizes his philosophy of embodiment. According to Merleau-Ponty, the origin of consciousness is the interaction between the body and the world;

"Consciousness is being-towards-the-thing through the intermediary of the body. A movement is learned when the body has understood it, that is, when it has incorporated it into its "world", and to move one's body is to aim at things through it" (2002:160).

The study of embodiment is a common denominator for many fields of philosophy and science. The following presents different views of embodiment from the positions of neuroscience, receptive music therapy, cultural sociology, developmental psychology, and phenomenology.

7.1. Embodied listening

It is an everyday experience of music listeners that music induces body movement. Cross states that "music embodies, entrains, and transposably intentionalizes time in sound and action" (2003:24). Davidson and Emberly (2012:136-149) have reviewed singing and dancing for quality of life across cultures. They highlight music's capacity to unite people and create attachment between mother and infant, and conclude that music affords an embodied communicative experience for well-being (p. 145). Dura (2002) emphasizes the kinesthetic dimension of music listening, and states that musical meaning is a result of music's "intimate connection with our bodies, with which we first come to know the world" (p. 257).

Hodges (2009:125-126) reports that music is connected to physical movement in cultures all over the world, and suggests that the neural systems of our brains and bodies are "wired" to respond to sound. He proposes that listening to music activates brain regions in a sequential order:

- (1) The auditory cortex initially analyses sound;
- (2) Frontal brain regions process musical structure;
- (3) The mesolimbic system, involved in arousal and pleasure, is activated and produces dopamine, further activating the nucleus accumbens;
- (4) The cerebellum and basal ganglia process rhythm and meter leading to physical movement.

Entrainment

Based on MEG and PET studies, Thaut et al. (NM I:364-373)¹ find that a widely distributed cortical and subcortical network subserves the motor, sensory, and cognitive aspects of rhythm processing. LaGasse & Thaut (2012:153-163) highlight the role of rhythmic entrainment in neurological rehabilitation.

In an fMRI study, Grahm (NM III:35-45) finds that the basal ganglia are strongly implicated in processing a regular beat. Zatorre et al. (2007:550) report that even when subjects only listen to rhythms, the basal ganglia, cerebellum, dorsal premotor cortex, and supplementary motor area are often activated.

¹ NM = The Neurosciences and Music, cf. chapter 3.

Body listening

In the context of Guided Music and Imagery therapy, Helen Bonny (1993/2002:325-334) has described her experience of bodily impact and free body movement to well-known classical music. She employed the GIM program *Imagery*, a selection of music by Ravel, Copland, Tchaikovsky, Respighi, and Turina that she had compiled herself and knew almost by heart. She began lying on the floor in a relaxed state, and felt that the first piece induced movement and tension in her body. Subsequently, she stood up and moved freely, following the music's flowing, jerky and jumping movements with her hands, feet and facial expressions. Simultaneously, she let her body respond to the moods and feelings of the music. Bonny reported that the experience was astonishing. Even though she had known the music for fifteen years, her first attempt at moving to the music yielded an unexpected new understanding of the music's potential.

Trondalen (2004:65-66, 73-74) reports that body listening adds important dimensions to her procedure for analyzing music therapy improvisations.² Body listening is used in the training of GIM therapists to heighten their awareness of inner versus outer movement and gestural qualities in the music (Bonde 2012, personal communication).

Music organizes the body

De Nora (2000:75-108) describes the use of music as a stabilizing factor for the body functions of prematurely born children, and as an organizing device of the body in rhythmic aerobic exercise.

In an intensive care unit for neonates, selected music can mask the noises of medical technologies, and regulate the disorganized body state of the infants, providing a supportive environment of stable, patterned and predictable musical sound (pp. 77-82).

In aerobic exercise, music creates the order underlying sequences of choreographed movements. Specially composed music for aerobics features high rhythmic and timbral clarity and carefully selected tempos. Timing, rhythm, melody and harmony are deliberately designed to support body conduct and coordination in the various phases of exercise. De Nora characterizes music as "a technology of body building, a device that affords capacity, motivation, co-ordination, energy and endurance" (p. 102).

7.2. Psychophysical responses to music

Investigations of psychophysical responses provide evidence of the impact of music on bodily functions. Listening to music can exert impact on heart rate, skin conductance, blood pressure, respiration, and the release of neurochemicals (Hodges 2009, 2010).

Skin response, heart rate, and breathing

"Chills" or "shivers down the spine" or "gooseflesh" is a bodily response to strong experiences of music in many listeners. In a pioneering study, Panksepp (1995:171-207) investigated chills in groups of listeners on the basis of questionnaires and subjective self-reports. He found large individual differences, but also a tendency that sad songs are more likely to evoke chills than happy songs (p. 187).³ This finding corresponds with Panksepp's hypothesis that chill responses may be related to "distress vocalizations – the primal cry of being lost or in despair" (Panksepp 1998a:278). As stimuli that may evoke chills, he suggests a high-pitched crescendo, or a single instrument which emerges from a soft background sound. Huron (2006:36, 281-283) modifies Panksepp's idea, suggesting that in music, chills arise when an initial negative response to a surprise is followed by a neutral or positive appraisal.

In another pioneering study, Blood and Zatorre (2001) investigated individual chill responses to self-selected music by means of PET. They found that intense chills were correlated with activity in

² Trondalen's procedure is described in chapter 2.

³ The participant-selected examples in Panksepp's study include a variety of popular music, e.g. the groups Pink Floyd, Boston, and Air Supply (1995:179).

brain regions involved in reward, emotion, and arousal. These findings were confirmed and refined a subsequent study by Salimpoor, Zatorre et al. (2011).⁴

Studies by Guhn et al. (2007:473) and Grewe et al. (2009:61) indicated that heart rate and skin conductance increased during music-induced chills.

All researchers agree that chill experiences are highly individual. However, musical passages that are apt to evoke chills display common characteristics. In a review of studies, Huron and Margulis (2010:594) summarize that chills are often correlated with a rapid large change of loudness, a broadening of the frequency range toward high treble or low bass, a sudden change of tempo, harmony or texture, the return of a melody, or the entry of one or more voices or instruments.

Bernardi et al. (2006:445-452) have investigated the bodily impact of raga, classical and dodecaphonic music, rap and techno. They found increase in respiration, blood pressure, and heart rate, and conclude that the music induced an arousal effect, predominantly related to tempo. A subsequent study by Bernardi et al. (2009:3171-3180) showed that the experience of crescendos in classical music by Puccini, Beethoven, and Verdi was significantly correlated with changes in heart rate, blood flow, and respiration.

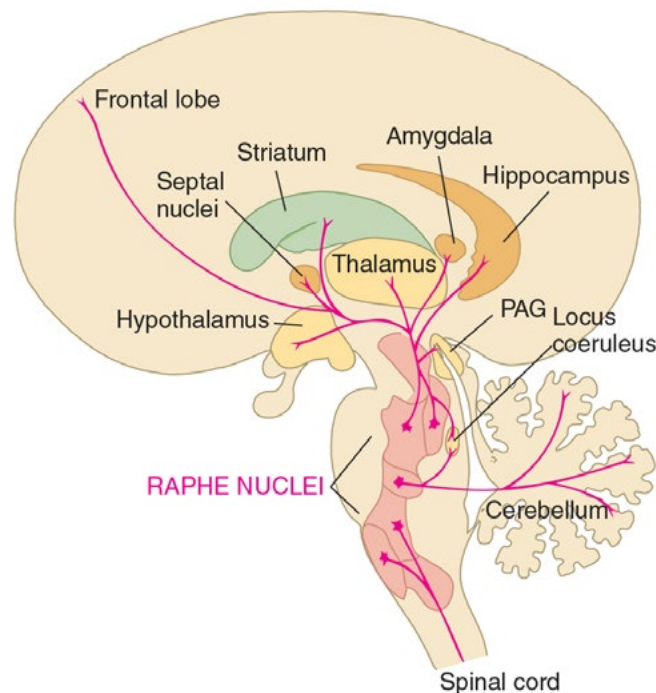


Figure 7.1 Serotonin and other neurotransmitters

Several raphe nuclei are located in the brain stem. They produce the neurotransmitter serotonin. The figure shows fibers that distribute serotonin to the frontal lobe, the striatum, the thalamus, the amygdala, the hippocampus, the cerebellum and the spinal cord.

The raphe nuclei also send fibers to the locus coeruleus, which produces norepinephrine, to the hypothalamus, which produces histamine, and the septal nuclei, which produce acetylcholine. Fibers from the raphe nuclei also project to the periaqueductal gray (PAG), which plays a role in regulation of pain and defensive behavior.

(Brodal 2010:377)

⁴ Cf. chapter six.

Neurotransmitters

As indicated in chapter six, neurotransmitters play an important role in the neural processing of music. Neurotransmitters are chemicals that are produced in specific subcortical nuclei, and distributed to large areas of the brain. Edelman & Tononi have described the distribution of neurotransmitters as diffusely projecting value systems, which are capable of signaling to neurons all over the brain (2000:88). Panksepp & Trevarthen (2009:120-121) propose as a working hypothesis that the general emotional effects of music may arise from fast changes in the neurotransmitter systems, assisted by the more subtle modulating influences of related chemicals, the neuropeptides.

The manufacture and functions of neurotransmitters have been investigated by Panksepp (1998a:98-111) and Pfaff (2006:26-54). Five distinct systems work together to regulate arousal. These systems distribute the neurotransmitters Norepinephrine, Serotonin, Dopamine, Acetylcholine, and Histamine.

Norepinephrine, Serotonin, and Dopamine are produced in nuclei of the brain stem.⁵

The Norepinephrine system supports sensory alertness, in particular attention to salient and unexpected sensory stimuli. It emphasizes projections to the posterior cerebral cortex.

Serotonin is involved in regulation of emotional behavior. It has various functions, including regulation of the balance between wakefulness and sleep. The serotonin system projects preferentially to the limbic cortex and hypothalamus. Panksepp specifies that serotonin reduces the impact of incoming information (1998a:107). Some antidepressant drugs⁶ raise the serotonin level in the brain by inhibiting the reuptake of serotonin in the neural synapses.

Dopamine influences motor control and mood. In studies of music, dopamine is known to induce pleasurable feelings by activating a "reward pathway". Pfaff indicates that dopamine seems to signal anticipation and prediction of a future rewarding event (2006:35-36).

Acetylcholine is produced in the basal nucleus and the septal nuclei of the basal forebrain. It mediates attention and arousal. Histamine is produced in nuclei of the posterior hypothalamus. It influences arousal and sleep.

In addition to the five specific arousal systems, Pfaff (2006:42-48) proposes the existence of a powerful general arousal system, based on "master cells" in the reticular formation of the brain stem. These cells use the neurotransmitter glutamate, which is the ubiquitous excitatory transmitter in the brain.

Pfaff sums up that the neuroscience of arousal investigates "change, uncertainty, unpredictability, and surprise" (2006:144). These are characteristic features of music, together with the opposites; stability, security, predictability, and fulfilled expectation.

Vitality and arousal

In his 2010 book *Forms of Vitality*, Daniel Stern integrates his theories of developmental psychology with Donald Pfaff's investigations of the arousal systems. In many publications, Stern has reported his observations of infants, pointing out that children possess sophisticated abilities for sensation and communication right from birth.⁷ In his latest book, Stern gathers previously presented terms such as "vitality affects" and "vitality contours" under the englobing term "dynamic forms of vitality" (p. 17). It is Stern's proposition that forms of vitality are fundamental for all human activity, including sensation, motion, emotion, feeling, communication, memory, and thinking. He describes the vitality forms as "the felt experience of force – in movement – with a temporal contour, and a sense of aliveness, of going somewhere. They do not belong to any particular content. They are more form than

5 Norepinephrine is produced in the *locus coeruleus*, Serotonin in the *raphe nuclei*. Dopamine is produced in two areas; the *substantia nigra pars compacta*, and the *ventral tegmental area*.

6 SSRIs: selective serotonin reuptake inhibitors.

7 Important previous publications by Daniel Stern are *The Interpersonal World of the Infant* (1985) and *The Present Moment in Psychotherapy and Everyday Life* (2004).

content. They concern the 'How', the manner, and the style, not the 'What' or the 'Why'" (p. 8).

Stern presents a list of words which elucidate dynamic forms of vitality, including "exploding, surging, accelerating / swelling, bursting, fading / drawn out, disappearing, fleeting / rushing, pulling, pushing / relaxing, languorous, floating / tense, gentle, halting", and explains that a vitality form is characterized by five dynamic features; movement, time, force, space, and intention/directionality (pp. 4-7).⁸ Vitality forms shape the features of musical expression, such as changes in movement, timing and tempo, intensity, accents and rhythm, flow and articulation, direction of melody, and tension of harmony.

Daniel Stern finds a possible neuroscientific basis for the vitality forms in Donald Pfaff's investigations of the five parallel arousal systems which distribute neurotransmitters to different parts of the brain or the whole brain (Pfaff 2006). Stern considers arousal the fundamental force for all bodily and mental activity. He suggests that the combinations of the systems which distribute Norepinephrine, Serotonin, Dopamine, Acetylcholine, and Histamine can give rise to a multiplicity of rapidly changing, highly complex and finely differentiated forms of vitality (pp. 58-63).

Stern states that the influences between the brain stem and the cortex are mutual. Neurotransmitters flow "up" from the arousal systems, and the cortex and emotion centers in the brain send regulating impulses "down" to the subcortical nuclei. However, it is his view that dynamic experiences of vitality can arise from the arousal systems in themselves (p. 71). He briefly discusses Antonio Damasio's ideas, and acknowledges that vitality dynamics are coextensive with Damasio's "background feelings". However, he points out a difference. Whereas background feelings refer to the overall feel of internal states and functions in the body, vitality dynamics mainly refer to the changes in active forces during an event in motion, and can be independent of emotion and sensation (pp. 44-46).

7.3. Phenomenology and neuroscience

Perception is embodied action

In their book *The Embodied Mind* (1991) Varela, Thompson and Rosch propose the view that perception and action cannot be separated. Perception is not a passive process, which leads to a kind of representation in the mind. Perception is active investigation of the environment in order to guide potential action of the body in the world (pp. 172-175). The authors find evidence in neuroscience that the pathways in the sensorimotor system are bidirectional, "perception and action, sensorium and motorium, are linked together as successively emergent and mutually selecting patterns" (p. 163). They find support in *The Structure of Behavior*, an early work by Merleau-Ponty, who states that,

"it is the organism itself - according to the proper nature of its receptors, the thresholds of its nerve centers and the movements of the organs - which chooses the stimuli in the physical world to which it will be sensitive" (Merleau-Ponty 1942/1963:13).

When we hear an unexpected sound, auditory perception guides the orientation of the head and the body towards detection of the possible sound source. This is a simple example of embodied auditory perception and action.

The investigations of current neuroscience demonstrate that the processing of auditory information is bidirectional. The ear sends auditory information to the cortex via the ascending pathway, and the cortex regulates the selective sensitivity of the ear via the descending auditory pathway.⁹

The philosopher Alva Noë elaborates on the theme of embodiment in his book *Action in Per-*

⁸ Stern's theory displays similarities with the dance theorist Rudolf Laban's movement analysis. Laban describes the dynamic categories of movement as weight, time, space, and flow (Halfyard 2003).

⁹ Cf. chapter 6.

ception, emphasizing that perception "is not a process in the brain, but a kind of skillful activity on the part of the animal as a whole" (2004:2).

Neurophenomenology – the beginnings

In continuation of his philosophy of embodiment as lived experience, Francisco Varela proposed a new direction in neuroscience. He aimed at integrating the investigations intended by phenomenology and the cognitive sciences, and named this approach Neurophenomenology (1996:330-349). Varela stated that in order to bridge the gap between the first-person description of phenomenology and the third-person description of cognitive science, it would be necessary "that both domains of phenomena have equal status in demanding a full attention and respect for their specificity" (p. 343). This implies that in a neuroscientific experiment, the researcher is obliged to integrate the test participants' first-person accounts of their experience in the validation of the experiment (p. 344).

Varela was aware that it might be a problem to convince scientists that first-person accounts represented a valid domain of investigation, and therefore proposed to gather a research community that could build a sustained tradition of phenomenological examination (p. 330, 346).

Varela passed away in 2001. He is the posthumous co-author of a paper that reports how first-person data can guide the study of brain dynamics (Lutz et al. 2002:1586-1591). In an EEG study of visual depth perception, the participants were trained to perform different perceptual tasks, and to report their experience afterwards (p. 1587). The study showed that EEG synchrony patterns depended on the task and the degree of preparation, and that the patterns were stable for several recordings. The authors found that the neural response was shaped by the preparation of the ongoing activity, as reported by the first-person data communicated by the participants (p. 1586). Similarly, Jack & Roepstorff (2002:333-339) argue that the systematic collection of introspective reports ought to be added in the protocols of brain imaging experiments.

Neurophenomenology – an unfinished project

Subsequently to the 1996 article on neurophenomenology, Francisco Varela and a group of authors published the book *Naturalizing Phenomenology* (1999). In this book, they launched the ambitious project of reconciling phenomenological philosophy with natural science. They defined naturalized phenomenology to be "integrated into an explanatory framework where every acceptable property is made continuous with the properties admitted by the natural sciences" (Petitot, Varela, Pachoud & Roy 1999:1-2).

The interest in this project at the beginning of the 21st Century gave rise to comprehensive research programs (Lutz & Thompson 2003). Thompson sums up that,

"the neurophenomenological approach is to obtain detailed first-person data through careful phenomenological investigation of experience and to use these original first-person data to uncover new third-person data about the physiological processes crucial for consciousness. One central aim of experimental neurophenomenology is thus to generate new data by incorporating careful phenomenological forms of investigation into the experimental protocols of neuroscientific research on consciousness" (2007:339).

However, only a limited number of neuroscientific experiments attempted the integration of first-person and third-person data. The EEG study by Lutz et al. (2002) appears to have produced convincing results. Gallagher and Zahavi (2008:162-166) discuss neuroscientific PET studies that investigated the neural correlates of intentional action (Farrer & Frith 2002; Farrer et al. 2003). These experiments did not lead to definitive conclusions.

The early attempts were not followed by related studies. Varela's project has not found widespread adoption (Allefeld 2008:18). Varela's wish of establishing a phenomenologically oriented research community has not been fulfilled.

In a recent publication, Zahavi (2010:14-15) discusses the possibility of establishing a naturalized phenomenology. He dissociates himself from the radical definition proposed by Petitot et al. in 1999, and suggests a more modest proposal, arguing that,

"a naturalized phenomenology is the kind of phenomenology that engages in a meaningful and productive exchange with empirical science. Phenomenology can question and elucidate basic theoretical assumptions made by empirical science, just as it might aid in the development of new experimental paradigms. Empirical science can present phenomenology with concrete findings that it cannot simply ignore, but must be able to accommodate; evidence that might force it to refine or revise its own analyses."

A reconciliation of phenomenology and neuroscience according to Zahavi's proposal may not be impossible. Yet, the integration of the first-person perspective of phenomenology and the third-person perspective of neuroscience remains a demanding task. It will require a considerable working effort from both parties, and an untiring willingness to reconsider established convictions and procedures in philosophy and science.

Chapter 8. Discussion

8.1. Summary and discussion of findings

Chapter 2. Music Phenomenology

The main result of chapter two is the proposal of a novel approach in phenomenology, the experimental listening procedure. This procedure is an application of Don Ihde's experimental phenomenology, which he has carried out in the domain of visual perception, combined with his philosophy of listening. The basis for experimental listening is the presupposition that it is possible to perform phenomenological variations by means of two different strategies, the focusing strategy and the hermeneutical strategy. It is suggested that experimental listening may be a tool for investigation of any kind of music. In particular, experimental listening may be useful for the investigation of musical expression, and the description and analysis of music that is not notated.

Further results in chapter two are the descriptions and discussions of Don Ihde's, Thomas Clifton's and Lawrence Ferrara's contributions to music phenomenology and their roots in phenomenological philosophy. Finally, a discussion of the applications of Ferrara's methods in music therapy research contributes to the clarification of strategies for phenomenological description and analysis in music therapy.

Chapter 3. The Neurosciences and Music

The main results of chapter three are the estimations of ecological validity and cultural orientation in the papers presented in the Neurosciences and Music Conferences 2002, 2005 and 2008. Based on systematic descriptions of approximately 200 research papers, it is concluded that a considerable number of studies do not imply high ecological validity due to the lack of acoustic sounds and real music as stimuli.

Furthermore, an overview of the presented research indicates that a number of musical genres and cultures are sparsely represented or not at all considered in the conference papers. Omitted genres are improvised music, art music of the 20th and 21st Centuries and percussion music. Sparsely represented are popular genres, music from non-western cultures and vocal music. Altogether, the orientation of research is biased towards Western major-minor tonal music.

These conclusions are topics for discussion. More than half of the papers date back to the 2002 and 2005 conferences, and their research approaches may to a certain degree be outdated and replaced by more ecologically valid and culturally unbiased protocols. Recent studies from 2011 and 2012 combine the use of real music with strict experimental control.

A further result in chapter three is the description of aims, methods and results of approximately 200 neuroscientific papers, and the highlighting of noteworthy studies. Finally, a comparison of the conference papers 2002-2008 with Danish doctoral dissertations in music therapy from the same period shows that the two fields of research only to a limited extent share concepts of music and musical practice. However, this is a preliminary estimation, as the material for the comparison is not comprehensive.

Chapter 4. The Musical Timespace

The important result of chapter four is the extract of a concise version from the original text of *The Musical Timespace*. All main steps of the original investigation are maintained, but weakly underpinned sections of text are omitted. This implies that the concise version represents a clearer and more tenable investigation of the musical space and the listening dimensions in music.

An important change is the omission of space from the model of listening dimensions. This omission is motivated by findings in hearing science, which indicate that the processing of spatial properties of sound in the auditory system is separated from the processing of spectrotemporal properties of sound.

The descriptions of musical examples do not meet the requirements of a proper phenomenological investigation, but represent a preliminary attempt at phenomenological description. However, the concept of a musical timespace is supported by reports of the experienced musical space in phenomenology.

Findings in hearing research support the basic presuppositions in *The Musical Timespace* that hearing is not designed for music listening, but for survival in the surrounding world, and that the identification and localization of sounds and the detection of movement are the essential functions of hearing.

The concise version of *The Musical Timespace* consists of excerpts, and does not represent a thoroughly reworked new edition of the original text. The definitions of the secondary listening dimensions melody and rhythm need further clarification and underpinning by musical examples, and the concept of musical memory needs updating from current research in neuroscience.

Chapter 5. Present Moments: A new GIM program

The result of the project described in chapter five is the design of a new program for Guided Imagery and Music Therapy based on art music from the 20th and 21st Centuries. A collaborative research process required comprehensive search of appropriate music by the author and careful selection by a skilled GIM therapist. The resulting program consisted of six selections of music. The therapeutical potential of this program was tested in non-clinical GIM sessions, and it was the conclusion of the tests that the program was well suited for clinical work with appropriate clients.

The prominent features of the music selections are in accordance with the criteria for music inclusion in GIM programs proposed by Helen Bonny, the founder of the GIM method. However, further research is needed to determine whether these criteria constitute universal criteria for inclusion of music in a GIM program.

Chapter 6. Subcortical and cortical processing of sound and music in the brain

This chapter does not present research by the author, but summarizes research that is considered important for the understanding of brain functions and the auditory system. The theories of Gerald Edelman and Antonio Damasio, founded on decades of research in neuroscience, facilitate the understanding of brain and consciousness.

Brief descriptions of the ascending and the descending auditory pathways, based on hearing research, indicate the different levels of sound processing in the auditory system. Finally, studies of extended brain networks implicated in music processing are highlighted. In particular, a recent neuroimaging study of the response to a complete piece of music represents an important novel approach in neuroscience.

Chapter 7. Embodiment

Similar to chapter six, this chapter summarizes research that is considered relevant for the present project. The investigation of embodiment is the focus of many fields of science, and implies the possibility of integrating diverse strategies of research.

Comparison of the investigation of bodily entrainment in neuroscience with the investigation of body movement in receptive music therapy is a field of particular interest. Another relevant theme is the relationship between the distribution of neurotransmitters in the brain and the forms of vitality proposed in developmental psychology. A third topic concerns the possible relationships between phenomenology and neuroscience.

In phenomenology as well as neuroscience, embodiment is a common field of investigation. At an early stage of the present project, it was expected that the first-person perspective of phenomenology and the third-person perspective of neuroscience could be integrated in a new research paradigm, entitled neurophenomenology. This expectation has not been fulfilled, as the first attempts at integrating first-person data in neuroscientific experiments were not continued. An integration may be

possible, but it will require a persistent effort of philosophers and scientists aimed at the revision of established research paradigms.

8.2. Limitations and suggestions for future research

It is an obvious limitation of the present study that it has not been possible to include a detailed report of the Neurosciences and Music Conference 2011 in Edinburgh. This inclusion is a relevant objective of forthcoming research.

It is another shortcoming that the concise version of *The Musical Timespace* does not represent a full-fledged revision of the original text. The concise version can be considered the first stage in a new process of research, which aims at integrating the methods of phenomenology and the findings of neuroscience in a new edition of the book.

Suggestions for future research include:

- The testing of experimental phenomenology as a tool for describing clinical music therapy improvisations and music employed in receptive music therapy.
- A comparison of investigations in phenomenology with Antonio Damasio's framework of hypotheses concerning consciousness and the self.
- Further neuroimaging studies based on complete pieces of music, and the inclusion of a variety of musical genres in neuroscientific research.
- The design of additional GIM programs based on contemporary art music, and an investigation of the prominent musical features in GIM programs that are not entirely based on classical music.
- Measurements of physiological variables in experimental GIM sessions, including skin conductance response, heart rate and breathing rate, combined with additional investigations of strong responses to music that evoke tears.
- Review of research on mirror neurons, and estimation of the relevance of mirror neuron theories for music therapy.

Summary

The present thesis includes parts of a previous publication, *The Musical Timespace* (1996), in accordance with the "senior's model" for PhD theses in Music Therapy Research at Aalborg University. *The Musical Timespace* presented an investigation of the listening dimensions in music. Soon after publication of the book, Lars Ole Bonde suggested that the listening dimensions might be useful for describing clinical improvisations in music therapy.

However, reviews of the book have pointed out certain limitations in its theoretical underpinning, in particular a lack of discussion related to cognitive science and music phenomenology. In order to remedy these limitations, the present thesis presents investigations of neuroscience and music phenomenology in relation to music therapy and the listening dimensions in music.

Chapter 2, Music Phenomenology: A Tool for Describing the Listening Experience presents the methods of the three main authors in music phenomenology, Don Ihde, Thomas Clifton and Lawrence Ferrara, and the application of their methods in music therapy research. Their approaches are different. Clifton is the enthusiastic investigator. He proposes pioneering ideas concerning the constitution and definition of music, but does not adhere to a strict phenomenological method. Ferrara is the pragmatic researcher. He proposes a seminal procedure for phenomenological description, but he later downgrades phenomenology in favor of score-based analysis. Ihde is the reflecting philosopher. He devises methodical procedures for the phenomenological investigation of sound, music and voices, but does not describe any piece of music.

Furthermore, this chapter documents and discusses the background of music phenomenology in the philosophy of Edmund Husserl, Martin Heidegger and Maurice Merleau-Ponty. Prominent themes are Husserl's philosophy of time-consciousness, Heidegger's investigations of interpretation and the human life-world, and Merleau-Ponty's view that the body's relationship to the world is the basis for consciousness. From the philosophies of Husserl, Heidegger and Merleau-Ponty, seven criteria for phenomenological investigation are distilled, aiming at the investigation of phenomena as they appear to consciousness, the way they appear to consciousness, and the conditions for appearance in consciousness.

Ferrara's systematic method for phenomenological description is applied by music therapy researchers. In their studies, they develop new versions of Ferrara's method, investigating client background, musical sound, musical structure, musical meaning, and pragmatic interpretation of music therapy sessions.

Forinash and Gonzalez (1989) conduct a pioneering study that demonstrates the application of a phenomenological approach in qualitative research. Kasayka (1991) investigates the relationships between music and the client's imagery in the Guided Imagery and Music Therapy method founded by Helen Bonny (BMGIM). In her study of pivotal moments in BMGIM, Grocke (1999) documents Helen Bonny's phenomenological approach to music listening, and develops a system for identifying and comparing Imagery Meaning Units and Music Meaning Units. Trondalen (2004) reconsiders previous procedures for phenomenological description of music therapy improvisations, and designs a procedure which emphasizes the elimination of the researcher's own biases. Bonde (2004) develops a method for designing intensity profiles of music, which permit the identification of emotional peaks and the estimation of the music's therapeutic potential in receptive music therapy.

Clifton's exploration of temporal and spatial structures in music has been the background for the present author's development of a procedure for intensive listening as a tool for opening, expanding and deepening the musical experience. A further development of this procedure is the proposal of a novel method of experimental listening, based on Ihde's investigation of experimental phenomenology.

Chapter 3, The Neurosciences and Music discusses the outcome of four international conferences which presented current neuroscientific research. The conference in Venice 2002 focused on the perceptual components of music and the import of musical training. The conference in Leipzig 2005 included studies of music and language, neurological disorders, music performance, and emotion in music. Prominent themes in the conference in Montreal 2008 were rhythms in the brain, music therapy and neuroscience, and musical memory. The conference in Edinburgh 2011 included studies of musical imagery, cultural neuroscience of music, and the role of music in stroke rehabilitation.

Reports of each conference indicate noteworthy papers, critical comments stated at the conference, and an evaluation of the achievements and research problems of the studies. A summary of research in the three conferences highlights noteworthy findings in neuroscience, including investigations of pitch perception and the auditory cortex, musical expression and strong emotional experiences of music, and mirror neuron systems.

A frequently occurring research problem in the conference papers is the low ecological validity due to the sparse use of acoustic tones and real music. Furthermore, a cultural bias is prevalent due to the preference for studies of western major-minor tonal music. Studies of improvisation, contemporary art music and percussion music are not considered in the conferences. Studies of voice, popular music and music from non-western cultures are sparsely represented.

In order to permit a comparison of music and music practice investigated in neuroscience and in music therapy research, a survey of music types reported in a number of Aalborg University (AAU) doctoral dissertations in music therapy 2002-2008 has been compiled.

Comparisons with research reported in the conferences 2002-2008 indicate the following. In music therapy, songs and vocalizations are widely used as an important means of communication and interaction. In the neuroscience papers, studies of the singing voice are scarce, and limited to studies of single sung words or syllables, or studies of infants.

In receptive music therapy, the client listens to selected music guided by the therapist. A music selection typically consists of entire pieces or movements of music, and the effect of the therapy is dependent upon exposure to music over a period of time. In the conference proceedings, studies of complete pieces of music are rare. Only two studies of strong emotions evoked by music are based on responses to whole pieces.

Musical improvisation is a core activity in music therapy. Musical improvisations are based on the spontaneous interplay between client and therapist, and can include vocal expression, playing on melodic and percussive instruments, gestures, body movement, and facial expressions. In neuroscience, the measurement methods typically require that the participant lies or sits still, and do not permit studies of active interplay and body movement. Thus, until robust portable measurement devices are developed, neuroscientific studies of music therapy improvisations are not probable.

On the basis of these comparisons, a number of future studies in the neurosciences and music are suggested, including studies of voice qualities and percussive sound, and studies based on complete pieces of music.

Chapter 4. The Musical Timespace includes 75 pages of text extracted from the 1996 edition of the book. These excerpts constitute a concise version of *The Musical Timespace*, which represents an investigation of the listening dimensions in music and the experience of musical space. It is a basic presupposition of the investigation that hearing is not designed for music listening, but for survival in the surrounding world. The essential functions of listening are the identification and localization of sound, and the detection of movement.

Material for the investigation is music that explores the natural continuum of sound, which is not divided into discrete steps. The natural continuum of sound is prominent in music of Xenakis, Ligeti, Lutoslawski and Ives. As a result of the investigation, it is proposed that the five basic listening dimensions in music are intensity, timbre, pitch, movement, and pulse. Four secondary listening

dimensions are melody, rhythm, harmony, and micromodulation. It is a further suggestion of the investigation that music listening integrates sensations of time and space in the experience of a virtual timespace.

Observations reported by music phenomenologists confirm the experience of a musical space. In addition, it can be concluded that it is possible to find support in neuroscience for the investigations of musical space and the basic listening dimensions in music.

Chapter 5. Present Moments describes a project in collaborative research. The author and a skilled Guided Imagery and Music therapist collaborated in a process of music selection that resulted in the design of a new program for GIM therapy. The program is based on music from the 20th and 21st Centuries by Bartok, Corigliano, Messiaen, Tavener, Pärt and Tormis. The therapeutical potential of this program was tested in non-clinical and clinical sessions, which confirmed that the program was well suited for clinical work with appropriate clients.

The aim of *Present Moments* is to offer the traveler an experience of centered presence and gentle bodily energy. A high degree of coherence facilitating introspection and slowly unfolding visual imagery enhances deep body imagery and kinaesthetic sensations.

Chapter 6. Subcortical and Cortical Processing of Sound and Music in the Brain summarizes research that is important for understanding the functions of the brain and the auditory system. Theories by Gerald Edelman and Antonio Damasio facilitate the understanding of brain and consciousness. Brief descriptions clarify the functions of the ascending auditory pathway, which sends information from the ear to the brain, and the descending auditory pathway, which sends information in the opposite direction, from the cortex of the brain to the cochlea in the ear. In each pathway, auditory information is processed on six levels.

Finally, this chapter reports studies of extended brain networks involved in the processing of music. A recent neuroimaging study by Alluri et al. is highlighted. The study presents pioneering research which opens new perspectives in neuroscience. It documents the brain's responses to a complete piece of music, a tango by Astor Piazzolla.

Chapter 7. Embodiment summarizes investigations of embodiment that are considered relevant for the present project. Of particular interest is the latest publication by Daniel Stern, *Forms of Vitality* (2010). In this book, Stern presents a definitive version of his concept of vitality in the body, and relates it to scientific research of neurotransmitters. Neurotransmitters are produced in the brain stem and distributed to large parts of the brain. Stern suggests that the interaction of five neurotransmitter systems constitutes the basis of the multivariable forms of vitality.

In phenomenology as well as neuroscience, embodiment is a common field of investigation. In the 1990's, Francisco Varela proposed a new research paradigm, aimed at the integration of phenomenology and neuroscience in *neuropsychophenomenology*. Ambitious research programs were prepared, but only a few experiments were carried out. Varela died in 2001, and neuropsychophenomenology remains an unfinished project.

Chapter 8. Discussion points out three main results of the present project. One result is the development of experimental listening, which is a phenomenological procedure that permits detailed investigation of musical expression and music which is not notated. Another result is the design and clinical testing of a new program for Guided Imagery and Music Therapy, *Present Moments*. A third result is a concise version of *The Musical Timespace*, which the author published in 1996. The new version is shorter, clearer and more tenable than the original text. Still, this version calls for further elaboration.

It is a limitation of the present project that it was not possible to include a detailed report of the proceedings of the latest conference on The Neurosciences and Music.

Dansk resumé

Denne afhandling inkluderer dele af en tidligere publikation, *The Musical Timespace* (1996), i overensstemmelse med "seniormodellen" for PhD-afhandlinger i musikterapiforskning ved Aalborg Universitet. *The Musical Timespace* præsenterede en undersøgelse af lyttedimensioner i musik. Kort efter bogens udgivelse foreslog Lars Ole Bonde, at lyttedimensionerne kunne være relevante for beskrivelse af kliniske improvisationer inden for musikterapi.

Anmeldelser af bogen påpegede visse begrænsninger i dens teoretiske grundlag, især at der manglede diskussioner i relation til kognitiv videnskab og musikfænomenologi. For at udbedre disse mangler præsenterer denne afhandling undersøgelser af hjerneforskning og musikfænomenologi i relation til musikterapi og musikkens lyttedimensioner.

Kapitel 2, Musikfænomenologi: Et redskab til at beskrive lytteoplevelsen præsenterer de metoder, som tre væsentlige forfattere inden for musikfænomenologi har udviklet. De tre forfattere er Don Ihde, Thomas Clifton og Lawrence Ferrara. Deres fremgangsmåder er forskellige. Clifton er den entusiastiske udforsker. Han fremsætter nye ideer om musikkens oprindelse og nye definitioner af musik, men han udvikler ikke en konsekvent fænomenologisk metode. Ferrara er den pragmatiske forsker. Han udformer en grundlæggende procedure for fænomenologisk beskrivelse, men senere nedjusterer han vigtigheden af fænomenologi til fordel for partituranalyse. Ihde er den reflekterende filosof. Han udtænker metodiske procedurer til fænomenologisk undersøgelse af lyd og stemmer, men han beskriver ikke musik.

Dette kapitel dokumenterer og beskriver baggrunden for musikfænomenologi i den fænomenologiske filosofi. Vigtige emner er Husserls tidsbevidsthed, Heideggers undersøgelser af fortolkning og livsverden, og Merleau-Pontys synspunkt, at kroppens relation til verden er basis for bevidstheden. På grundlag af Husserls, Heideggers og Merleau-Pontys filosofi formuleres syv kriterier for fænomenologisk undersøgelse. Disse kriterier sigter på undersøgelse af fænomener som de viser sig for bevidstheden, den måde de viser sig i bevidstheden, og betingelserne for fremtrædelse i bevidstheden.

Ferraras systematiske metode til fænomenologisk beskrivelse bringes i anvendelse af musikterapiforskere. De udvikler nye versioner af Ferraras metode for at beskrive musikkens lyd og struktur, musikalsk betydning, klientens baggrund og den pragmatiske fortolkning af musikterapisessioner.

Forinash & Gonzalez (1989) anvender fænomenologisk metode til beskrivelse af en musikterapisession og fremlægger den i en banebrydende artikel. Kasayka (1991) undersøger forbindelserne mellem musik og billeddannelse i GIM terapi. I sin afhandling om afgørende øjeblikke i GIM terapi dokumenterer Grocke (1999) Helen Bonnys fænomenologiske tilgang til musiklytning, og udvikler et system til sammenligning af betydningsenheder i musik og i billeddannelse. Trondalen (2004) gennemgår kritisk tidligere procedurer for fænomenologisk beskrivelse, og udvikler sin egen metode, som lægger vægt på at eliminere terapeutens forudfattede meninger og holdninger. Bonde (2004) udvikler en metode til at tegne intensitetsprofiler af musik, som kan bruges til at identificere emotionelle højdepunkter og vurdere musikkens terapeutiske potentiale.

Cliftons udforskning af tidslige og rumlige strukturer i musik er baggrund for nærværende forfatters udvikling af en procedure for intensiv lytning som et værktøj til at åbne, udvide og fordybe den musikalske oplevelse. Denne procedure videreudvikles til en eksperimentel lyttemetode, baseret på Don Ihdes metodiske udforskning af eksperimentel fænomenologi.

Kapitel 3, Hjerneforskning og musik diskuterer resultaterne af fire internationale konferencer om hjerneforskning og musik. Konferencen i Venedig i 2002 fokuserede på musikperceptionens elementer og betydningen af musikuddannelse. Konferencen i Leipzig i 2005 omfattede studier af musik og

sprog, neurologiske lidelser, opførelse af musik og følelser i musik. Vigtige emner i konferencen i Montreal 2008 var rytmer i hjernen, musikterapi og musikalsk hukommelse. Konferencen i Edinburgh 2011 præsenterede forskning i auditiv genkaldelse af musik, kulturelt orienteret hjerneforskning og musikkens rolle i genoptræning efter hjerneskade.

Rapporter om hver enkelt konference fremhæver vigtige undersøgelser, påpeger kritiske kommentarer der blev fremsat ved konferencen, og vurderer forskningsresultater og forskningsproblemer. En opsummering fremhæver bemærkelsesværdig ny forskning, blandt andet undersøgelser af tonehøjdeperception og den auditive cortex, musikalsk udtryk og stærke følelsesoplevelser, og betydningen af spejlneuronsystemer.

Et forskningsproblem der ofte dukkede op i konferencepræsentationerne, var spørgsmålet om økologisk validitet, det vil sige betydningen af forskningens resultater i det virkelige liv uden for laboratoriet. Den økologiske validitet var ofte lav, fordi der blev brugt sinustoner og syntetiske toner i forsøgene i stedet for akustiske toner og rigtig musik. Desuden var der en overvægt af dur-moll tonal musik i forsøgene. Studier af improvisation, ny musik og slagtøjsmusik var helt fraværende, og der var kun få studier af vokalmusik, populærmusik og musik fra ikke-vestlige kulturer.

En oversigt over musiktyper i PhD-afhandlinger i musikterapi 2002-2008 fra AAU er grundlag for at sammenligne musik og musikalsk praksis i hjerneforskning og musikterapiforskning. En sammenligning med hjerneforskning fra konferencerne 2002-2008 viser følgende:

I musikterapi bruges sang og stemme i vidt omfang som middel til kommunikation og interaktion. I hjerneforskningen er der kun få studier af sangstemmen, og de er begrænset til studier af enkelte toner eller studier af børnestemmer.

I receptiv musikterapi lytter klienten til udvalgt musik guidet af en terapeut. Musikudvalget består typisk af hele musikstykker eller satser, og virkningen af terapien afhænger af musiklytning over en vis tid. I hjerneforskningen indgår hele musikstykker kun sjældent. Kun to studier af stærke musikoplevelser er baseret på hele stykker.

I musikterapi er improvisation en kerneaktivitet. Musikalske improvisationer er baseret på spontant samspil mellem klient og terapeut, og kan omfatte stemmeudfoldelse, spil på melodi- og slagtøj-sinstrumenter, gestus, kropsbevægelse og ansigtsudtryk. I hjerneforskning kræver målemetoderne at forsøgspersonen sidder eller ligger stille, så studier af aktivt samspil og kropsbevægelse er udelukket. Det vil sige at neurovidenskabelige studier af improvisationer ikke kan lade sig gøre.

Kapitel 4. The Musical Timespace inkluderer 75 sider af bogen fra 1996. Disse uddrag præsenterer en kort sammenfatning af bogen, som indeholder redegørelsen for de musikalske lyttedimensioner og oplevelsen af musikkens rum. Det er bogens udgangspunkt at hørelsen ikke er skabt til musiklytning, men til overlevelse i den omgivende verden. Lytningens grundlæggende funktioner er identifikation og lokalisering af lyd, og registrering af bevægelse.

Materiale til undersøgelse af lyttedimensionerne er musik der bygger på det naturlige lyd-kontinuum, som ikke er inddelt i skalatrin. Det naturlige lydkontinuum udnyttes i kompositioner af Xenakis, Ligeti, Lutoslawski og Ives. Det er undersøgelsens resultat, at de fem basale lyttedimensioner i musik er intensitet, klangfarve, tonehøjde, bevægelse og puls. De fire sekundære lyttedimensioner er melodi, rytme, harmoni og mikromodulation. Undersøgelsen viser også, at musiklytning integrerer oplevelsen af tid og rum i et virtuelt tids-rum, et *timespace*.

Musikfænomenologers observationer bekræfter oplevelsen af et musikalsk rum. Udforskning af hørelsens funktioner bekræfter også den rumlige lytning og de basale lyttedimensioner.

Kapitel 5, Present Moments beskriver et fælles forskningsprojekt. Forfatteren og en erfaren GIM-terapeut samarbejdede om at designe et nyt program til GIM-terapi. Programmet er baseret på nutidig musik af Bartok, Corigliano, Messiaen, Tavener, Pärt og Tormis. Programmets terapeutiske potentiale blev testet i ikke-kliniske og kliniske sessioner, som viste at programmet var velegnet til klinisk terapeutisk arbejde med et passende udvalg af patienter. Målet med *Present Moments* er at tilbyde

en oplevelse af centreret nærvær og blid kropsenergi. Musikkens gennemgående sammenhæng fremmer introspektion, rolig billeddannelse og dyb oplevelse af krop og bevægelse.

Kapitel 6. Subcortikal og cortical bearbejdning af lyd og musik i hjernen opsummerer forskning der er vigtig for forståelsen af hjernens og de auditive systemers funktioner. Gerald Edelmans og Antonio Damasio's teorier underbygger forståelsen af hjerne og bevidsthed. Korte beskrivelser klarlægger de auditive nerveforbindelser, som både går fra øret op til hjernen og den anden vej fra den auditive cortex til sneglen i det indre øre. I disse forbindelser bearbejdes lyden på seks niveauer.

Til slut rapporterer dette kapitel studier af de omfattende netværk i hjernen, som aktiveres af musik. Et helt nyt eksperiment er værd at fremhæve. Det er et studie af de hjerneaktiviteter der fremkaldes ved lytning af et helt stykke musik, en tango af Piazzolla.

Kapitel 7. Embodiment opsummerer forskning i kropsoplevelse. Af særlig interesse er Daniel Sterns nyeste bog, *Forms of Vitality* fra 2010. Her præsenterer Stern en endegyldig version af sin teori om oplevelsen af vitalitetsfølelser, vitalitetskonturer og vitalitetsformer i kroppen, og han sætter sin teori i forbindelse med forskning i neurotransmittere. Neurotransmittere produceres i hjernestammen og sendes ud til store dele af hjernen. Det er Sterns opfattelse, at interaktionen mellem fem neurotransmittersystemer udgør grundlaget for utallige variationer af vitalitetsformer.

Både fænomenologi og hjerneforskning udforsker kropsoplevelsen, *embodiment*. I 1990'erne udarbejdede Francisco Varela et forskningsparadigme, der skulle forene fænomenologi og hjerneforskning i *neurophenomenology*. Ambitiøse forskningsprogrammer blev fremlagt, men der blev kun udført få eksperimenter. Varela døde i 2001, og *neurofænomenologi* er stadig et uafsluttet projekt.

Kapitel 8. Diskussion fremhæver tre resultater af denne afhandling. Et resultat er udviklingen af en eksperimentel fænomenologisk lyttemetode. Et andet resultat er det nye GIM-program *Present Moments*. Det tredje resultat er den korte version af *The Musical Timespace*, som er klarere og mere velunderbygget end den oprindelige tekst. Dog er der stadig behov for mere grundig udforskning af lyttedimensionerne.

Endelig må det påpeges, at det er en mangel ved afhandlingen, at den seneste konference *The Neurosciences and Music IV 2011* ikke indgår i fuldt omfang i undersøgelserne.

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Erik Christensen: *An Introduction to Intensive Listening*.
Working papers, The University of Sheffield, February 2007.

Intensive listening: A tool for opening, expanding and deepening musical experience

Advice for individual listening

1. Forget about your musical likes and dislikes (John Cage says). Don't be scared or annoyed by noisy or unfamiliar music. Accept extreme simplicity and high complexity, chaos and order, coherence and incoherence. If you are bored by the music, listen a few more times and see what happens.
2. Keep alternating between receptive (effortless, "passive") listening¹ and deliberate, active observation and description. Always begin with receptive listening, and listen twice before you begin to describe the music.
3. Listen many times (no less than seven, no upper limit). Divide the music into large chunks before you go down to details. In the end, you will be able to "replay" the music from memory in your mind and to sing parts of it and mimic it with physical gestures. But the process may take time (sometimes weeks, if the music is really unfamiliar).
4. Use paper and pencil and the marked time of the CD as an aid for your memory. Describe the music in words, drawings and diagrams. You may add transcription. Change your deliberate focus of observation (see next page). Use the CD player's search function to go back and forth and re-listen to both large parts and details.

¹ "Receptive listening" is equal to "Open listening" in Lawrence Ferrara's terminology (Ferrara 1984)

**Intensive listening - What to listen for in music (some suggestions).
Attention can be focused on:**

states, events, movements, changes
attacks, gestures, figures, lines, shapes, contours
sheets, layers, surfaces, patterns, textures

dense / transparent
distinct/ diffuse
appearing / disappearing
growing /diminishing
rising / falling
approaching / receding

foreground / middleground / background; distance
fusion / segregation of sounds
goal-directed / undirected motion; turning, waving, rotating, undulating

sensuous qualities, differences	
bright / dark	near / distant
soft / sharp	clear / distorted
high / low	rigid / flexible

intensity, timbre, space
pitch height registers; the entire pitch range from the highest to the lowest audible pitches
melody, rhythm, harmony, micromodulation (vibrato, tremolo, flutter)
gliding or stepwise motion, modes, scales, tone bending; noise / sound / tone
real space / virtual space; resonance, room acoustics

tempo, tempo changes, time layers
time of being, time of movement, pulse time; relations, tension, balance, swing
synchronization /non-synchronization
space / pulse relation

noise, sound, tone
materials, sizes and forms of sound sources; wood, metal, skin, glass ...
voice, words, instruments
mood, expression, emotions

continuity, evolution, process / interruptions, cuts, breaks, silence
expectation / surprise
simplicity / complexity
regularity / irregularity
order / chaos

Intensive Listening – a practical guideline for listening in a group

Intensive listening is repeated listening deploying varied focusing.
The purpose of intensive listening is:

- To get the listeners to accept unknown and unfamiliar music as well as familiar music.
- To sharpen and educate their attention, so that they will gradually hear more and more in the music – layers, nuances, aspects, parts and unified wholes, foreground and background...
- To make them describe the musical experience in their own words. All kinds of words and descriptions are valid – not merely the musicological terminology. Descriptions of moods, events, images, emotions, stories and dramatic actions are also relevant.

For intensive listening in a group, it is preferable to select short musical quotations (1-3 minutes) so that all the music can be retained in memory. Divide slightly longer pieces (3-5 minutes) into sections to be listened and described separately. Dealing with long pieces or movements, select a well-defined section for intensive listening. This will facilitate subsequent listening of the whole piece.

It may be profitable to compare two pieces. Comparison encourages inventive verbalization.

Ensure the best possible sound quality, so that the music stands forward in its full richness. The sound of MP3-files and other reduction systems does not comprehend the depth, details and nuances of the music.

As a tutor, prepare the listening session by listening many times yourself, if possible with a colleague. And practice the handling of the amplifier and CD player in the classroom, so that you can play precise quotations without errors. Fumbling with the equipment will spoil the listeners' concentration.

A basic model for the practical progression of intensive listening in a class
(to be modified as required)

1. Listen
2. Listen once more
Talk together in pairs, describe what you have heard.
3. Listen a third time, listening for something your dialogue partner has told you.
Talk together again.
Short general discussion: The tutor asks all groups, collecting their impressions and descriptions on the whiteboard or a flip chart (it is a good idea to keep the results on paper for later use)
4. *The tutor asks one clear and simple question*
Listen and talk together in pairs. Short general discussion.

5. The tutor asks another clear and simple question

Listen and talk together in pairs. Short general discussion.

6. The tutor asks a third question

Listen (dialogue may not be necessary at this stage). Short general discussion.

7. The listeners talk together in pairs and formulate questions for the next listening.

Collection of all questions.

8...

It is important to listen twice before you begin talking about the music. After the second listening, the listeners are qualified, because they can remember the music, and because personal preferences and prejudices are less dominant after a second listening.

It is important to talk together in pairs about the music. In dialogue, everybody is able to find words for his or her musical experience, and nobody needs to be afraid of speaking up.

It is of great value to listen a third time, listening for something your dialogue partner has heard. This enhances attention, stimulates curiosity and deepens the musical experience.

After listening three times, everybody is able to contribute to the description of the music. The tutor asks every single two-person group. A multiplicity of descriptions may come out; expressions, emotions, moods, events, images, dramatic courses of events, and many kinds of musicological description.

Now the path is clear for the enhancement of consciousness and the deepening and refining of the descriptions. Here it is the tutor's task to present a simple and clear question to focus the next listening. And, when listening again in order to answer the question, the listeners will often hear something else and more, which will be profitable for further listening.

It is continually important that the listeners talk together in pairs before the collection of descriptions and impressions. It is the dialogue that evokes the description. Proceeding to another piece of music, it may be a good idea to change dialogue partners. This creates variation of the descriptions and furthers mutual confidence in the group.

Later in the progression, when everybody knows the music well, the tutor may skip the dialogue and ask for response from the whole group. Comprehensive and detailed descriptions may be assigned as homework.

Allow for ample time for listening and talking.

Experimental listening 16 Aug 2011. EC's preparation
Bartok: Orchestral piece "An Evening in the Village" / "Ein Abend auf dem Lande"
/ "An Evening with the Szekely", Hungarian Sketches Sz 97 no. 1.
Chicago Symphony Orchestra cond. Pierre Boulez. CD: DG 445 825-2

Abbreviations: **open:** open listening
 foc: music-focused listening
 herm: hermeneutical listening

EC's preliminary observations and reactions, new questions, new tasks, and problems:

1st and 2nd listening: Open listenings **open**

The tones are "brushed into existence"
Two kinds of music, one fluent, the other one with marked rhythm
A salient pause, music continues immediately afterwards
The last tone is like a trail of light
Soft happiness

3rd listening: Question: Foreground and background? **foc**

A static background is floating like surfaces of light in the sky by sunset
One tone continues from section to section, creates presence
Different backgrounds in different sections
In slow sections: first very soft, then more clear and present, last time voluminous

New tasks: Listen for transparence. Listen for form. Concentrate on the slow sections

4th listening: Question: Form? **foc**

A1 0'00 song
B1 0'39 dance
A2 1'01 song
B2 1'35 dance
A3 1'59 song, finished 2'47

New task: Listen for vibrato and tone quality

5th listening: Question: Background in the slow sections?	foc
A1: Falling surfaces, luminous in the beginning. Repetition of the two first surfaces, harmonic change the second time. Surfaces unite with foreground in the last chord.	
A2: Background: In the beginning one sustained tone, continues downwards	
New question: What do you hear, pitch or harmony?	
A3: Not foreground and background, but statement and response. Heaviness both in melody and accompaniment. A touch of birdsong.	
New question: How many layers?	
New task: Listen for background in the dancing sections	
6th listening: Open listening	open
Sustained tones create continuity, especially from A1 to B1 Increasing tranquillity and fullness, calming effect	
7th listening: Open listening	open
I experience the layers visually	
New tasks: Listen for the vibrato, especially in flutes. Listen for the "shaking" movement in B2	
8th listening: Open listening	open
Only two layers in A1. Three or more layers in the dancing sections B1 and B2. Luminous quality in A2. Multi-layered last chord in A3.	
New questions: When does a harmony merge completely, when do you hear separate tones? What do you retain in your memory by now?	
9th listening: Question: Background in B1 and B2?	foc
B1: three layers: jumping melody, sustained bands of tones, precise pizzicato rhythm in strings	
B2: lively melody in piccolo flutes, animating bass, subdued background in the beginning, then intensified trills on offbeats. An extra voice added in the final chord	
New tasks and questions: Describe the melodic lines. What characterizes the quality of a pizzicato? Listen for small tempo variations, rubato. What harmony in the final chord?	

10th listening: Open listening – lying down

open

This was a different experience. I had a feeling of floating, being carried by the music

B2 is "unfinished", one tone is missing

New task: Describe the refined variation in orchestration

11th listening: Task: Describe the qualities of the clear tones

foc

A1: Wonderful wind instrument. The tone appears out of nothingness and disappears in nothingness. Also rich tones, touchable

B1: Saturated flute sound. Animated vibrato on long tones

A2: Luminous presence of an oboe. Every tone has a distinct dynamic shape

New tasks and questions: Describe the attack and the trailing-off of tones.

Silences in foreground and background?

B2: Lively piccolo flute, almost without vibrato. Shrill in high register.

A3: Unison expanded in several octaves. Sensuous flute vibrato in deep and middle register

12th listening: Question: How do tones and phrases end?

foc

A1 solo: Phrase 1 and 2 end with a subdued breathing, Phrase 3 no breathing, Phrase 4 no ending – the tone continues

New question: Does the tone continue in the same or in another instrument?

B1 The tone continues, like in A1

A2: It seems that he does not breathe between phrases.. Short pause after the last phrase

B2: Long pause after the last phrase

A3: The end of melody phrases cannot be discerned because of the continuous accompaniment

The very last phrase: The sound disappears imperceptibly

13th and 14 listening: Open listenings – lying down

open

The music appears to be slower. The end: Large, calm waves

New task: Describe the total space of sound

15th listening: All five Hungarian sketches, Open listening

open

The first piece is far better than the following four pieces. It is well-balanced, and the instrumentation is exquisite.

Experimental listening 17 Aug 2011. LCB and EC
Bartok: Orchestral piece "An Evening in the Village" / "Ein Abend auf dem Lande"
/ "An Evening with the Szekely", Hungarian Sketches Sz 97 no. 1.
Chicago Symphony Orchestra cond. Pierre Boulez. CD: DG 445 825-2

EC: Short introduction to Don Ihde's *Listening and Voice* (1976) and *Experimental Phenomenology* (1977), Ihde's listening strategies, and his model of fields of investigation:

The musical object "noema"	-	The way of listening "noesis"	-	The listener "I"	-	The intersubjective interchange "You"
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The survey of listenings reports observations and comments by LCB, if not otherwise indicated.

1st and 2nd listening: Open listening **open**
Information: "This is an orchestral piece by Bartok"

The first tone enters me directly, a very fine tone, it is like a spearhead, a unicorn's horn, it does not snarl. The intro hit something in me. "I miss playing".

The following section is happy music, halfway Chinese. Begins in major, ends in minor.

The first melody returns, main characters oboe and flute. The impression is not as strong this time.

The funny Chinese music comes again.

At the end a final chord which is not a final chord. It is fun to listen, and peculiar that Bartok is so tonal.

3rd-4th-5th listenings are hermeneutical strategies. A title evokes a context (Ihde 1977:88)
Three listenings according to three different titles indicated in the score.

3rd listening: Hermeneutic listening **herm**
Information: The title is "An Evening in the Countryside"

Associations to Carl Nielsen, the Danish countryside of Funen. Fields, gravel road, dusk, ground mist. Standstill. Then birds fly off, parting.

The melody returns in oboe. Memories of Prokofiev's Peter and the Wolf, the duck, water, Hans Christian Andersen, a village pond. Carl Nielsen's My Childhood in Funen.

A happy section, associations to the Disney cartoon Mulan. Action, apple blossoms.

Final section, "grand music". I stick to the Orient, China, Japan. Nothing happens.

4th listening: Hermeneutic listening

herm

Information: The title is "An Evening in the Village"

Associations: Images from a Murakami Novel "Kafka on the Beach".

A village below a slope. Small cottages, it is possible to look inside. Green vegetation around. No people.

Next section: Children come out to play. A child falls and hurts itself.

Next section: A strong person comes out to comfort the child. Women in long gowns.

Next section: Suddenly the lights are turned on, a circus roars into the village. Stops in pause.

Last section: Crucially new. A different century. Like a black-and-white movie. Peeking out through the bars of a prison cell. Raw concrete, rainy.

LCB New question: How is the chord material?

5th listening: Hermeneutic listening

herm

Information: The title is "An Evening with the Szekelys". The Szekelys are Hungarians who live in exile in Roumania

Total theatre, like an operetta. The Szekely people are in exile, they are homesick. One writes a letter, another looks into the flame of a candle.

Then a letter from the homeland arrives!

The oboe is the narrator's voice, reads aloud.

Activity: We want to go home! The section ends with a break: the final phrase omits the last tone, then a pause.

Last section: In the midst of euphoria: Thoughtfulness. Dare we go? We have to say farewell ... They decide to go. The great patriarch wishes good luck in the journey. Sadness of leaving.

6th through 10th listenings adopt perceptual focusing strategies (Ihde 1977:89). Task of 6th listening: Listen for "auditory spatiality" (Ihde 1976:61) by focusing on the background of the music. 7th through 10th listenings aim at clarifying the musical form (ABABA), so that it is evident what parts of the music we are describing.

6th listening: Question: What do you hear in the accompaniment?

foc

It is cool suddenly to concentrate on something else!

First section: Delicate strings, two chords. Subsequently contrary motion and a skip down

Second section: Major. Different rhythm, rocking, "dung dung"

Third section: New variant of the first section. Counter-melody against the solo voice. Four chords in each A section.

Fourth section: Happy section, fluttering

Last section: Full orchestra. Preparing the last chord sequence

EC: We agree that the form of the piece is A B A B A

7th listening: Question: What is the difference between the three A sections?
Instruction: Ignore the B sections

foc

A1: The most lovable. The deepest secret. The oboe continues the whole way into the next section, remains as a thread.

A2: Another instrument, the strong narrator's voice. The accompaniment enters at a different time, displaced.

A3: New orchestration. Begins with a full orchestra. Chords push in. Is there also a crescendo? Melody doubled in octaves at the beginning, many winds together. They do not play completely in tune, there is a slight interference, a more unattractive sound quality. In the first A section the very first tone made a strong impression, here it is completely different.

8th-9th-10th listening: Question: What is the difference between the two B sections?
Instruction: Ignore the A sections

foc

B1: New voice between melody and bass. Something happens to the syncopation. A tightrope walker appears in the midst of everything. Measured bass, first a second interval, then a pedal point and third interval.

B2: More shrill piccolo flutes. Measured basses all in a row, now in double tempo.

EC: I now hear the pronounced trills in winds on offbeats interconnected with the measured basses. Until now, I heard them fluttering independently.

11th listening: Open listening

open

Leads to a talk about personal experiences, associations and memories

12th-13th-14th listenings adopt a "narrow temporal focus" (Ihde 1976:90), that is, focusing first on the quality of the single tone, then on the beginning of the tone (the attack), finally focusing on the ending of the tone (trailing off).

12th listening: Question: What are the differences between the sonorous qualities of the single tones?

foc

Clarinet: Grows out of nothingness. No vibrato. Disappears again. Only some of the tones reveal that it is a clarinet.

Flutes: We hear hissing and breathing. Wings flutter around the tone. Lots of vibrato at varying speed.

Oboe: Clear, dense, vividly present

Full orchestra: Interference, not completely in tune. One hears the vibrations of the flute, but not its tone quality.

EC New questions: What is the relationship between an instrument's tone and noise?
How can we characterize the compound sounds?

13th listening: How do the single tones begin?

foc

Clarinet and oboe: Attack without vibrato. Flute: Attack with air

Final chord: Incredibly precise, no vibrato

EC New question: How is the inner life and dynamics between the beginning and end of a tone?

14th listening: How do the single tones end and disappear?

foc

LCB: One sees the music from the other side, from the back door **

Oboe grows out of the flute. A2 and A3: Strings overlap the final tones of the winds

EC: A1: An overwhelming new experience to hear the emptiness every time the strings in the background disappear **

** indicates a significant change in the way of listening, similar to the change between states of multistability in visual phenomena, described in Ihde (1977) *Experimental Phenomenology*.

Experimental listening 24 Aug 2011. LCB and EC (Bartok continued)

Observations and comments by LCB, if not otherwise indicated

15th listening: Open listening

open

LCB: The very first tone pushes me back in the chair, and lowers my personal tempo immediately. And I know the music very well, I expect the merry sections.

The piccolo in B2 is very good, his playing is "laid back", he does not rush the tempo, does not stumble.

I feel my attention as a pressure around the eyes, as if I am observing from the back side of my eyeballs

EC's afterthought: sensory integration; listening activates not only auditory attention, but also the skin and muscles around the eyes.

"We feel ourselves seeing with the eyes" (Damasio 2010: 91,196)

16th listening: Open listening, lying down

open

LCB: It is dangerous to lie down, I don't concentrate on the music, I come to think of other things, the weather, a choir rehearsal yesterday, a Disney movie...

I come to think of the sound, I am curious to see the notation in the printed score.

The direction of the sound is different, flowing over my body.

And I feel the basses physically as vibrations in the floor

17th listening: Instruction: Listen for transparency and density

foc/herm

I feel there is a membrane between me and the music, thicker than the surface of a soap bubble.

A1: I am looking through the surface, then comes the first tone

B1: The music is whirling, like a surface of pixels partly filled in

A2: The sound of the oboe is like fire, quiet flames which penetrate and enliven the membrane

B2: The membrane dissolves and disappears completely

A3: The melody is like columns in an open scene. The accompaniment plays in the orchestra pit

EC's afterthought: LCB understood the instruction as hermeneutical, setting a scene behind a transparent surface. The alternative possibility is to adopt a wide focus, listening for the texture of the music in order to observe varying degrees of transparency or density.

18th listening: Question: How are the surfaces of the accompaniment displaced in relation to the melody? (Compare 7th listening, observation of displaced surfaces) **foc**

A1: soloist and accompaniment are equal, standing still close to each other in a flat vertical plane. The chords are placed vertically under the melody, like big playing cards.

B1: larger distance. The soloist is above, the accompaniment is below, and there are unruly points in between.

A2: The oboe is more on the forefront, but still close to the accompaniment. The accompanying surfaces enter at displaced temporal positions. Solo and accompaniment build up a crescendo together.

B2: Large distance between flutes above and basses below. They move on the same axis. Variegated contrasting colors.

A3: melody and accompaniment both grow to large proportions. The accompanying surfaces shove themselves into the solo.

EC's afterthought 1: In A1, LCB first understood the question as asking for displaced spatial relations. Later she chose the alternative possibility, listening for displaced temporal relations between melody and accompaniment in A2.

EC's Afterthought 2: It is possible to visualize the virtual space of the music either as 3-dimensional depth or as a 2-dimensional plane. This can be changed at will ****

19th listening: Question: In the composite sounds, do you hear fusion or segregation? **foc**

Many composite sounds have a common attack, then the sound begins its dynamic life. One instrument may display a certain kind of energy, such as a vibrato.

A1: Sounds of strings in the background, suddenly it is possible to hear individual threads or movements that distinguish themselves.

20th listening: Same question, primarily focusing on the final chords of each section **foc**

Final chord of A2: no vibrato. In the harmony, fifth and seventh are salient. The oboe soloist remains a few milliseconds after the end of the composite sound. LCB's remark: Fortunately, this is not a sampled sound.

B2: A new dimension is added, the gentle sound of woodwinds, which seems to shed sunshine in the soundscape.

Final chord of A3: The woodwinds seem to suck the power out of the strings. Their volume disappears, like magic. It would be possible to keep on observing the the strings – but in that case one would tend to forget about the woodwinds **. A diminuendo is common to all instruments.

21th listening: Open listening of B2

open

Awareness of the voluminous sounds. The rhythmic accompaniment backs up the soloist, filling in the musical picture in a complementary way.

The accompanying pizzicati change direction: up-down, down-up

EC: New question: How many instruments participate in the accompaniment?

22nd listening: Question: What is the special quality of the pizzicato sounds?

foc

B1: Two sounds in one, a snap and a tone, taking place simultaneously. More voluminous snaps in deeper tones

B2: More tone in the low pizzicati. In composite pizzicati, the lower tones adopt an edge from the higher tones. Ascending pizzicati in the middle.

LCB's comment: By focusing on something, one listens in a different way**

EC's afterthought: Effects of the descending nerve connections from the cortex to the inner ear: voluntary focusing of auditory attention

23rd listening: How do you perceive the sound: Does it come from a particular direction, or does it surround you? (Directionality and surroundability, Ihde 1976:77)

foc

LCB: I become receptive of a broader focus. I can feel the sound surrounding my shoulders, but not the back side of my body.

The sound hits me in different ways. The very first tone is penetrating, like a precise spearhead

The general pause after B2 (CD 1'57): I am surrounded by non-sound! **

A3: the sound grows big, I am in the middle of the sound's volume and polyphony

LCB's question: I wonder if I lose my focus, or I abandon it? ****

EC's afterthoughts: Distinction between narrow, fine and broad attentional focus (Ihde 1976: 90). "Sound penetrates my awareness" (Ihde 1976:81). Immersion and penetration (Ihde 1976:78-79). Silence appears at the horizon of listening (Ihde 1976:106). Surroundability and directionality: "For the description to be accurate, both surroundability and directionality must be copresent" (Ihde 1976:77)

** indicates a significant change in the way of listening

**** indicates a tentative reflection on the conditions for appearance in consciousness

24th listening: Can one deliberately change the relation between directionality and surroundability? **foc**

LCB: I can decide to listen from my neck and my back side, then the music surrounds me the whole time, and I see nothing in front of me.

It is possible to vary the relationship between directionality and surroundability deliberately**

B1: It is like watching a scene

B2: When the sunshine appears, I am on the stage with it, standing on the scaffolding

25th listening: Focusing on the single sounds, especially the long, sustained sounds: How is the inner dynamic of the sounds, the minute changes of timbre and volume? **foc**

Oboe and clarinet grow in volume after the attack, so do the accompanying strings. However, the clarinet tone in A1 is very straight.

The single tone is forward-directed, it insists, attracts the attention of the listener, entrains the listener who has to surrender to the tone.

EC's afterthought: Ihde has described the attention-attracting power of the tone: "In ordinary affairs, we are so involved with entities within the fields, that we "forget" the fields as a whole." (Ihde: "Auditory Imagination" (1970/2007:204)

26th listening: Same question, focusing on the oboe in A2 **foc**

The oboe can change its timbre between dense and more open sound. Vibrato after the attack.

27th listening: Question: Variations in tempo? **foc**

A1: Rather static. The soloist plays laid back

A2: The oboe increases the tempo a little in phrases 1-2-3, calms down in the final phrase 4.

A3: Great ritardando, the music comes to a standstill in a tough way. The entries of the accompaniment are delayed by and by.

EC's afterthought 1: Further listenings can focus on large, overall tempo variations, or focus on the rubato tempo variations within a single phrase of a melody.

EC's Afterthought 2: Musical expression is based on small variations of tempo and volume

28th listening: Open listening for pleasure	open
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Experimental listening 24 Aug 2011. EC's preparation
Webern: Bagatelle for String Quartet op. 9 no. 1: Mässig (1913) 0'30
Emerson String Quartet DGG CD 445 828-2

Abbreviations: **open:** open listening
 foc: music-focused listening
 herm: hermeneutical listening

EC's preliminary observations and reactions, new questions, new tasks, and problems.

Preceding preparation: A number of open listenings to get acquainted with the music.

1st and 2nd listening: open listenings	open
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3rd listening: Hear the music as movement	foc
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Beginning: Like caresses. Towards the end: abruptly jumping

New question: What physical surfaces meet to produce the sound?

New task: Division in sections

4th listening: Hear the music as gestures and body movements	herm
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The gentle movements are most likely to be understood as body movements

5th listening: Hear the music as voices	herm
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Intimate conversation – agitation – calming down

Problem: Everything happens very fast, hard to grasp

New task: Listen for emotions

6th and 7th listening: Listen for sections	foc
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Two sections, which may be subdivided:

0'00-0'12

0'13-0'30

8th listening: Listen for subdivisions	foc
Four sections: 0'00-0'07 0'08-0'12 0'13-0'23 0'23-0'30	
New questions: Why are the sections heard as sections? What is going on in the ticking background?	
9th listening: Open listening	open
Beautiful, emotive music. The agitated section is important, cannot be eliminated	
10th listening: Question: What characterizes the different sound qualities?	foc
Coherent versus solitary Deep versus high Thuds, excited sounds	
11th and 12th listening: open listenings	open
New task: Let the melody slide into the background	
13th listening : Question: What can you hear apart from the melody?	open/foc
Tic-toc deep cello, vibrating high tremolo	
14th listening: open listening	open
New question: What similarities, what contrasts?	

Experimental listening 24 Aug 2011 LCB and EC
Webern: Bagatelle for String Quartet op. 9 no. 1: Mässig (1913) 0'30
Emerson String Quartet DGG CD 445 828-2

Observations and descriptions by LCB. Occasional comments by EC

1st 2nd 3rd and 4th listening: Open listenings

open

Neat, clear, elegant. One tone unfolds in three
Everything is in fragments. Many different effects and attacks. Fierce variations. Giga crescendo.
Shriek at the top, deep tone at the bottom, pizzicato in the middle
Single sounds, not very much form yet. No harmony.
Tiptoe gently, ballet-like

5th listening: Question: What unfolds?

open/foc

Tiptoe rhythm, humming, short and long tones, crescendo.
One sound scratches like the beginning of a flageolet, but changes its character
Onsets closer to each other. Tones broaden, longer strokes. Gathering in one tone at the end.

EC: Because of your ballet comment, I heard this piece as a ballet scene, visualized dancers moving around in ballet skirts

6th listening: Instruction: Hear the music as bodily gestures

herm

Different instruments are different persons. A scene with gentle and strong bodies
Tiptoe walk, elf-like, floating. First deep tone: a man
A big monster-sound, something evil.
One person stands up, her hands on her hips, proclaims
Another person yields, gentle in his expression

EC: I imagine arm gestures and strong jumps

7th listening: Instruction: Hear the music as voices

herm

Wow, how rapidly they are talking!

Beginning: A little too vague, a feeble voice. Comment: a deep tone, sighing.
The vague voice continues.
A group of children takes over, they say something unanimously. The parents leave the scene.

Then everything happens at the same time. The vague voice returns, gathering

8th listening: same instruction	herm
The deep tone, "the father", is not sighing, but more insisting	
9th 10th 11th 12th listening: Instruction: divide into sections	foc
1st and 2nd phrase are similar. 3rd section: The big crescendo leads to a strong exclamation by a lady who has plenty of grit 4th phrase: short, similar to 1st and 2nd phrase. LCB's timing of sections coincides with EC's 8th listening, see above: S1: 0'00-0'07 gentle phrase S2: 0'08-0'12 gentle phrase S3: 0'13-0'23 intense activity S4: 0'23-0'30 gentle phrase	
13th listening: Open listening	open
EC: Now I recognize the shout of the strong lady: one particular full-bodied tone near the end of S3	
14th listening: Question: What can you hear as voices, what do you hear as something else?	herm
LCB : All the sounds can be heard as voices EC: What about the tic-toc? LCB: Can be tsk, tsk	
15th listening: Listen for emotional expression	herm
S1: LCB: All the voices are kind, they do not state anything particular. The voice of an insipid, flimsy waiter EC: A feminine, caressing voice LCB: The first deep tone: Not insisting, but supporting: "I hear what you are saying" S2: The flimsy person and the deep remark again S3: Everybody disagree, rising their voices wildly, high up and deep down S4: A polite phrase and a dry remark: "well..."	

16th listening: same instruction

herm

LCB: S1 reminds me of a black and white TV show, "Super Karla", featuring a particular character: a tall flimsy waiter

EC: OK, I can clearly hear the tall flimsy waiter

LCB: S3: A high violin tremolo makes an impression, but the impact is not violent.

The strong Spanish woman manifests her one-tone swan song

Elegant movements as well

17th listening: Question: What are the particular qualities of the single tones?

foc

S1: Light strokes on the violin strings. Tic-toc sounds. One deep, vibrating tone

S3: For the first time: Compact tones in high and low registers, ripping in the bottom, pizzicati in the middle. The Spanish singer launches the most full-bodied tone in the whole piece

S4: the flimsy waiter again, and one dry grunt at the bottom.

18th and 19th listening: What are the qualities of the deep tones?

foc

The first deep tone: impressive crescendo, vibrato and decrescendo. The next deep tone: not particular impressive, merely "fvvv". Plus one deep tone I had not noticed before.

Later a very deep marcato, scratching attack. At last a friendly pizzicato

20th listening: What are the qualities of the high tones?

foc

The first violin performs a roller coaster ride from high to deep, starting as a flageolet, soaring into the air in the high tremolo tone, descending to the marvellous single tone of the strong Spanish woman

**21th listening: Question: When high and deep tones sound simultaneously:
How is the space between them?**

foc

LCB: The space between simultaneous tremolos is torn apart

EC: Additional question: In which way did you listen now?

LCB: I whirl myself into the sound, I try to grasp both sounds, it is difficult to grab hold of them, I lose the overview **

S3: is blown up in atoms and stretched out, it is scattered. I hear war cries, and try to keep watch of top, bottom and middle

EC: In S1, for the first time I heard "seufzers" twice, simultaneously with a deep tone

** indicates a significant change in the way of listening, similar to the change between states of multistability in visual phenomena, described in Ihde (1977) *Experimental Phenomenology*.

22nd listening: What is foreground, what is background?

foc

I now hear S1 in a different way, as a new kind of sound. It is no longer flimsy, the first violin is foreground, in a leading position. **

The image of the music gains depth, The first violin is in front, the others further behind.

The overall picture is clarified, order prevails over chaos

EC's afterthought: The virtual musical space can change from two-dimensional: flat, to three-dimensional: with depth

23rd listening: Instruction: Listen for coherence and interruptions

foc

The interruption in S3 is a crater!

S1 and S2 are coherent, S3 is characterized by clefts, S4 is coherent, with a little comma

24th listening: In S3, listen for coherence and interruptions

foc

LCB: It is possible to argue for coherence as well as for interruption.

The fragments in S3 are connected as a large whole. The same can be said about S4.

This provides a new way of listening **

Listening for flow and interruption is different from listening for depth, foreground and background.

EC's afterthought: Spatial versus temporal focusing

EC: Refers to Husserl's model: RETENTION – NOW – PROTENTION (Ihde 1976/2007:92-93)

and draws a possible 3-dimensional system of coordinates of the virtual musical space:

x-axis: time: temporal coherence and interruption

y- axis: pitch height: high - low

z-axis: depth: foreground – background

LCB: Musical mass and volume is something impalpable

LCB: Sound has a direction, it creates space. You rapidly produce coordinates

25th listening: Sound production: Question: What surfaces meet to produce the sound, and how do they meet? **foc**

Many light bow strokes bordering on nothing, soft movement, the sound of the bow is heard

Flageolets: the string is touched lightly, without pressure

The first deep tone: full stroke, lovely vibrato

Snarling sound without tone, continues as a tone

S3: impressive pizzicati, intensive tremolo, marcato deep sound, change to gentle sounds, good contrast

General factors in sound production:

pressure, speed, touch of the finger, touch of the bow, size and thickness of string

EC's afterthought: The way surfaces meet to produce the sound of string instruments is often prescribed and described in the score and taught as instrumental technique

LCB defines the three last listenings

26th listening: Focus on particular surfaces that meet: LCB wants to listen for a certain scratching sound: whzzzz!, like a wasp, in order to find out how it continues **foc**

LCB: No precise answer

EC: Identified the sound that LCB pointed out, and unexpectedly heard the music in a new way, from a new viewpoint, focusing on the sound in question. "Three dark voices and something around them" **

27th listening: S4: How does the music come to an end? **foc**

The last sound but one is a particularly lovely concord. This is also the case in S3

Additional observation: double pizzicati in S3, may be played by one or two instruments

28th listening: Open listening of all six bagatelles **open**

LCB: Lots of fun!

Experimental listening 12 Oct 2011. EC's preparation
Coleman Hawkins, Saxophone: Body and Soul
Recorded 11 Oct 1939

Abbreviations: **open**: open listening. **foc**: music-focused listening.
 herm: hermeneutical listening.

EC's preliminary observations and reactions, new questions, new tasks, and problems:

1st and 2nd listening : Open listening (intro + two choruses) **open/herm**

The sax tone displays an intimate, caressing, persuasive or imploring nature

New question: If this is speech, what does he say?

New task: Listen only for background

3rd listening: Listen for form (intro + two choruses) **foc**

Intro AABA AABA, 8-bar periods

New tasks: Describe as movement (gliding, jumping....)

Describe as voice (exclamations, whispering...)

Subsequent listenings: Only intro + the first chorus

4th listening: Listen only for background **foc**

New task: listen for piano, bass, drums separately

5th listening: Listen for the piano. Are there other instruments in the background? **foc**

One chord per beat. Difficult to hear details due to mediocre recording quality

New question: Is there a climax?

New task: Describe as bodily gestures

6th-7th listening: Listen for the bass **foc**

The bass plays on the 1st and 3rd beat. Tone quality: A soft thud

8th listening: What happens on the 2nd and 4th beat? Percussion plays on all four beats, accentuating 2 and 4	foc
9th listening: open listening New question: In the solo, do you hear small tempo variations?	open
10th listening: Is the pulse absolutely regular? Hard to hear...	foc
11th listening: Sax solo: How many kinds of tone quality? ... so beautiful that I cannot be bothered to describe...	foc
12th listening: Divide into sections, listen for tone quality A: 0'09-0'31 A: 0'32-0'51 B: 0'52-1'11 A: 1'12-1'32	foc
13th listening. Where are the soloist's top tones? No definite answer. New question: What is the nature of the tones in deep, medium and high range?	foc
14th listening: Do you hear interruptions, pauses, silence? Very fluent and continuous – merely very short pauses for breathing New questions for the solo: Mood, emotion, expression? Phrasing? What tones are particularly expressive? What tones hit right on the beat? Tension-relaxation? Body and Soul?	foc herm

Experimental listening 12 Oct 2011. LCB and EC
Coleman Hawkins, Saxophone: Body and Soul
Recorded 11 Oct 1939

EC asks questions or indicates listening tasks. LCB provides observations and comments, which EC notates. In some cases, EC includes his own observations, ideas, and reflections.

1st and 2nd listening: Open listenings (two choruses)

open

EC: Continuity. "Body": deep, vibrating, intimate. "Soul": high, heavenly.
Focused attention. Compare Ihde (2007): attention on the speaking voice

New questions: Tone bending? On what tones does he linger? Light and darkness?

LCB: A treasure from the past. Crackling noise, the sound of an old recording.
The good old days, cosiness: Lean back and relax.

Piano clear in the intro, then it recedes into the background, like playing in a cardboard box
Saxophone: Retro sound, steady drive, "mannered" vibrato – can't he skip it at least once?

Improvisation in defined sections according to fixed chord progressions. Subdued accompaniment.

3rd-5th listening: Listen for form (two choruses)

foc

Intro AABA AABA, 8-bar periods. Is the last section different from the first A sections?
(EC: I don't think so)

EC's reflection: 3rd listening: I can also hear the "retro" character of the improvisation. We face the problem of divergent interpretations. EC hears the music as an expressive love song. LCB hears the music as outdated, on the verge of provoking laughter.

EC decides: To avoid embarrassing disagreements, we will postpone questions which invite interpretation, and stick to "technical" focusing questions for some time.

6th listening: What happens in the background?

foc

Bass plays on 1 and 3, provides harmonic reference points. Skips: fourths, fifths, sixths, few connecting tones. Piano in the middle between bass and percussion, plays on all 4 beats.

7th listening: Percussion?

foc

Percussion plays on all 4 beats, accentuates 2 and 4, the sound is "stopped"

8th listening: how does the percussionist stop the sound on 2 and 4?	foc
Perhaps a hihat?	
9th-10th listening: focus on the percussion sound	foc
The sound on 2 and 4 "turns" until it stops. A little in front of the beat, changing. EC: Now I agree it may be a hihat.	
11th listening: Does the bass play on the beat?	foc
In doubt... he does not push or pull, he secures the good flow	
12th listening: Do other instruments join the piano on all four beats?	foc
Hard to hear. Brass join in at the end of the B section.	
13th listening (both choruses) Brass?	foc
Sustained brass sound in the background of 2nd chorus	
14th listening: Open listening	open/herm
Bassist: Laid back Sax solo: a lovely soft way of avoiding sharp corners. Incredibly pleasurable. Clings softly and warmly around the beats, never plays on the first beat. EC's reflection: This is a relief. LCB is beginning to hear the qualities of the sax solo I appreciate	
15th listening: Bass?	foc
On the beat	

16th listening: Light and shadow?	herm
Modulating B section adds light. The sax sound glows.	
17th listening: Describe the sax solo as movement	foc
Throughout soft movements, skips are soft as well. Very calm, but never static. Repeats and embellishes tones from below or from above.	
18th-19th listening: Sax solo: Interruptions, pauses, silence?	foc
No or very few gaps between phrases, consistent continuity. A small gap after an elegant sequencing phrase.	
20th listening: If the sax solo is speech, what does he say?	herm
A narrator who is not quite young. Narrates calmly, like a farmer in the countryside. Not very surprising. "How are you?" ... "I would like to underline that..." I imagine a scene in the 1930's, barn and hay, golden colors, evening sun.	
21th listening: Sax solo: What kinds of tone qualities?	foc
Very soft, gentle. Supple variety, fills everything up. Large difference between registers. Deep register absolutely fantastic. EC: Now I can also hear the elderly farmer	
22nd listening: What is the quality of the high tones?	foc
Festoons of tones. Intonation is extremely variable. Bright tones: Like a voice. Two tones almost disappear. Deep tones: Cigar smoke.	
23rd listening: Listen to the sax sound as bodily touch	herm
Total well-being. Lovely, affectionate, warm, gentle, supple. Excess. If I were caressed by somebody in that way, I would feel being in safe hands.	

24th listening: Open I imagined the band playing together	open
25th listening: EC: I will point out two tones which I feel convey particular glimpses of happiness LCB: Oh, really?	herm
26th listening: Sax solo: Are there small tempo changes? I don't hear any tempo changes. The solo moves very flexibly and elegantly, some movements take longer time. He avoids accentuated beats	foc
27th-28th listening: What is the relationship between soloist and accompaniment? The soloist turns and twists, usually avoids the accentuated beat, but not always. He may hit the third beat.	foc
29th listening: EC: I hear the soloist playing in the rhythm of the breath, and the accompaniment playing in the rhythm of the pulse. What do you think? LCB: It makes sense	foc
30th listening: In the single phrase, what is the itinerary to the target tone? Never the same itinerary. In a few cases, three "run-ups" precede the target tone.	foc
31st listening: Why do we hear that this music has swing? It is a result of collective interplay. We hear sounds in movement, and the relationships are continuously changing, never the same.	foc

EC's afterthought: This experimental listening shows how differences in personal contexts determine or influence the initial interpretation and understanding of the music's meaning.

It also shows that interpretation can change as a result of repeated listening, and that intersubjective exchange of opinions and impressions can contribute to the change of interpretation and understanding.

The Neurosciences and Music I: Mutual Interactions and Implications on Developmental Functions. Conference October 25-27, 2002 in Venice, Italy.
A survey of papers in the conference proceedings:
Avanzini, G. et al. (eds.) (2003) *The Neurosciences and Music*. Annals of the New York Academy of Sciences, Volume **999**.

Contents:	Number of papers
Part I. Cerebral Organization of Music-Related Functions Including Roundtable I: Dissecting the Perceptual Components of Music	29 (1-29)
Part II. Brain Sciences versus Music Including Roundtable II: A Common High-Level Ground for Scientists and Musicians	15 (30-44)
Part III. Music and Development Including Roundtable III: Import of Musical Training on Cognition, Behavior, and Skills	17 (45-61)
The survey presents, in brief and schematic form, for each paper:	
Abbreviated title as indicated in the conference proceedings, with page numbers. Categorization of the issue of the paper.	
Aim of the study	
Musical material or sound applied as stimuli in the study. Cultural references of the material.	
Technology and Procedure	
Main focus of interest	
Conclusion	
A number of notable papers are marked with an asterisk *. Some notable findings are written in bold type .	
Current Abbreviations:	
EEG : Electroencephalography	
MEG : Magnetoencephalography	
PET : Positron Emission Tomography. Detects blood flow in regions of the brain.	
fMRI : functional Magnetic Resonance Imaging. Detects BOLD : Blood Oxygenation Level Dependent response in regions of the brain.	
SMI : Sound source <i>not indicated</i>	
CR : Cultural Reference	

Part I. Cerebral Organization of Music-Related Functions

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*1. Koelsch & Friederici (15-28) Processing of Musical Syntax Cat. 2: Harmony Cat. 13: Expectation	Brain responses to In-key chords compared to sequences with Neapolitan chords ("syntactic violation")	Five-chord sequences. <i>Sound source not indicated (SNI)</i> CR: Western	EEG and MEG while listening Support: fMRI	Brain signatures of musical syntax: Event-related electric brain potentials (ERP): Early Right Anterior Negativity (ERAN). Distinct negativity or positivity after 200, 500, 300 milliseconds (N2, N5, P3)	Early right anterior negativity (ERAN) reflects the violation of a musical sound expectancy
*2. Tervaniemi & Huotilainen (29-39) Change-Related Brain Potentials Cat. 1: Pitch Cat. 3: Complex sounds	Cortical representations of musical sound and phonetic sound	1) Single tones: Synthesized piano tones and pure tones 2) Single Chords 3) Phonetic sounds CR: Western	EEG and MEG while listening Support: PET	Sound representation indexed by Event-Related Potential (ERP): Mismatch negativity (MMN), P3, Late Discriminative Negativity (LDN)	Complex sounds are automatically encoded in the auditory cortex: Fundamental difference between musical sounds versus pure tones and speech sounds
*3. Griffiths (40-49) Functional Imaging of Pitch Analysis Cat. 1: Melody	Brain basis for the analysis of pitch and pitch patterns	Review of different studies which apply 1) Single pure tones 2) Tonal melody 3) Harmonic stimuli 4) Random pitch patterns 5) Iterated rippled noise, which evokes a perception of pitch CR: Western	PET and fMRI while listening <i>Includes introduction to functional imaging by means of PET and fMRI</i>	Pitch processing in the brain. Includes review	Sound features relevant to pitch are represented in brain stem and cortex. Pitch patterns are processed in larger networks

Pure tones = Sinus tones

Title, Category	Aim	Mus. material, Cultural ref.	Technology & Procedure	Main focus of interest	Conclusion
4. Vignolo (50-57) Music Agnosia and Auditory Agnosia Cat. 11: Deficit Cat. 13: Recognition	Dissociations between the recognition of music and environmental sounds in stroke patients	1) Montreal Battery of Evaluation of Amusia (MBEA) melodies: Synthesized piano tones. 2) Environmental Sound Recognition Test CR: Western	1) Same-different recognition test. 2) Point to picture showing the sound source. Plus Review	Recognition of sound in 40 patients with unilateral stroke, 20 right and 20 left hemisphere	Music agnosia and environmental sound agnosia are not unitary disorders, but compound disorders, consisting of different defects
5. Peretz et al. (58-75) Varieties of Musical Disorders Cat. 1: Pitch, melody Cat. 4: Rhythm	Assessing the Montreal Battery of Evaluation of Amusia (MBEA) as a tool for evaluating musical abilities Brain regions involved in pitch discrimination and musical pleasure	MBEA: Melodies in synthesized piano tones. CR: Western 1) Various tests, including Seashore 1922: Melodies, Rhythm patterns 2) Mazzola's music test (SN). CR: Western	Same-different recognition test. 160 neurologically intact adults . 1) Review 2) EEG while listening	Diagnostic value of six tests: contour, interval, scale, rhythm, meter, memory 1) Brain regions and music 2) Consonance / dissonance processing	MBEA is reliable in identifying disorders in music recognition in Western listeners 1) Right temporal lobe is crucial for pitch processing 2) Directly recorded EEG from hippocampus reflects the consonance / dissonance dichotomy
6. Wieser (76-94) Music and the Brain Cat. 1: Melody Cat. 2: Consonance / Dissonance	Investigation of music-induced epileptic seizures	<i>Recorded and live music</i> , different styles and genres CR: Not indicated	Review of 67 observations. EEG, SPECT, fMRI	Brain mechanisms responsible for seizures	Systems in temporal lobe involved. Emotional aspects play a role
7. Avanzini (95-102) Musicogenic Seizures Cat. 18: Bodily impact					

Roundtable I: Dissecting the Perceptual Components of Music

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*8. Demorest & Morrison (112-117) Cultural Familiarity Cat. 7: Culture	Comparing Western subjects' responses to music of a familiar and an unfamiliar culture	<i>Recordings: Excerpts from a sonata by A. Scarlatti and a traditional Chinese piece, Liu Qin Niang</i> CR: Western, Chinese	Western subjects: Six professional string players and six untrained control subjects. fMRI while listening	Differences in brain activation due to cultural familiarity of the music. The term "musical accommodation" might be more accurate than "musical comprehension" (p. 114)	Activation did not differ on the basis of cultural familiarity, but on the basis of musical expertise. Each listener may universally apply his or her comprehension strategies to all music (p. 114)
*9. De Poli (118-123) Expressive Intentions in Music Performance Cat. 20: Musical expression ¹	Understanding musicians' strategies for different expressive intentions	<i>Recordings of professional performances of scores from Western classical and African-American music. 10-20 sec. melodies played with seven different expressive intentions: Neutral, bright, dark, hard, soft, heavy, light.</i> CR: Western, European ethnic, African-American	Questionnaire, proposing the selection of descriptive adjectives; factor analysis of adjectives. Computer modeling	Computer modeling of expressive intentions by means of analysis-by-synthesis	Kinematics (Tempo and tempo variations) correlated with expressive intentions: "bright" versus "dark". Energy (intensity and attack time) correlated with expressive intentions: "hard" versus "soft"
*10. Lopez et al. (124-130) Musicians versus Nonmusicians Cat. 1: Pitch, melody Cat. 8: Musicians	Auditory responses to simple musical stimuli and to melodies	Pure tones: 1) Single tones 2) Single chords 3) Arpeggios Synthesized piano sound: Mozart: Twinkle twinkle little star, Bach Invention no. 8 CR: Western <i>A precisely described set of stimuli</i>	10 performing amateur musicians, 10 non-musicians. EEG and MEG simultaneously while listening. Five Oddball paradigms	Differences in amplitudes and latencies between musicians and non-musicians. Mismatch Negativity (MMN), N1, P300	Mismatch Negativity (MMN) in all subjects. Hypothesis: Each future tone is predicted. The advantage of "musicianship" is more evident in more complex musical sequences (p. 129)

MMN: Mismatch negativity: In EEG, a deflection in the auditory evoked response when a deviance is randomly inserted in a series of otherwise equal stimuli (the **Oddball paradigm**) (Paper No. 10: Lopez p.124). "A unique indicator of automatic cerebral processing of auditory stimuli" (Paper No. 26: Sittiprapaporn p.199)

¹ See also Bigand (NM II, 2005:430)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*11. Münte et al. (131-139) Event-Related Potentials (ERP) in Professional Musicians Cat. 1: Pitch Cat. 8: Musicians	Neural correlates of processing of auditory stimuli: pitch, auditory space, time	1) Single tones: Brief pure-tone pips, 60 msec. 2) Six sound sources, three in front, three to the right. (SN) 3) Real drum sequence CR: Neutral	1) 12 musicians, 10 with strings as primary instrument. 12 nonmusicians. 2) 7 conductors, 7 pianists, 7 nonmusicians. 3) 10 drummers, 10 woodwind players, 10 non-musicians. EEG while listening. Multichannel ERPs using standard procedures	EEG: Differences in auditory processing by string players, conductors and drummers. ERP: Negative displacement (ND).	Qualitative differences of the neural correlates of auditory processing between non-musicians and musicians. Differences appear to be shaped by the specific training of a musician: conductors versus pianists,, drummers versus woodwind players (p. 131)
12. Patel (140-143) Rhythm in Language and Music Cat. 4: Rhythm Cat. 7: Culture	To test the idea that the linguistic rhythm of a culture might leave an imprint on its musical rhythm	Notated music: Instrumental musical themes of 6 English and 10 French turn-of-the-century composers CR: Western	Quantitative measure of vowel duration variability and tone duration variability	Comparison of English versus French linguistic and musical rhythm	Tone durations are more variable in English than in French music. This tendency is similar to language
*13. Samson (144-151) Musical Timbre Cat. 3: Timbre Cat. 11: Deficit	Involvement of right and left temporal lobe areas and neural networks in timbre processing	Single sounds: Synthesized timbres 1) with spectral changes: one, four or eight harmonics. 2) with temporal changes: 1, 100 and 190 msec rise time duration CR: Neutral	Patients with unilateral temporal lobe lesions: Same-different recognition test. Review of EEG, MEG, PET and fMRI studies	Possible contributions of right and left temporal lobe structures in timbre perception	Support for involvement of right temporal lobe in timbre processing. The contribution of left temporal regions is also apparent. Suggestion: The different durations and frequencies heard within a musical context facilitate timbre perception

Part I: Poster Papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
14P. Bey & Zatorre (152-154) Interleaved Melodies Cat. 1: Melody	Neural basis of auditory stream segregation	Two unfamiliar six-tone melodies, one with distractor tones (SN) CR: Western	fMRI. Decide whether the melodies are identical or different. 8 listeners	Difference if the target melody is presented before or after the melody with distractor tones?	Similar cortical networks involved in both conditions
15P. Brattico et al. (155-157) Electrical Brain Responses to Music Cat. 2: Harmony	Neural correlates of aesthetic vs. descriptive listening of the same musical cadences	180 five-chord cadences. 10 with correct, 10 with incorrect ending (SN) CR: Western	15 nonmusicians. EEG while listening. Judging tasks: correct / incorrect or like / dislike	Activated neural resources, especially right frontocentral negativity	More neural resources are devoted to prepare an evaluative (aesthetic) listening
16P. Brattico et al. (158-160) Acquired Deafness to Dissonance Cat. 2: Consonance / Dissonance Cat. 11: Deficit	Distinction between consonant and dissonant intervals by a patient and control subjects	Two sets of four intervals: a "consonant" and a "dissonant" context (SN) CR: Neutral	One patient, who had bilateral lesions in the auditory cortex, but intact hearing. EEG while listening	Effects of patient's bilateral lesions in the auditory cortex Event-Related Potentials (ERP), Mismatch Negativity (MMN)	The electrical brain responses did not differentiate between dissonance and consonance. Neural substrates underlying MMN generation are altered by patient's brain lesions.

P: indicates a short poster paper, e.g. 14P

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
17P. Dahl & Granqvist (161-165) Estimating Internal Drift and Tempo Drift Cat. 4: Tempo	To investigate the extent to which a continuous tempo drift is perceivable	Click sequences, increasing or decreasing tempo CR: Neutral	7 subjects did 3 listening sessions. Method for Parameter Estimation by Sequential Testing (PEST)	Is there such a thing as an internal representation of a "steady tempo"?	Internal drift is consistent within subjects, differs between subjects
18P. Dalla Bella & Peretz (166-169) Congenital Amusia and Synchronization Cat. 4: Timing Cat. 11: Deficit	To examine whether persons with congenital amusia are also impaired in timing tasks	<i>Recordings</i> : Ravel's <i>Bolero</i> , Instrumental folk music, Bee Gees: <i>Stayin' Alive</i> . Isochronous sequences of noise bursts CR: Western, Western popular, Neutral	8 amusic persons, 9 controls. Task: Tap in time to the auditory stimuli: Music or isochronous (in regular tempo) sequences of noise bursts. 6 different tempi	Comparing tapping performance of amusic persons and control participants	Amusic subjects have difficulty in synchronizing with music, but no difficulty in synchronizing with regular noise bursts
19P. De Baene et al. (170-172) Roughness Perception by Mismatch Negativity (MMN) paradigm Cat. 3: Complex sounds	Neural correlates of roughness perception	Single tones. Standard stimulus: Pure tone 1000 Hz. Deviant stimulus: Same tone amplitude modulated, different roughness CR: Neutral	Event-Related Potentials (ERP): MMN at Fz (Midline frontal electrode) and co-occurring Mismatch positivity (MMP) at the mastoid electrodes. The mastoid is the rounded protrusion of bone just behind the ear	Oddball paradigm: Neural reflections of deviant tones in an inattentive condition, watching silent movie	Roughness is reflected by the MMP at the mastoid electrodes in the inattentive condition
20P. Hyde & Peretz (173-176) Congenital amusia Cat. 1: Pitch Cat. 11: Deficit	Perceptual deficit underlying congenital amusia ("tone deafness")	Five-tone sequences. Tones synthesized in a piano timbre CR: Western	10 amusic persons, 10 controls. Task: In a five-tone sequence, detect a change in constant pitch or isochronous sequence	Perception of pitch change and time change in amusic persons and control group	Amusic adults have an auditory perceptual deficit in discriminating pitch but not time changes

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
21P. Jones, S.J. (177-179) Evoked potentials of human auditory cortex Cat. 2: Harmony Cat. 3: Complex tones	Cortical processing of harmonic and inharmonic complex tones	Sequences of six complex harmonic or inharmonic tones, each made of four pure tones CR: Neutral	8 normally hearing subjects where tested while reading a book. Evoked potentials: Obligatory N1 and P2 potentials, specified as CN1, CP2 and MN1, MP2	"C potentials" produced at onset of change. "M potentials" produced at offset of change	Discussion
22P. Jongsma et al.(180-183) Evoked potentials to test rhythm perception Cat. 4: Rhythm Cat. 8: Musicians	How rhythmic information is processed in the brain by musicians and nonmusicians	Bars of duple- or triple-meter context followed by a variable probe beat (SN) CR: Neutral	14 musicians, 14 non-musicians. Evoked potentials: P3 occurring when expectancy is violated	How a mental representation of rhythm leads to expectancies of events in the near future	Support of the view that temporal patterns are processed sequentially in nonmusicians, hierarchically in musicians
23P. Neuhaus (184-188) Perceiving musical scale structures Cat. 7: Culture	Investigating the processing of musical scales from a cross-cultural perspective	Synthetic tones: Four 7-tone scales: major, minor, Thai scale with equal steps, Turkish makam Hicaz. CR: Western, Thai, Turkish	5 German, 5 Turkish, 5 Indian musicians. Event-Related Potentials (ERP): P300 component used to indicate underlying cognitive processes	ERP: Oddball paradigm: a standard and a deviant scale. Response of German, Turkish, Indian musicians	Universal mechanisms of perception are influenced by culturally "imprinted" musical contents
24P. Schön et al. (189-192) Retrieval of musical intervals Cat. 1: Pitch Cat. 11: Deficit	Dissociation between discrimination and retrieval of musical information in a patient with right hemisphere lesion	Short musical sequences that could be used in both discrimination and reproduction tasks (SN) CR: Western	One patient with a right hemisphere lesion. Pitch and rhythm: discrimination and reproduction tasks	Due to right hemisphere lesion, impairment in tasks involving production of pitch intervals	This patient shows a dissociation between pitch discrimination and pitch production

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
25P. Schön & Besson (193-198) Audiovisual music interactions Cat. 8: Musicians Cat. 16: Audiovisual	Determine if musicians can develop expectancies for plausible or implausible auditory events on the sole basis of score	Five-note auditory musical sequences, tonally stable or unstable (SN) CR: Western	Musicians were asked to judge whether an auditory sequence matches or mismatches information simultaneously presented on a score	Variations in Reaction time and Event-Related Potentials (ERP): Early Right Anterior Negativity (ERAN), N5, P300 due to plausibility of ending and match / mismatch	Stable visual endings create stronger musical expectancy than unstable visual endings
*26P. Sittiprapaporn et al. (199-203) Processing of lexical tone perception Cat. 7: Culture	Difference in cerebral lateralization in preattentive perception of native and non-native words	Consonant-vowel syllables in tonal languages: A Thai word and a Chinese morpheme CR: Thai, Chinese	9 healthy native Thai speakers. Event-Related Potentials (ERP): Mismatch Negativity (MMN) and detection of scalp areas of maximal electric potential power. Oddball paradigm	MMN: Preattentive responses of native Thai speakers to native and non-native words, while reading aloud	Hearing a native-language deviation elicits greater electric sources of the mismatch response
27P. Stewart et al. (204-208) Becoming a pianist Cat. 10: Training Cat. 17: Sensory-motor	Neural correlates of musical skill acquisition	<i>Live music</i> : Notated five-note melodies played on keyboard CR: Western	Musically naive subjects attended music lessons for 15 weeks. Before and after learning: fMRI while playing melody on keyboard	Brain activation before and after 15 music lessons	Training effect in right superior parietal cortex (sensorimotor mapping)
28P. Tillmann et al. (209-211) Frontal cortex in musical priming Cat. 2: Harmony	Neural correlates of processing related and unrelated musical events	8-chord sequences (SN), the last chord strongly related (tonic) or unrelated (distant key) CR: Western	fMRI while listening	Differences in activation. Locations of activated network	Targets that violate expectations (low probability events) induce increased activation of networks for target detection and novelty processing.
29P. Warren et al. (212-214) Analyzing pitch in human brain Cat. 1: Pitch	Representations of pitch chroma and pitch height in the human brain	Synthesized successive harmonic complexes. Pitch chroma and pitch height varied between successive complexes CR: Neutral	10 normal subjects. BOLD response measured in a sparse imaging fMRI protocol during passive listening	Hypothesis: Pitch chroma and pitch height have distinct mappings in the human brain	Chroma is represented in cortical areas anterior to primary auditory cortex. Height is represented posterior to primary auditory cortex

Priming is an implicit memory effect: Preceding exposure to a stimulus influences response to a subsequent stimulus.

Sparse imaging is a way of overcoming the considerable noise produced by the MRI scanner during measurement of the BOLD response (Paper No. 3: Griffiths p.42)

Part II: Brain Sciences versus Music

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*30. Jones, E.G. (218-233) Parallel pathways in monkey auditory system Cat. 1: Pitch Cat. 6: Animal sounds <i>Well-documented and ground-breaking study by E.G. Jones</i>	To delineate two parallel pathways ascending through the brain stem to the medial geniculate complex of the thalamus and projecting to two different areas of the auditory cortex	Single pure tones versus recordings of monkey communication calls ("coo sounds") CR: Monkey communication	Anatomical studies of the neural pathways, and imaging studies of auditory processing in monkey cerebral cortex by means of PET	Two different areas of the auditory cortex, a tonotopically organized core area responding to pitch, and a belt area responding to more biologically significant sounds	Studies of the auditory cortical areas on the basis of best frequency analysis and tonotopic organization may have reached a point of limited usefulness. (p. 231) Challenge: Examination of brain regions from the perspective of sounds that are of greater biological relevance, including music
31. Bentivoglio (234-243) Legacy of the brains of musicians Cat. 8: Musicians	Overview of the history of debates on correlation of musical skills and neurological functions	None CR: ---	Reviews of "Phrenology" and other attempts at brain research. Case stories of composers' diseases	Synthetic historical account of the debates on musical skills and neural functions	Regions of the brain concerned with biologically significant auditory communication which is more complex than mere pitch discrimination are relevant for humans. Warning against a too precise "localizationalist" approach in contemporary neuroscience
32. Kuck et al. (244-253) Brain processing of meter and rhythm Cat. 4: Meter, Rhythm	To determine cortical structures involved in "global" meter and "local" rhythm processing	Pairs of monophonic sequences, MIDI piano sounds played at the pitch of b flat CR: Neutral	18 experienced musicians. 32-channel DC (Direct Current) EEG, recording slow brain potentials. Same / different task	Localization of cortical activation for "meter" and "rhythm" test conditions. Testing Lerdahl and Jackendoff hypothesis: Rhythm processing in left, meter in right hemisphere	For both: Predominant right prefrontal activation. For rhythm: more centroparietal activation. No support for Lerdahl and Jackendoff hypothesis

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
33. Duckworth (254-262) Virtual music on the web Cat. 21: Creative project	Creating a website with tools that allow listeners to participate actively in the creation of music	Created online CR: ---	Web-based tools and virtual instruments for creating music	To create an imaginative, ongoing artistic experience that builds community	Creative project, blurring distinction between art and gaming.
34. Rosenboom (263-271) Propositional music Cat. 21: Creative project	Creating interactive, feedback-based, self-organizing musical structures	Generative models of music based on measured EEG waveforms and computer algorithms CR: ---	Direct monitoring of biological phenomena	Integration of performance, composition and improvisation. Active imaginative listening	Creative project
*35. Roads (272-281) Perception of microsound Cat. 3: Complex sounds Cat. 17: Sensory-motor <i>Thought-provoking paper by a microsound composer and scientist</i>	Contributing to a theory of microsound: sound particles which last only a few milliseconds	Electronically synthesized new tones made up of streams or clouds of sonic particles CR: Atonal Western	Paper sound synthesis techniques: granular and pulsar synthesis	Preattentive and subliminal perception. Liquid-like or cloud-like structures of microsound	"Foundations of music cognition extend far deeper than any musical theory dogma. Ultimately, music is rooted in the senso-motoric dynamics of the human nervous system " (p. 278)
36. Minciocchi (282-301) Translation of neurobiological data Cat. 21: Creative project	Using biological information for the realization of music	Various instrumentations of sound parameters, e.g. three pianos CR: ---	Neurobiological data are converted into structures from which sound objects are generated	To challenge the classical quest for universals in music	Creative project on the basis of neurobiological data

Roundtable II: A Common High-Level Ground for Scientists and Musicians

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*37. Bigand (304-312) Musical expertise of untrained listeners Cat. 8: Musicians and non-musicians Cat. 15: Musical structures	To compare the abilities of musicians and non-musicians to process subtle changes in musical structures	1) Pairs of melodies 2) Sequences of 14 chords 3) Excerpts from Haydn sonatas 4) Newly composed dodecaphonic canons (SN) CR: Western, Atonal Western	Groups of musicians and non-musicians. 1) Judgment of musical tension for each melody note 2) Response to target chords 3-4) Memorization and comparison tasks	Processing of musical structures (in contrast to musical tones)	Untrained listeners exhibit sophisticated musical abilities similar to those of musical experts. Mere exposure is sufficient for developing auditory expertise
*38. Molinari et al. (313-321) Rhythmic motor entrainment Cat. 4: Timing Cat. 8: Musicians Cat. 11: Deficit	Better understanding of the brain timing mechanism, especially the cerebellar role of timing	Auditory rhythmic stimuli (SN) CR: Not indicated	a) Patients with cerebellar damage. Tasks: 1) Consciously detect rhythm changes in the stimulus 2) Tap in synchrony with the stimulus. b) fMRI study of musicians and nonmusicians. Task = 2)	Different neural circuits that can process time information. Participation of cerebellar processing	Different levels of time processing exist, one conscious and one not
39. Radulescu (322-363) Brain and sound resonance Cat. 3: Complex sounds Cat. 21: Creative project	Innovative creation of sound spectra	Complex spectra based on ring modulation, producing sum and difference tones CR: ---	Mathematical operations describing spectral self-generative processes	Composition of spectral music	Creative project
40. Thaut (364-373) Rhythmic timing networks in brain Cat. 4: Timing Cat. 17: Sensory-motor	Neural networks involved in motor synchronization to auditory rhythm	Metronome-like pulse beat sequences. Random step changes in tempo CR: Neutral	Various experiments. 1) MEG and 2) PET during finger tapping in synchrony with pulse-beat sequences	1) M100 component of the brain magnetic field 2) Basic neural network underlying rhythmic synchronization M100 is the MEG Brain response indicated at the surface of the scalp by magnet peak of amplitude, occurring approximately 100ms after the onset of the stimuli.	1) Auditory rhythms rapidly entrain motor responses 2) A widely distributed cortical and subcortical network subserves the motor, sensory, and cognitive aspects of rhythm processing (p. 371)

Part II: Poster Papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
41P. Khalfa et al. (374-376) Music, stress, and salivary cortisol Cat. 18: Bodily impact	Effect of relaxing music for recovery after a psychologically stressful task	<i>Recordings</i> : Relaxing music excerpts from Enya, Vangelis and Yanni via loudspeakers CR: Western popular	24 francophone male university students. Measurement of salivary cortisol before and after stressful task	Difference between music listening and silence during recovery period	Cortisol in the saliva decreased more rapidly in subjects exposed to music
42P. Lancelot et al. (377-380) Temporal lobe resection in short-term memory Cat. 6: Animal sounds Cat. 14: Memory	To investigate auditory spatial and non-spatial short-term memory (STM)	Bird songs CR: Nature	Patients: 9 had undergone right, 10 had undergone left temporal lobe resection. Two tasks: 1) Auditory object discrimination: same or different? 2) Location discrimination: Identical or different?	Difference between patients with left and right temporal lobe removal	Right temporal lesions: impaired object discrimination. Left temporal lesions: impaired location discrimination
43P. Quoniam et al. (381-384) Melodic memory in Alzheimer's disease (AD) and depression Cat. 11: Deficit Cat. 14: Memory	Impact of emotional deficits on implicit and explicit memory	Novel but conventional melodies (SNI) CR: Western	10 AD patients, 10 depressed patients, 16 controls. 1) Study phase: Presentation of melodies 1, 5 or 10 times. 2) Preference task 3) Recognition task	Differences between Alzheimer's disease patients and elderly depressed patients	Impaired recognition in Alzheimer patients. Impaired emotional processing of positive stimuli in depressed patients
44P. Gaab and Schlaug (385-388) Brain activation in musicians Cat. 1: Melody Cat. 8: Musicians	Different brain activation in musicians and non-musicians	Sequences of 6-7 tones (SNI) CR: Not indicated	10 musicians, 10 non-musicians. Sparse fMRI during pitch memory task: same or different?	Localization of brain activation	Musicians: greater right posterior temporal activation. Non-musicians: greater activation of left secondary auditory cortex

Explicit memory: Memory in which there is a need for conscious recollection in order to recall something.

By contrast, in **implicit memory** there is a lack of conscious awareness in the act of recollection.

Priming is an implicit memory effect: Exposure to a stimulus influences response to a subsequent stimulus

Part III: Music and Development

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
45. Saffran (397-401) Musical learning and language development Cat. 6: Phonetic sounds Cat. 9: Child development	The role of statistical learning for infants' acquisition of language and music: tracking patterns in the environment	Nonsense sequences of syllables, word boundaries not marked. Pseudo-musical analog, each syllable translated into pure tone CR: Neutral	Eight -month-old infants were tested using the Headturn Preference Procedure	Potential contributions of statistical learning: ability to track consistent patterns in the input to discover units and structures	Infants can detect structure using statistical cues, rapidly and in the absence of reinforcement
*46. Trehub (402-413) Toward a developmental psychology of music Cat. 7: Culture Cat. 9: Child development	Emphasizing the importance of studying perceptual abilities of children for a general understanding of cognition	<i>Recordings:</i> Numerous kinds of musical material in different types of research. Instrumental excerpts from popular TV programs CR: Western, Western popular, Japanese	Comprehensive review of research in developmental psychology. 93 references	Consonance / dissonance. Pitch, Tempo, Absolute Pitch (AP).	A developmental approach can provide insights of comparable importance on many issues of music cognition. At times, naïveté about cultural conventions leads infants to outperform adults on specific speech and music tasks. (p. 404)
47. Krumhansl (414-428) Experience in music cognition Cat. 1: Melody Cat. 13: Expectation	Ecological methodology, related to melodic patterns representative of listeners' musical experience	Piano timbre: 4-tone melodic patterns that clearly specify a tonality: scale degrees 5123 and 5176, frequent in Western music CR: Western	12 musically trained subjects. Sparse fMRI while listening to initial patterns followed by tones that were or not were frequent continuations. Plus review of research.	Participants judge how well continuation tones fit their expectations. Timing and task effects on brain activations	Right inferior frontal activation in the processing of melodies compared to monotone patterns
*48. Drake & Ben el Heni (429-437) Synchronizing with music Cat. 4: Timing Cat. 7: Culture	Hypothesis: Passive acculturation by implicit learning. We pick up regularities in the music we hear	<i>Recordings of</i> typical popular music, 6 French and 6 Tunisian songs CR: French, Tunisian	24 Tunisian, 24 French adults. In each group, half were musicians. Task: Tapping procedures according to the Dynamic Attending Theory: spontaneous tapping and tapping in time w. music	Number of hierarchical levels of synchronized tapping with music. Task: to tap slower and faster in synchrony. The Dynamic Attending Theory proposes that each individual has an internal rhythm or rate at which event processing is optimal	A person taps slower with the music from a familiar culture, synchronizing at higher hierarchical levels. Passive acculturation plays an important role in perceiving music of own culture. Stronger influence than musical training

The Headturn Preference Procedure: A technique used to collect behavioral data from infant subjects. It involves teaching the infant that when they turn their head in a certain way, usually to face a visual stimuli, an auditory stimulus will take place. This way the infant controls what he/she listens too. <http://www.psychology.uiowa.edu/labs/mac/lab/references.asp>

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
49. Pantev et al. (438-450) Music and cortical plasticity Cat. 10: Training Cat. 17: Sensory-motor	To investigate changes that occur in the human auditory cortex when a skill is acquired	1) Melody of 8 synthesized harmonic complex tones. Each tone could be perceived according to either the spectrum frequencies (spectral pitch) or the virtual pitch corresponding to the missing fundamental frequency. 2) Single violin and trumpet tones 3) Five-note melodies and sequences of pure tones CR: Western	1) 10 subjects were intensively trained, until they were able to perceive the virtual pitch melody. MEG during listening to melodies before and after training. 2) MEG during listening with or without tactile stimulation 3) MEG: Magnetic mismatch response (MMNm) to standard and deviant melodies	1) Effect of training 2) Testing auditory plus tactile stimulation 3) Neural mechanisms for automatic encoding of melodic features	Musical training affects a network of brain areas involved in stimulus encoding, cross-modal integration, and deviance detection
50. Oerter (451-460) Correlates of exceptional performance Cat. 8: Musicians Cat. 10: Training	Discussion of the issue of exceptional performance	None. Review of theories and research CR: ---	References to PET and MRI results	Roles of genetic factors, gene-environment interaction, neurobiological findings, deliberate practice	Genetic conditions of musical talent must join deliberate practice and a supportive social network
51. Magne et al. (461-476) Prosody and melody Cat. 6: Phonetic sounds Cat. 8: Musicians	Comparing the prosodic level of processing in language with the melodic level of processing in music	Sentences and musical phrases (SN/) with or without pitch violation at the end CR: Western	A group of adults and a group of 7-9 year old children. Half of each group were musicians. EEG during task: To determine if the pitch of the final word or note is congruous or incongruous	Adults and 7-9 year old children: Comparison of musicians and non-musicians	Musical expertise clearly seems to facilitate the detection of pitch violation in language

Roundtable III: Import of Musical Training on Cognition, Behavior, and Skills

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
52. Costa-Giomi (477-484) Children's harmonic perception Cat. 2: Harmony Cat. 9: Child development	The role of age in children's sensitivity to implied harmony	1) Simple melody superimposed on dominant and tonic chords. 2) Familiar song abruptly changing key. "Ornichord" sound CR: Western	In a series of studies, 5-10 year-old children received instruction on tonic and dominant chords. Tasks after 10-20 weeks of instruction: 1) Detect chord changes. 2) Sing along with the accompaniment	Differences between 5-6 year olds, 7-8 year olds and 9-10 year olds	Harmonic instruction has limited effects on children's perception of hamony. Drastic improvement in the perception of implied harmony at age 9 is due to development rather than instruction
53. Gruhn et al. (485-496) Mental speed versus musical ability Cat. 10: Training	To investigate whether interaction between general mental abilities and musical practice or training can be found	Gordon's Primary Measures of Music Audiation test (PMMA) for measuring musical aptitude. CR: Western	Comparison of 3 groups of 6-year-old children: 1) musically active 2) violin students 3) no musical background. PMMA tests and measurement of saccadic eye movements	Saccadic eye movements as a possible indicator of mental speed, supposed to co-vary with general mental ability	No clear conclusions. Data show a correlation – which is no causal link – between mental speed and musical experience.
54. Overy (497-505) Dyslexia and music Cat. 6: Language Cat. 10: Training	Hypotheses: Dyslexic children have difficulties with musical timing skills. Classroom music lessons can have positive effects	Training: Singing-based music lessons, and a series of musical games CR: Western	A collection of musical aptitude tests, including motor skill tasks, placing emphasis on timing skills	A general model of the potential relationship between musical training and improved language and literary skills	Dyslexic children show difficulties with musical timing skills. Classroom music lessons have an effect on phonologic and spelling skills, not on reading
*55. Trainor et al. (506-513) Musical training and cortical plasticity Cat. 3: Acoustic tones Cat. 8: Musicians	Effects of musical experience on sound representations in the auditory cortex	Violin tones, piano tones, pure tones CR: Western	Seven 4-year old children taking Suzuki music lessons, 6 pianists. 1 violin. Six age-matched control children. EEG: Event-related potentials (ERP): Negative and positive responses measured in EEG after 100 and 200 msec (N1, N1b, N1c, P1, P2)	Adults and 4-5 year old children: Differences between musicians and non-musicians reflected in evoked responses	Effects of musical experience early in development. The P2-evoked response is larger in musicians, both adults and children. Differences in ERPs between pure tones and musical tones

Part III: Poster papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
56P. Gaser & Schlaug (514-517) Gray matter differences in musicians Cat. 8: Musicians Cat. 10: Training	Structural adaptation of the brain in response to long-term skill learning and repetitive rehearsal of skills	None CR: ---	20 professional musicians, 20 amateur musicians and 40 non-musicians, all male. Magnetic Resonance (MR) data acquisition and image analysis.	Image analysis, searching for gray matter differences between groups	Professional musicians: Areas of increased gray matter in motor as well as auditory and visuospatial brain regions
57P. Lamont (518-519) Toddlers' musical preferences Cat. 9: Child development	Pilot study: musical preferences of children aged 2- 3½ years for different kinds of music	<i>Recordings:</i> Four real music extracts (<i>not specified</i>). Music not the same for all participants CR: Not indicated	The child can choose music by pressing one of four keys on a toy keyboard with flashing lights	Listening time for each piece out of a total playing time of 10 minutes	General preferences for fast and loud music over slow and quiet music irrespective of style
58P. Plantinga & Trainor (520-521) Long-term memory (LTM) for pitch in infants Cat. 9: Child development Cat. 14: Memory	6-month-old infants' LTM representations for the pitch of familiar melodies	<i>Recordings:</i> One of two English folk songs, "The Country Lass" or "The Painful Plough" CR: Western traditional	1) 16 infants heard 6 repetitions each day for 7 days of one of the songs. On the 8th day: Preference test, choosing between familiar and unfamiliar song 2) Task: recognize a familiar song in transposition 3) Testing whether infants remembered the absolute pitch of melodies	To determine the nature of infants' long-term memory representations	1) Infants remembered the familiarized melody. 2) Indication that infants encoded the relative pitch of the melodies in LTM 3) Six-month-old infants remember melodies in terms of relative pitch, not absolute pitch
59P. Ross et al. (522-526) Absolute pitch and early musical training Cat. 1: Pitch	To test the importance of musical training for Absolute Pitch (AP) by means of new test paradigm	Pure tones from a sinus tone generator CR: Neutral	27 experienced musicians, 6 with AP, 21 without. Plus one person, R.M., claiming to have AP without musical training. Task: Listen to a tone. Reproduce the tone by means of a sinus tone generator 1) after a silent interval 2) after distracting tones	Differences between AP-group and Non-AP group, plus one person, R.M., claiming to have AP without musical training	R.M. possesses AP. Musical training is not necessary for the development of AP

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
60P. Ruzza et al. (527-529) Musical quality of early infant sounds Cat. 6: Infant sounds Cat. 7: Culture	Early vocalizations in 2-month old Italian and Moroccan infants are examined	Cooing, gooing, babbling, vowel-like, consonant-like sounds CR: Italian, Moroccan	Five 2-month-old infants, three Moroccan, two Italian. Statistical analysis of acoustic parameters	Protophones (precursors of speech). Differences between the two ethnic groups	In both groups, speech utterances prevail over non-speech sounds
61P. Thompson et al. (530-532) Perceiving prosody in speech Cat. 6: Phonetic sounds Cat. 8: Musicians	To test whether musical training is associated with enhanced ability to perceive prosody in speech	Four happy-sounding utterances, and intonation melodies (SN//), matching utterances in pitch and temporal variation CR: Neutral	22 musically trained, 16 untrained listeners. Task: To listen to pairs of utterances and melodies, and judge whether or not the intonation melody matched the prosody of the phrase	Differences between musically trained and untrained listeners	Musically trained participants are better than untrained participants at extracting prosodic information from speech

The Neurosciences and Music II: From Perception to Performance. Conference May 5-8, 2005 in Leipzig, Germany.
A survey of papers in the conference proceedings:
Avanzini, G. et al. (eds., 2005) *The Neurosciences and Music II*. Annals of the New York Academy of Sciences, Volume **1060**.

Contents:	Number of papers
Part I. Ethology/Evolution: Do Animals have Music or Something Else?	5 (1-5)
Part II. Music and Language	5 (6-10)
Part III. Mental Representations	9 (11-19)
Part IV. Developmental Aspects and Impact of Music on Education	8 (20-27)
Roundtable on Music Therapy	4 (28-31)
Part V. Neurological Disorders and Music	4 (32-35)
Part VI. Music Performance	8 (36-43)
Part VII. Emotion in Music	10 (44-53)

The survey presents, in brief and schematic form, for each paper:

Abbreviated title as indicated in the conference proceedings, with page numbers. Category of investigation

Aim of the study

Musical material applied as stimuli in the study. Cultural references of the Musical material.

Technology and Procedure

Main focus of interest

Conclusion

A number of notable papers are marked with an asterisk *. Some notable findings are written in **bold type**.

Recurrent abbreviations:

EEG: Electroencephalography.

MEG: Magnetoencephalography.

PET: Positron emission tomography.

fMRI: functional Magnetic Resonance Imaging.

MRI: Magnetic Resonance Imaging.

CR: Cultural reference.

SNi: Source not indicated.

Part I. Ethology/Evolution: Do Animals have Music or Something Else? 5 papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
1. McDermott & Hauser (6-16) Origins of Music Perception Cat. 2: Consonance / dissonance Cat. 3: Complex sounds	Testing whether human musical preferences for consonances and non-disturbing sounds exist in nonhuman primates	1) Dissonant versus consonant two-note chords of synthesized complex tones with ten harmonics. 2) Aversive "screeching" sound versus white noise CR: Western / Neutral	a) Humans, b) Tamarin monkeys can trigger two kinds of sound by choosing their position in experiment areas. Time spent on each side is measured	Comparing human acoustic preferences with preferences of monkeys	The studies suggest that simple acoustic preferences that are pronounced in humans are not shared by primate relatives. Additional cross-cultural research is needed
2. Merker (17-28) Conformal Motive in Birdsong Cat. 6: Animal sounds	To highlight the uniqueness of human culture by contrasting ritual and instrumental (goal-oriented) behavior. Emphasize vocal learning as an enabling device for ritual culture	Discussion of vocal learning in humans and birds. Songs of whales, seals, parrots, hummingbirds, and songbirds CR: ---	Review of ritual human culture and of vocal learning, which is restricted to humans, whales, seals, and birds, not shared by apes	Stages of imitation of "conformal motive" in vocal output: 1) Subsong, babbling production 3) High-fidelity replication	We broke with the apes by adding ritual culture to instrumental (practically oriented) culture. Suggestion: The "conformal motive" seems to play a profound role in ritual culture
3. Fitch (29-49) Music Evolution Cat. 6: Animal sounds	Providing an empirical basis for research on the evolution of music making in humans	Human and animal sound production. Discussion of music and language: similarities and differences, design features. Sound production in birds, whales, dolphins, seals. Ape drumming. CR: ---	Review of vocal learning in birds, cetaceans (whales and dolphins), pinnipeds (seals and sea lions), hominids. Clapping and drumming in apes	Phylogeny of musical abilities. Possible adaptive functions of music in evolution	Arguments for the evolutionary significance of song and motherese in childcare. Ape drumming: potential homologue of instrumental music
4P. Langner (50-52) Neuronal Mechanisms of Pitch and Harmony Cat. 1: Pitch Cat. 2: Harmony	Explanation for pitch perception and the preference of the hearing system for harmonic relationships	No musical material CR: ---	Review of theory and anatomical details suggesting an explanation of the brain's extraction of periodicity pitch	Temporal processing of periodic acoustic signals in brain stem and inferior colliculus. Anatomy of ventrolateral lemniscus	Suggestion: The recognition of musical harmony, or consonance, is an intrinsic property of our brains

P: indicates a short poster paper, e.g. 4P

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
5P. Large & Tretakis (53-56) Tonality and Nonlinear Resonance Cat. 1: Scales	To outline a theory of tonality that predicts tonal stability, attraction and categorization	No musical material CR: ---	Mathematical analysis of resonator networks, providing possible analogues of psycho-acoustic phenomena	Hypothesis: Nonlinear frequency analysis by the cochlea, further trans-formation in networks of neural resonators	Theoretical predictions of perceptual categorization are hypothesized

Part II. Music and Language **5 papers**

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
6. Patel (59-70) Melody and syntax Cat. 2: Harmony Cat. 6: Language	1) To investigate the notion that instrumental music reflects speech patterns in the composer's native language 2) To investigate the relationship between musical and linguistic syntax processing via the study of aphasia	1) Spoken sentences in English and French. 300 classical themes by six English and ten French composers 2) Spoken sentences, five levels of syntactic complexity. Sets of two successive chords (SN//) CR: Western	1) Measuring the variation of pitches and pitch intervals in speech (prosogram representations, glides ignored) and in musical themes Prosogram: A semi-automatic quantitative graphic analysis of speech intonation 2) Nine Dutch-speaking aphasics, twelve controls. Sentence-picture matching task and harmonic priming task	1) What aspects of intonation patterns are learned and reflected in music? 2) Do aphasics with syntactic comprehension problems in language also have a musical syntactic deficit?	New evidence for the relationship between linguistic prosody and musical structure, and between syntactic processing in music and language. A good deal more can be done

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
7. Schön et al. (71-81) Song Perception Cat. 5: Song	Understanding whether the different levels of music and language processing are independent or interactive	1) Pairs of spoken words, sung words, vocalises and noises. 2-3) Pairs of sung words CR: French	Nonmusician participants. 1) fMRI: same or different judging task 2) Event-related brain potential (ERP): same or different judging task: a) focusing on words b) focusing on melody 3) fMRI: same tasks as 2)	Cerebral structures involved in song processing. Relationship between the linguistic and musical dimensions of song	Linguistic and musical dimensions of songs are processed by similar, overlapping brain areas. The use of simple material (pairs of stimuli) may limit the scope of the conclusion. Need for research based on more ecological materials
8P. Gaab et al. (82-88) Neural correlates of rapid processing Cat. 8: Musicians	To investigate if musical training alters the functional anatomy of rapid spectrotemporal processing	Three-tone sequences comprising two complex tones (SNI) CR: Neutral	20 musicians and 20 non-musicians. Task: Listen and reproduce the order of the tones by button press.	Potential effect of musical training for improving language and reading skills	Musical training may enhance skills essential to language and reading
9P. Schönwiesner et al. (89-92) Spectral and temporal processing Cat. 3: Complex sounds	To identify cortical areas in which the functional magnetic resonance covaries with spectral and temporal acoustic complexity	Novel noise-like stimuli differing in temporal complexity and spectral complexity, but not in bandwidth and energy CR: Neutral	19 normal subjects. fMRI, sparse imaging. Ten stimulus conditions and silent condition presented in random order.	Acoustic basis of the hemispheric lateralization of speech / music perception	Left Superior Temporal Gyrus (STG) activity covaries preferentially with temporal modulation, Right STG activity with spectral modulation
10P. Moreno & Besson (93-97) Musical Training and Pitch Processing Cat. 6: Language Cat. 10: Training	To determine whether eight weeks of musical training based on pitch processing could help 8-year old children detect pitch changes in language	Short sentences from children's books. Fundamental frequency of final word manipulated to create weak or strong pitch violation. CR: French	10 children with musical training, 10 with painting training. EEG: Event-Related Potential (ERP); Reaction time. Task: Determine if final words sounded normal or strange.	Effect of musical training on language skill	Some evidence for an influence of music training on pitch processing in language after eight weeks of training

Part III. Mental Representations 9 papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
11. Tillmann (100-110) Tonal knowledge in nonmusicians Cat. 13: Expectation	Investigation of implicitly acquired tonal knowledge: musical expectations in nonmusicians	Recent study: Musical material played with instrumental timbres or sung with artificial syllables. CR: Western	Priming paradigm: Relationships between priming context and target event are systematically manipulated. Speed of processing is measured	Extensive review of research. Recent study: To isolate neural correlates of musical structure violation	Inferior frontal regions are sensitive to musical expectancy violations and involved in the processing of music-syntactic relationships
*12. Janata (111-124) Brain networks that track musical structure Cat. 13: Attention Cat. 18: Bodily impact	1) To illustrate that brain responses to musical stimuli depend on tasks and methods 2) To identify brain regions that follow the movement of a melody through tonal space	<i>Recorded music</i> : 1) Schubert piano trio, 15 sec. excerpt 2) Composed melody that systematically moves through 24 major and minor keys CR: Western	fMRI: 1) Listeners orient their attention to a single instrument or to the whole 2) Listeners perform a tonal-deviance judgment task or a timbral-deviance detection task	1) Influence of task demands on brain processes 2) Functions of the rostral medial prefrontal cortex (RMPFC). Correlation of heart rate and respiration with Blood Oxygenation Level Dependent (BOLD) response in the brain	1) Task demands shape the brain's processing of music. 2) Significant correlation of heart rate and respiration with BOLD. Hypothesis: The RMPFC is a locus at which music and autobiographical memories are bound together.
13. Rauschecker (125-135) Neural encoding of sound sequences Cat. 13: Anticipation Cat. 14: Memory	To contribute to the understanding of processing and storage of tone sequences in the cerebral cortex	<i>Recorded music</i> : 1) Sound tracks from each subject's favorite CD 2) Repeated three-tone sequences (ABA), variable frequency separation between A and B (SN). CR: Western / Western popular	1) Humans: fMRI during silent anticipation of next CD track 2) Monkeys: recording of single-unit neural responses to ABA tone patterns in primary auditory cortex	1) Difference between anticipating familiar music vs. waiting for unfamiliar music 2) Monkey neuron's responses to one-stream and two-stream perception	1) Anticipatory musical imagery activates left anterior prefrontal cortex (Brodmann area 10), cerebellum, and other regions. 2) Correspondence between changes in neural response and perception
14. Platel (136-147) Semantic and episodic musical memory Cat. 14: Memory	To determine the neural substrates underlying the semantic and episodic components of music using familiar and nonfamiliar tunes	64 familiar and 64 unfamiliar melodies, 5 sec, flute timbre CR: Western	Nine healthy young men, common listeners. PET during tasks: 1) Semantic memory: is the extract familiar or not? 2) Episodic memory: Do you recognize this melody from task 1? 3) Control: Same or different final pitches? 4) Rest	Activated brain regions; differences between hemispheres	1-2) Functional asymmetry in favor of left hemisphere for semantic memory, right hemisphere dominance for episodic retrieval. 3-4) Bilateral activation in pitch judgment, more on right side

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
15. Tramo et al. (148-174) Pitch perception and the auditory cortex Cat. 1: Pitch	To contribute to correcting longstanding misconceptions about the functional role of auditory cortex in frequency discrimination and pitch perception	Selections of pure tones and harmonic tones with and without energy at the fundamental frequency applied in a large number of reviewed experiments CR: Neutral	Comprehensive critical review of literature from the past 50 years. Discussion of cortical mechanisms mediating pitch perception. 108 references	1) Gross and microanatomical distribution of cortical mechanisms 2) Candidate neural coding schemes	1) Pitch change detection and pitch direction discrimination are different functions 2) The cortical code for pitch is not likely to be a function of simple rate profiles or synchronous temporal patterns.
16. Hodges et al. (175-185) Integration of visual and auditory information Cat. 8: Musicians Cat. 16: Audiovisual	To examine multisensory processing in conductors and a matched set of control subjects	Sinus tones Visual stimuli (LED) Broadband noise bursts CR: Neutral	10 conductors, 10 musically untrained controls. Behavioral tasks: 1) Pitch discrimination 2) Temporal-order judgment (TOJ) 3) TOJ with multisensory cues 4) Target localization fMRI: Task 3) repeated	Integration of auditory and visual information	Conductors are more accurate in all tasks. fMRI: Cortex Brodmann Areas BA 37, 39/40 implicated in conductors' superior multisensory performance
17P. Baumann et al. (186-188) Network for sensory-motor integration Cat. 17: Sensory-motor	What happens in the auditory cortex during piano playing without acoustic feedback?	1) <i>Material for performance task</i> : Mozart: Sonata Facile and scales for silent performance 2) <i>Recorded music</i> : Listening to recordings of the Mozart Sonata and scales. CR: Western	fMRI during pure motor tasks and pure listening tasks. 7 pianists, 7 non-musicians	Audiomotor integration: Information transfer between auditory and motor cortices	Piano playing movements activate secondary auditory cortex. Listening evokes activity in secondary motor regions
18P. Lahav et al. (189-194) The power of listening Cat. 17: Sensory-motor	To test musically naive subjects' potential to achieve a functional linkage between actions and sounds	<i>Material for performance task</i> : Five-note musical piece to be played with right hand on piano keyboard, and to be listened to passively CR: Western	58 non-musicians. 1) Learning sessions, pitch recognition test. 2) Three groups: a) listened passively to the same piece b) listened to nature sounds c) got additional practice	Testing the effect of passive listening on music performance	1) A single piano session facilitates pitch recognition 2) Passive listening to music improves motor performance

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
19P. Rusconi et al. (195-197) Pitch height Cat. 1: Pitch	To test whether sound frequency (pitch height) elicits a mental spatial representation	1) Single tone and a reference tone (<i>SW</i>) 2-3) Single tone played by a wind or a percussion instrument CR: Neutral	1) Determine whether the tone is higher or lower than the reference by pressing one of two keys 2-3) Indicate wind or percussion by pressing one of two keys 1 & 2: Nonmusicians. 3: Trained musicians	Comparing reaction time and accuracy in compatible condition (upper key press for high pitches) and incompatible condition (lower key press for high pitches)	Pitch height influenced performance consistently with vertically aligned responses irrespective of its relevance to the task, suggesting that the cognitive system maps pitch onto a mental representation of space

Part IV. Developmental Aspects and Impact of Music on Education 8 papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*20. Schellenberg & Hallam (2002-2009) Music listening Cat. 19: Mood, emotion	Testing the spatial abilities of a large sample of 10-11 year olds after listening to pop music, Mozart or a verbal discussion	<i>Recorded music:</i> a) Pop recordings by Blur, Mark Morrison, PJ & Duncan b) 10 min. of Mozart String Quintet K.593 c) A discussion of the experiment. CR: Western / W. popular	After listening to a) b) or c) in 3 groups, performing two tests of spatial abilities: Square completion and paper folding	Re-testing the "Mozart effect" experiment. The article includes a review of a number of studies which aim at replicating this experiment	The group that listened to popular music performed better than the two other groups. The arousal and mood of a pleasant stimulus can enhance cognitive performance
21. Overy et al. (210-218) Examining rhythm and melody processing by fMRI Cat. 1: Melody Cat. 4: Rhythm	Designing a fMRI protocol specifically for young children aged 5 to 7	Pairs of melodies on C major scale or rhythms with constant pitch. Five notes, marimba-like sound CR: Western	fMRI during same-or-different task. Sparse sampling, button press cued by short noise burst	To help children feel comfortable and confident during the scanning session	Protocol effective, children comfortable. Clear auditory activations. Useful methodology
22. Schlaug et al. (219-230) Effect of music training on the child's brain Cat. 10: Training	To examine the brain and cognitive effects of instrumental music training on 5-7 years old and 9-11 years old Children	Pairs of short musical phrases (SNL, probably material similar to 21 above) CR: Western	fMRI during same-or-different task. Sparse sampling, button press	Functional brain changes after one year and after four years of instrumental training	Preliminary results suggest cognitive and brain effects from instrumental music training. Only a longitudinal study can prove causality
23. Jentschke et al. (231-242) Music and language in children Cat. 2: Harmony Cat. 6: Language	To examine brain processes in children related to violation of harmonic expectancies and linguistic syntax	1) Five-chord sequences, ending in tonic or supertonic. In some sequences, one chord is played in another instrumental timbre. 2) Correct and incorrect sentences. In some sentences, male/female voice is changed in one word CR: Western	EEG: Event-related potentials (ERP) recorded during tasks: 1) Detect different instrumental timbre 2) Detect change in voice timbre. a) 11 years-old musicians vs. non-musicians. b) 5 years-old children with or without Specific Language Impairment (SLI)	Early right anterior negativity (ERAN), Early left anterior negativity (ELAN)	a) ERAN is present in both groups, larger amplitude in musically trained 11 years-old children. b) ERAN is present in linguistically nonimpaired 5 years-old children, but not in children with language impairment

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
24. Thaut et al. (243-254) Temporal entrainment of cognitive functions Cat. 14: Memory	To investigate the effect of music as a mnemonic device on learning and memory and the underlying plasticity of oscillatory neural networks	15 words presented in spoken form or in a song CR: Western	After learning trials: EEG during immediate recall trial and second recall trial after 20 min. delay. a) 20 nonmusicians b) 40 patients with multiple sclerosis	Whether external timing embedded in learning stimuli, via music, can modulate oscillatory synchrony in learning-related neural networks	Data suggests that music, via melodic-rhythmic structures, enhances memory performance by mapping temporal order on learning information
*25. Sloboda et al. (255-261) Tone deafness in general population Cat. 11: Deficit Caat. 20: Musical expression	1) To investigate whether adults defining themselves as tone-deaf or unmusical are neurologically normal or not. 2) Adding new subtests to the MBEA	<i>Recorded music: Recordings of 5 performances by a violinist</i> of each target melody in the Montreal Battery for the Evaluation of Amusia (MBEA): happy, very happy, sad, very sad, neutral. CR: Western	1) Interview inquiry: What do you think tone deafness is? 2) Nine amusic persons, 23 controls. Task: same / different judgment of conveyed emotion	Whether persons known to have anomalies in the processing of musical pitch and rhythm are sensitive to expressive variation in performance	Amusic participants perform equally well as the controls. They retain the ability to process variations in articulation, tempo, and timbre.
26P. Costa-Giomi (262-264) Music instruction and fine motor abilities Cat. 10: Training	To investigate whether two years of piano instruction improves fine motor abilities	Two years of weekly individual piano lessons to experimental group, n=51, none to control group, n=39. CR: Western	Bruinsky-Oseretsky test of motor proficiency, pre and post. Subtests: Response speed, Visual-motor control, Upper-limb speed and dexterity	Effects of two years of piano instruction	Fine motor skills of the piano group improved significantly more than controls, especially in response speed
27P. Penhune et al. (265-268) Effect of early musical training Cat. 10: Training	Is there a sensitive period in childhood for motor training, similar to that observed for language learning?	<i>Visual stimuli for performing tapping task</i> : 10-element sequences of long and short white squares presented sequentially in the center of computer screen CR: Neutral	Performing task: Tap in synchrony with visual stimulus. Five days of practice before test. Measurements: Response accuracy, variance, synchronization	To compare performances of musicians who began training before age seven and musicians who began training after age seven	Considerable overlap in performance between groups. Early trained musicians show an advantage in response synchronization

Roundtable on Music Therapy (28-31)

Title, Category	Aim	Mus. material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
28. Hillecke et al. (271-282) Perspectives on music therapy Cat. 12: Music Therapy	To contribute to the development of an adequate research strategy for evidence-based music therapy	No particular musical material CR: Neutral	A table of therapy research strategies	Effective ingredients in the field of music therapy: Modulation of attention, emotion, cognition, behavior, communication	A number of questions about the relevance of neurocognitive theories and methods for music therapy research
29. Nickel et al. (283-293) Research in music therapy Cat. 12: Music Therapy	To present selected outcome studies carried out in order to give music therapy a scientific and empirical base	No particular musical material mentioned. CR: Not indicated	3 randomized controlled trials (RCT): 1) Chronic pain 2) Children with migraine 3) Chronic tinnitus	Clinically and statistically significant results of music therapy	Evidence for the effect of music therapy in specific clinical fields: 1) Chronic pain 2) Children with migraine 3) Chronic tinnitus
30. Sabbatella (294-302) Research in Ibero-American countries Cat. 12: Music Therapy	An overview of the status of music therapy in Ibero-American countries	No particular musical material mentioned. CR: Not indicated	Review of 11 music therapy journals and 12 conference proceedings	Assessment and clinical evaluation of music therapy clinical practice	Need to develop assessment and clinical evaluation tools on a higher scientific level
31. Thaut (303-308) The future of music in therapy and medicine Cat. 12: Music Therapy	A brief overview of theory and clinical practice in music therapy	No particular musical material mentioned. CR: Not indicated	Review of selected research and clinical practice	The rhythmic patterns of music can help movement in Parkinson's disease patients. Musical information is retained in Alzheimers' disease patients	Music can communicate information to the brain that has profound effects on learning, development, recovery of function, and aesthetic engagement

Part V. Neurological Disorders and Music 4 papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
32. Cuddy et al. (311-324) Musical difficulties are rare Cat. 11: Deficit	To compare self-reports of tone deafness (TD) with tests of perceptual difficulties. And to compare the tests of TD group with a Non-TD control group	Six subtests of the Montreal Battery of Evaluation of Amusia (MBEA): scale, contour, interval, rhythm, meter, memory. Synthesized tones. CR: Western	1-5: Same-different trials: A standard melody is followed by a comparison melody. 6: Memory recognition test. Plus self-report questionnaire	Whether self-report of tone deafness is a strong indicator of amusia	A tendency for Non-TD participants to obtain higher scores than TD. But many individuals who consider themselves "tone-deaf" may not have perceptual difficulties
33. Levitin (325-334) Evidence from Williams syndrome Cat. 11: Disorder	To summarize a series of studies on music and Williams Syndrome (WS), a neurogenetic developmental disorder	Excerpts from familiar and unfamiliar classical music, and types of noisy sounds that WS individuals are often sensitive to CR: Western	fMRI study: Music vs. rest, noise vs. rest, music vs. noise. Other studies: rhythmic production and melodic production ability	Musical abilities of WS individuals compared with Downs' syndrome, Autism and normal controls	WS individuals are more engaged with music than members of other groups. Music perception and rhythm production are equivalent to normal. fMRI: WS have greater right amygdala activation
34. Candia et al. (335-342) Hand Dystonia Cat. 11: Deficit	In patients with hand dystonia, to assess whether motivated training can retune brain anomaly	No particular musical material CR: ---	MEG: studying finger representations in somatosensory cortex pre and post treatment: immobilizing finger(s) with a hand splint	Somatosensory finger representation in the two hemispheres: Different = one side affected by dystonia. Similar = relief of dystonia	In guitarists and pianists: Cortical changes, together with emergent neurological dysfunction, can be redressed by context-specific treatment
35P. Pressnitzer et al. (343-345) Music to electric ears Cat. 11: Deficit	To better understand how recipients of cochlear implants (CI) perceive basic sound attributes involved in music listening	Bandpass-filtered harmonic complexes delivered acoustically CR: Neutral	Tasks: 1) Higher-lower pitch judgement. 2) Comparison of melodies 3) Just-noticeable difference (JND) on timbre: attack time and spectral centroid	Pitch and timbre perception by cochlear implant patients	High pitch discrimination thresholds. Melody task impossible. Timbre task: CI group performs almost as well as control group

Part VI. Music Performance 8 papers

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
36. Lim et al. (349-359) Enhanced P1-N1 auditory evoked potential Cat. 11: Deficit	To investigate whether there are electrophysiological changes in patients with musicians' cramp	Single pure tone 261.6 Hz, middle C, presented monaurally in earphones CR: Neutral	2000 stimuli divided in 8 blocks of 250. Alternating presentations to left and right ear. Patient group of guitarists compared to control group	EEG: Auditory evoked potentials, especially P1, N1a, N1, N1b, P2, and possible generators. Peak-to-peak amplitudes calculated	Patients have larger peak-to-peak difference in P1 and N1a than control group. Suggestion: Patients have multiple sensory deficiencies
37. Palmer (360-367) Time course of retrieval and movement preparation Cat. 14: Memory	To consider whether item retrieval and movement preparation in music is best described as serial stages or cascaded processes	No particular musical material CR: ---	Review of literature	Choice of best model: serial (subsequent preparation), cascade or single model (simultaneous preparation)	Early evidence is most consistent with cascade models: Multiple processes are activated at least partly in parallel
38. Ullén et al. (368-376) Neural control of rhythmic sequences Cat. 4: Timing	To investigate whether the temporal structure of movement sequences can be represented and learned independently of their ordinal structure	<i>Material for performance task:</i> Rhythmic sequences to be performed with right index finger on the numerical keypad of a PC CR: Neutral	fMRI during performance tasks: 1) Combined ordinal + temporal. 2) Temporal only, performed on one key. 3) Ordinal only, performed in regular rhythm.	Dissociation between brain regions involved in ordinal and temporal control in spatiotemporal sequence performance	The processing of temporal sequences in voluntarily timed motor tasks is largely independent from the processing of ordinal information
39. Stewart (377-386) Neurocognitive approach to music reading Cat. 8: Musicians Cat. 16: Audiovisual	To investigate how musical symbols on the page are decoded into a musical response	<i>Material for performance task:</i> Notated five-note melodies to be played on keyboard CR: Western	1) Performance task: Play five-note melody. Conditions: a) Numbers superimposed on musical notes are congruent with scale step. b) incongruent with scale step 2) fMRI before and after learning to read music	1) Difference in reaction time of musicians and non-musicians between a) and b). 2) measuring changes in the brains after 3 month learning period	1) Musicians are slower when notes and numbers are incongruent. 2) Learning-related changes: Melody reading ("what"): superior parietal cortex. Rhythm reading ("when"): fusiform gyrus

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*40. Schneider et al. (387-394) HG and musical instrument preference Cat. 8: Musicians	To classify music listeners, including professional musicians, as fundamental or spectral pitch listeners, and to investigate their neural basis	144 pairs of synthesized complex tones, which may be perceived as a fundamental pitch or as single harmonics of the complex tone CR: Neutral	1) n= 463. Task: identify the dominant direction of pitch shift in tone pairs 2) in a subgroup, n= 87: MRI and MEG to demonstrate neural differences	1) classification in fundamental and spectral listeners, and 2) their differences in gray matter volume of left and right Heschl's gyrus, plus functional P50m activity	Fundamental pitch listeners exhibit a pronounced leftward asymmetry, spectral pitch listeners a pronounced rightward asymmetry
*41P. Bermudez & Zatorre (395-399) Differences in gray matter Cat. 8: Musicians	To examine differences in cerebral morphology between musicians and non-musicians	No particular musical material. CR: ---	MRI of 52 nonmusicians and 43 musicians. Voxel-based morphometry	Differences in gray matter (GM) concentration btw. musicians and non-musicians	Greater GM concentration in musicians in the right lateral surface of the Superior Temporal Gyrus
42P. Chen et al. (400-403) Tapping in synchrony to auditory rhythms Cat. 4: Rhythm Cat. 17: Sensory-motor	To examine how synchronizing movements to auditory rhythms affects behavioral performance and neural activity	Woodblock sound. Three auditory rhythms: metric simple, metric complex, nonmetric CR: Neutral	Task: Tap in synchrony with rhythm. fMRI during tapping	Tapping performance and BOLD covariation as a function of increasing rhythm complexity	Increasing complexity results in more asynchronous tapping, and increased activity in cerebellum and premotor cortex
43P. Zarate & Zatorre (404-408) Neural substrates Cat. 5: Song Cat. 17: Sensory-motor	To determine the neural substrates governing audiovisual integration for vocal pitch regulation in singing	Five target notes (SN//) CR: Neutral	fMRI during Task: To sing back note a) normal b) with 200 cents shifted auditory feedback c) instructed to correct for pitch shift	Differences in neural substrates involved	Increased activity in the anterior cingulate cortex and insula in tasks that specifically require monitoring of auditory feedback and pitch control

Part VII. Emotion in Music **10 papers**

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
44. Koelsch (412-418) Investigating emotion with music Cat. 19: Emotion	Review of functional imaging studies on the investigation of emotion with music	Different kinds of musical material in reviewed research. 20 references CR: ---	Mainly fMRI and PET. Also included: EEG and physiological measures: cardiac, vascular, electrodermal and respiratory functions	Involvement of cerebral structures during the processing of pleasant and unpleasant music, unexpected harmonies and emotional changes over time	Processing of music with emotional valence involves a number of limbic and paralimbic structures. Synaptic processes may be excitatory or inhibitory
45. Samson & Peretz (419-428) Prior exposure effects on music liking Cat. 11: Deficit Cat. 19: Preference	To examine the contribution of the right and left medial temporal lobes to musical preference and recognition	Presentation of 20 familiar and 20 unfamiliar melodic excerpts (<i>SNM</i>) CR: Western	Test: The 40 studied melodies were mixed with 40 nonstudied ones. Task 1: Rate liking on a 10-point scale. Task 2: Rate if melody was heard before on a 10-point scale	After surgical treatment of epilepsy: Effects of right temporal lobe (RTL) resection (n=19) vs. left temporal lobe (LTL) resection (n=18). Control group (n=16)	Suggestion: RTL structures play a critical role in the formation of melody representations. LTL structures are more involved in the explicit retrieval of melodies
*46. Bigand et al. (429-437) Time course of emotional responses to music Cat. 8: Musicians Cat. 19: Emotion	To investigate the time course of emotional responses to music	<i>Recorded music:</i> 1) 27 excerpts of classical nonvocal music, 1 or 25 sec. chosen to illustrate a variety of emotions. 2) excerpts of classical and pop/rock music, 250 msec. to 20 sec. CR: Western / W. popular	Groups of musically trained and untrained listeners. 1) Task: To group excerpts that convey a similar emotional meaning 2) Task: To differentiate between "highly moving" and "less moving" music	1a) Correlation of emotional responses between participants. 1b) Time required for response 2) Time required for differentiation	1) Highly correlated matrices of emotional similarity. No difference between musicians and non-musicians. 1-2) Less than 1 sec. of music is enough to instill elaborated emotional responses in listeners

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
47P. Eschrich et al. (438-442) Remember Bach Cat. 14: Memory Cat. 19: Emotion	To investigate whether emotional music is kept better in episodic long-term memory than less emotional music	<i>Recorded music</i> : Target pieces: 30 J.S. Bach piano pieces, 30-60 sec, pre-categorized by valence and arousal ratings CR: Western	Ten non-musicians. 1) Rate the emotions induced by the target pieces: arousal, valence and strength. 2) Two weeks later: Recognition test, target pieces mixed with other pieces.	The effect of emotion on musical episodic long-term memory	Preliminary result from small sample: Emotional arousal seems to be more important for episodic long-term storage and retrieval of music than emotional valence
48P. Filipic & Bigand (443-445) Key processing precedes valence appraisal Cat. 19: Emotion	To investigate prediction: key processing precedes the appraisal of valence in music	24 musical excerpts, 12 peaceful, 12 sad, played on MIDI keyboard by professional pianist. CR: Western	Clips ordered in 48 pairs: same or different emotion, same or different key. Tasks: 1) Indicate emotion 2) indicate as fast as possible whether 2nd clip expresses same emotion	Response time for task 2	1) 90% correct identification of emotion 2) Longer response times for pairs of melodies in different keys: Support for prediction
*49P. Grewe et al. (446-449) How does music arouse chills? Cat. 18: Bodily impact Cat. 19: Emotion	To investigate chill experiences related to distinct musical events	<i>Recorded music</i> : Seven pieces from different musical styles used for all subjects, n=38. Plus pieces chosen by subjects, known to induce strong emotions CR: Western, Western popular	While listening to music, press a button whenever chill is experienced. Skin conductance is measured, and timing of music and button press recorded	Relations between structural musical elements and chill reactions. Retest with one subject for 7 subsequent days to check for reproducibility	Chills are results of attentive, experienced, and conscious musical enjoyment. Factors: harmonic sequences, changes in loudness, entrance of voice, new beginning
50P. Pallesen et al. (450-453) Emotion processing of chords Cat. 2: Harmony Cat. 19: Emotion	To study whether simple musical chords activate brain areas associated with emotion analysis	Nine synthesized piano chords: major, minor and dissonant, each spanning 3 octaves from A3 to A5 CR: Western	fMRI scanning during passive listening to the chords, and during working memory task: cognitive evaluation of the chords.	Differences in BOLD brain responses to major, minor and dissonant chords	Minor and dissonant chords elicit larger responses than major chords in amygdala, retrosplenial cortex, brain stem and cerebellum

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
51P. Passynkova et al. (454-456) Left auditory cortex specialization Cat. 2: Consonance / Dissonance	To investigate the representation of consonant and dissonant chords in the auditory cortex	Synthesized chords and individual notes. Piano timbre using Cubasis software CR: Western	fMRI during listening to consonant and dissonant chords, and the individual harmonic tones of chords	Activation of auditory cortex	Stronger BOLD response to consonant than to dissonant chords in left posterior auditory cortex, mainly planum temporale
52P. Steinbeis et al. (457-461) Processing of harmonic expectancy violations Cat. 2: Harmony Cat. 19: Emotion	To study if harmonic expectancy violations can trigger emotional processes	<i>Recorded music</i> : Six Bach chorales containing unexpected harmonies, plus altered versions containing expected and very unexpected harmonies CR: Western	EEG in 30 locations, plus measurement of Electrodermal activity (EDA) Judgement task: comparing durations, to show attention	Differences in Event-related potentials (ERP) and EDA between responses	Harmonically unexpected events elicit emotional effects
53P. Vines et al. (462-466) Dimensions of emotions in performance Cat. 19: Emotion Cat. 20: Musical expression	To explore the dimensions of emotions conveyed by music	<i>Recorded music</i> : Audio-video recordings of two clarinetists playing a Stravinsky piece in three manners: immobile, standard and exaggerated CR: Western	12 musicians, 12 non-musicians. 3 groups: auditory only, visual only, and auditory + visual. For each stimulus, the experience of 19 emotions was rated on Likert scales. Factor analysis.	Differences in emotional experiences between groups: auditory only, visual only, and auditory + visual.	Visual experiences was the primary channel through which the clarinetists' performance intentions influenced the emotions of observers

The Neurosciences and Music III: Disorders and Plasticity. Conference June 25-28, 2008 at McGill University, Montreal, Quebec, Canada.
A survey of papers in the conference proceedings:
Dalla Bella, S. et al. (eds., 2009) *The Neurosciences and Music III*. Annals of the New York Academy of Sciences, Volume **1169**.

Contents:	Number of papers
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Part IV. Musical Memory: Music is Memory	12 (31-42)
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The survey presents, in brief and schematic form, for each paper:

Abbreviated title as indicated in the conference proceedings, with page numbers. Category of investigation.

Aim of the study

Musical material applied as stimuli in the study. Cultural references of the Musical material.

Technology and Procedure

Main focus of interest

Conclusion

A number of notable papers are marked with an asterisk *. Some notable findings are written in **bold type**.

Recurrent abbreviations: PET: Positron emission tomography.

fMRI: functional Magnetic Resonance Imaging. MRI: Magnetic Resonance Imaging.

EEG: Electroencephalography. MEG: Magnetoencephalography.

CR: Cultural reference. *SNI: Source not indicated*.

Part I. Rhythms in the Brain: Basic Science and Clinical Perspectives (1-9)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
1. Chen et al. (15-34) Auditory-motor interactions Cat. 4: Rhythm Cat. 17: Sensory-motor	To elucidate the neural basis for interactions between the auditory and motor systems in the context of musical rhythm perception and production	1) Isochronous rhythm, progressively altered metric saliency 2-3) Three rhythms differing in complexity: simple, complex, ambiguous (nonmetric) (SNJ) CR: Neutral	fMRI: Tasks: 1) tapping to rhythm. 2) a) listening b) tapping to rhythm. 3) a) listening b) listening with anticipation to tap c) tapping to rhythm	To investigate different couplings between the auditory and motor systems	Dorsal premotor cortex (PMC) is sensitive to rhythm's metric structure. Ventral PMC is not, but it is sensitive to processing action-related sounds. The mid-PMC is engaged during both passive listening and tapping.
2. Grahn (35-45) The role of the basal ganglia in beat perception Cat. 4: Rhythm Cat. 11: Deficit Cat. 17: Sensory-motor	To examine the neural basis of beat perception	1) Novel rhythmic sequences, 3 sec: metric simple, metric complex, nonmetric. 2) Beat and nonbeat versions of sequences, 11-18 sec: Volume accented, duration accented, unaccented (SNJ) CR: Neutral	1a) Behavioral study: Tapping back after hearing 3 times. b) fMRI study of a discrimination paradigm. c) comparison: Parkinson's Disease patients and controls 2) fMRI while healthy participants complete an unrelated task	Functional connectivity between part of the basal ganglia (putamen) and cortical areas: premotor and supplementary motor areas	The basal ganglia is strongly implicated in processing a regular beat, especially when internal generation of the beat is required
3. Large and Snyder (46-57) Pulse and meter as neural resonance Cat. 4: Rhythm	To investigate proposal: Neural resonance provides an excellent account of many aspects of rhythm perception	No particular musical material, multiple references CR: ---	Review of literature, especially EEG and MEG studies. Proposal of a theoretical framework	Neural correlates of rhythm perception in high-frequency oscillatory activity	Hypothesis: Perception of pulse and meter result from rhythmic bursts of high-frequency neural activity in response to musical rhythms
4. Iversen et al. (58-73) Brain mechanisms of metrical interpretation Cat. 4: Meter	To investigate how top-down control of rhythm perception modulates early auditory responses	A repeating sequence of two tones followed by a rest. 45 msec duration pure tones: 1 kHz pips, inter-onset intervals 200 msec CR: Neutral	1) "imagined beat" condition. Instruction: mentally place the beat a) on 1st tone b) on 2nd tone 2) "physical accent" condition. One tone is accented, a) 1st tone b) 2nd tone	MEG: 1) To test whether voluntary metrical interpretation modulates brain responses 2) To test the contribution of exogenous factors in shaping brain responses	1) Metrical interpretation influenced early evoked neural responses to tones, specifically in the upper beta range (20-30 Hz) 2) This beta increase resembles that due to physical accents

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
5S. Abecasis et al. (74-78) Brain lateralization of metrical accenting Cat. 4: Meter	To assess the perception of meter in musically trained listeners	Sequences of identical tones: Repeated patterns of two pairs of tones separated by a single tone (SN/) CR: Neutral	MEG during inattentive listening. Diverting task: Blinking only when visual signal appears	MEG: Differences in dipole strength corresponding to strong and weak beats	Support of a relatively early left-hemispheric effect of metrical processing in musicians
6S. Chakravarty & Vuust (79-83) Musical morphology Cat. 8: Musicians	To compare brain morphology within a cohort of subjects	No musical material CR: ---	MRI: Deformation-based morphological measures of 17 jazz/rock musicians of high rhythmic aptitude	To determine effects of specific learning tasks on cerebral structure	Increased local gray-matter density in motor and auditory areas is correlated to rhythmic ability
7S. Dennis et al. (84-88) Strong- and weak-meter rhythm in Spina Bifida Meningomyelocele Cat. 11: Disorder	To test rhythm perception in children and adolescents with Spina bifida meningomyelocele (SBM), a disabling birth defect of the spinal column	Permutations of equal-intensity tones on a snare drum. Variable onsets of longer intervals: On the beat = Strong-meter rhythms. Off the beat = Weak-meter rhythms. CR: Neutral	1) SBM and control group. Task: To judge two rhythms patterns as same or different 2) MRI of cerebellum of both groups	Volume of cerebellar regions important for rhythm functions	1) SBM perform more poorly than controls. 2) Abnormal configuration of cerebellar volume fractions in SBM
8S. Fujioaka et al. (89-92) Musical beat in auditory cortex Cat. 4: Meter Cat. 17: Sensory-motor	To examine Beta (~20 Hz) and Gamma (~40) band activity in auditory cortices during passive listening to a regular musical beat	262-Hz pure tones, 60 msec duration, with an onset-to-onset interval of 390 msec. Every second tone reduced in intensity to make an alternating loud-soft accent pattern. CR: Neutral	MEG during passive listening. Watching a silent movie, 12 young adults listened to 8 400-sec blocks. Half of the blocks occasionally (30%) omitted the loud tone, and half the soft tone	To assess the effect of accent and omission of accented and unaccented beats	In the auditory cortex, Beta rhythm may play a role in auditory-motor communication. Gamma rhythm may be related to musical beat encoding and anticipation of the next pulse
9S. Honing et al. (93-96) Is beat induction innate or learned? Cat. 4: Meter	To investigate whether meter is more likely a learned phenomenon, possibly a result of musical expertise, or whether sensitivity to meter is also active in adult nonmusicians and infants	Variants of a rhythmic rock pattern. Four standard (S): strictly metrical variants. Two deviants, omitting events on salient positions in the base pattern, D1: strong syncopation, and D2: weaker syncopation. CR: Western popular	EEG: Mismatch Negativity (MMN) responses. 1) 11 subjects listened to two blocks of 300 patterns: 90% S, 5% D1, 5% D2. Task: indicate D by button press. 2) 14 sleeping newborns were presented with five blocks of 300 patterns: 90% S, 10% D1	1) Differences in MMN for stronger and weaker syncopation 2) Comparison of deviant patterns, standard patterns and control patterns	Results suggest that meter induction is active in adult nonmusicians, and that beat induction is already functional right after birth.

S indicates a short paper, e.g. 5S

Part II. Normal and Impaired Singing (10-15)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
10. Dalla Bella & Berkowska (99-107) Singing proficiency in the majority Cat. 1: Pitch Cat. 5: Song	We systematically examined singing proficiency in a group of occasional singers, with the goal of characterizing the different patterns of poor singing	<i>Task material:</i> Sung Performance Battery (SPB), requiring repetition of isolated pitches, intervals, and short novel melodies. In addition, singing three well-known melodies at a natural tempo and a slow tempo, indicated by a metronome CR: Western	39 occasional singers. Tasks: 1) Production task: Sing the beginning of 3 melodies with Polish lyrics. 2) Repetition task: Imitate the same songs at a fixed slow tempo, indicated by metronome beat	Note onset times and pitch heights served to compute various measures of pitch and time accuracy (as below, 11S)	Poor singers were mostly impaired on the pitch dimension. Repeating familiar melodies at a slow tempo improved accuracy on both the pitch and time dimensions
11S. Berkowska & Dalla Bella (108-11) Linguistic information and singing Cat. 5: Song Cat. 6: Language	To examine the effect of reducing linguistic information on singing proficiency in occasional singers (Polish) without formal musical training	<i>Task material:</i> Three highly familiar songs: "Brother John", "Jingle Bells" "Sto lat", with Polish lyrics CR: Western	39 occasional singers. Task: Sing melodies a) with lyrics, b) on the syllable /la/. 1a & 1b) Production task: singing from memory. 2a & 2b) Repetition task: the same songs at a fixed slow tempo	Differences in pitch precision: Interval errors, contour errors, interval deviation errors, initial pitch deviation. Differences in temporal precision: Note durations, temporal variability, tempo deviation	Higher accuracy, mostly in the pitch dimension, when singers produced melodies on a syllable as compared to singing with lyrics

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
12S. Cohen et al. (112-115) Cross-cultural research in the acquisition of singing Cat. 5: Song Cat. 7: Culture	To propose a test battery of singing skills and a protocol for obtaining audiovisual information reflecting aspects of the ability to sing	<i>Task material:</i> 11 components, including singing back intervals and scales, familiar and unfamiliar songs, improvisation and free composition. CR: Western	Two researchers administered the battery to 12 children age 3, 5 and 7, and 8 adults. Sessions were videotaped	To develop a digital library for storing audiovisual data of singing : Children's International Media Exchange for Singing (CHIMES).	Data analysis in progress
13S. Hutchins & Campbell (116-120) Time to reach target frequency in singing Cat. 1: Pitch Cat. 5: Song	To describe a new technique for estimating the time to reach a target frequency in singing (TRTF)	<i>Task material:</i> Participants sing back the pitch of the final tone in a short melody CR: Western	An adaptive windowing time-frequency estimation method performed using MATLAB software	To examine the way singers correct an inaccurate initial pitch, and their trajectory through pitch space	For analyzing sung vocal production, this method has advantages compared with onset latency (OL) measures
14S. Loui & Schlaug (121-125) Investigating musical disorders with DTI Cat. 11: Disorder	To investigate the connectivity of the Arcuate Fasciculus (AF) using Diffusion Tensor Imaging (DTI)	No musical material CR: ---	Acquiring anatomical images using Structural MRI with DTI. Participants: 12 subjects, 6 tone-deaf and 6 controls	Tractography to reconstruct white-matter tracts, especially the Arcuate Fasciculus (AF) connecting Broca's and Wernicke's areas in the frontal and temporal lobes	Musically tone-deaf individuals, who show impairments in pitch discrimination, have reduced connectivity in the AF compared to musically normal-functioning control subjects
15S. Mesz & Eguia (126-130) Time-frequency model for pitch of vibrato tones Cat. 1: Pitch Cat. 3: Complex tones	To study vibrato as the manifestation of a non-stationary tone that can evoke a single overall pitch, by means of time-frequency representations (TFR), which provide accurate representations of rapidly changing sounds	Frequency-modulated sinusoids CR: Neutral	Four subjects, varying degree of musical training, ages 25-38 years. Task: to match the pitch of the modulated tone and an unmodulated sinusoid	Some results suggest that the perceived pitch could be governed by some stability-sensitive mechanism	A recently proposed time-frequency representation (TFR) could be the simplest framework to explain this hypothetical stability-sensitive mechanism

Part III. Music Training and Induced Cortical Plasticity (16-30)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
16. Trainor et al. (133-142) Music training and oscillatory activity Cat. 10: Training	To investigate the effects of musical training on gamma-band activity	Six synthesized 500 msec tones: violin, piano, and sinus tones at pitches of 220 and 141 Hz CR: Neutral	EEG during passive listening while tones were delivered in random order. 11 professional violinists, 9 amateur pianists, 14 non-musicians. 12 children, 4 1/2 years, half of them beginning Suzuki piano lessons. Retest after 1 year	Induced gamma-band response has been associated with attention, expectation, memory retrieval, and integration of top-down, bottom-up, and multisensory processes.	Evoked gamma-band response is stronger for musical tones than for sinus tones in both musicians and non-musicians. Clear effect of musical training on gamma-band responses to musical tones.
17. Pantev et al. (143-150) Multimodal integration and plasticity in musical training Cat. 10: Training	To investigate the impact of short-term uni- and multi-modal musical training on auditory-somatosensory integration and plasticity	For MEG: Piano tones: a) 3-tone standard sequence: G major broken chord. Deviant: last tone a minor third lower. b) 6-tone standard sequence: Melody in C major. Deviant: last tone a minor third lower CR: Western	23 nonmusicians randomly assigned to a sensorimotor-auditory group (SA) or an auditory group (A). SA learned to play a training sequence on the piano. A actively listened to the same sequence	Magnetoencephalographic (MEG) measurements of musically induced mismatch negativity (MMN) before and after training	SA showed significant enlargement of MMN after training compared to A, reflecting greater enhancement of musical representations in auditory cortex
*18. Tervaniemi (151-156) Musicians – same or different? Cat. 8: Musicians Cat. 10: Training	To review the evidence available about various neurocognitive profiles of musicians playing different instruments and genres	a) Instrumental sounds compared to sinus tones b) Instrumental and sinus tones: chords in tune and mistuned. c) sounds originating from one of six loudspeakers CR: Western	Review of studies. a) MEG: N1m response in musicians and nonmusicians b) Mismatch Negativity (MMN) response in musicians and nonmusicians. c) EEG: P3a response	a & b) Difference in response to sinus tones and to tones in the timbre of a musician's own instrument. c) in conductors: accuracy to process spatial sound information	a) Musicians had an enhanced response to the timbre of their own instrument. b & c) attentional neural processes can be modified by the type of musical expertise
*19. Wong et al. (157-163) Asymmetric cultural experiences and the auditory pathway Cat. 7: Culture Cat. 10: Training	To discuss the impact of short- and long-term asymmetric musical experiences on how the nervous system responds to complex sounds	a) Spoken sounds from tone languages. <i>Recorded music:</i> b) Excerpts from Bach partitas. c) 30-sec excerpts of Western and Indian compositions for recognition task. 10-18 sec Western and Indian melodies for tension judgment task CR: Western, Indian	a-b) Review of studies on the effects of musical training. c) Recognition and tension judgment tasks: 3 groups: 1) Monomusical Western. 2) Monomusical Indian. 3) Bimusical Western and Indian	a) Brainstem processing: Frequency-following Response (FFR). b) cortical processing. c) Whether "bimusicality" can arise in response to exposure to music from two cultures, even without experience playing an instrument. Differences between 1-2) and 3)	a) Musicians exhibit enhanced encoding of linguistic pitch in the brain stem. c) People can acquire sensitivities to music associated with multiple cultures simply through exposure and enculturation. Listening to music is enough

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
20S. Corrigan & Trainor (164-166) Musical training and perception of key and harmony Cat. 10: Training	To investigate whether musical training accelerates the development of key membership and harmony perception in younger children	A familiar song, e.g. "Twinkle Twinkle Little Star" presented in piano timbre CR: Western	40 children: 19 nonmusicians, 21 beginning music lessons. Task: After initial training, to judge 10 test trials: 6 in standard form, 2 with out-of-key change and 2 with out-of-harmony change on the last chord	Comparison of the first test with a similar test 8-12 months later, when the second group had received music lessons	Formal music training influences key and harmony perception in 3- to 6-year-olds, and even nonmusicians as young as 3 years have some knowledge of key membership and harmony
21S. Duke et al. (169-172) Procedural memory consolidation Cat. 10: Training Cat. 14: Memory	To test the extent to which overnight procedural memory consolidation is affected by extended rest breaks during training	<i>Task material:</i> 1) 5-element finger-tapping sequence 2) 13-note keyboard melody CR: Western	1) 36 nonmusicians 2) 48 non-pianist musicians. Task: 12 30-sec practice blocks. 1/3 took rest break after 3 blocks, 1/3 after 9 blocks, 1/3 no breaks	Retest next day: Comparison of gains in performance due to early rest breaks, late rest breaks, or no rest breaks	Extended intervals of rest early in training lead to largest gain in performance after overnight sleep
22S. Herholz et al. (173-177) Imagery mismatch negativity in musicians Cat. 8: Musicians	To investigate musical imagery in musicians and nonmusicians	Nine well-known songs composed of sinus tones CR: Western	MEG: 15 musicians, 14 non-musicians. Task: After 6 tones of melody, continue the melody in your mind, and judge if a further presented tone is a correct continuation	Imagery mismatch negativity (iMMN) elicited by incorrect tones	Incorrect tones elicited an iMMN in musicians, but not in nonmusicians. MMN is not limited to acoustic sensory input
23S. Huotilainen et al. (178-181) Automatic memory functions in children Cat. 9: Child development Cat. 14: Memory	To record brain responses in order to assess the automatic perception and memory-related brain processes in 2-year old children	1) Modified Multi-feature paradigm (MFP): A simple repeated tone, including changes in pitch, loudness, duration, sound-source location, and temporal structure of sound. 2) Roving Melody Paradigm (RMP): 3-sec musical pieces repeated, with low-level and high-level changes. CR: Western	EEG: five scalp electrodes. 2-year old children participating in musical play school 1) n = 14. 2) n=30	Mismatch negativity (MMN) elicited by changes	Clear indicators of change-detection to all change types. However, several individual children did not show MMN to a specific change type. Both modified MFP and RMP are suitable for studying brain processes in 2-year old children

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
24S. Hyde et al. (182-186) Music and structural brain development Cat. 9: Child development Cat. 10: Training	To demonstrate structural brain changes in relation to behavioral changes in children who received 15 months of instrumental training	<i>Task material:</i> For behavioral tests: 4-finger motor sequencing test, and a "Melodic and Rhythmic Discrimination Test Battery" assessing music listening and discrimination skills CR: Western	MRI scanning followed by automated Deformation-Based Morphometry (DBM) analyses. 15 6-year children receiving keyboard instruction for 15 months, 16 controls	Training-induced brain plasticity	Instrumental children showed areas of greater voxel size change in motor brain areas. Also differences in other brain regions
25S. Marin (187-190) Musical training and syntax development Cat. 6: Language Cat. 10: Training	To investigate children's knowledge of western harmony, and the relationship between musical training and language abilities	Piano or trumpet timbre. Priming paradigm: 3 chords, a target chord preceded by priming: IV-V or no-priming: bVI-bIII chords. CR: Western	31 German-speaking children, mean age 4 years 11 months. 13 attended an early musical training course. 36 trials of paradigm	Dependent variables: Response time and accuracy	Preschoolers possess implicit knowledge of Western harmony regardless of early musical training. Children with musical training showed enhanced language abilities
26S. Moreau et al. (191-194) Mismatch negativity in congenital amusia Cat. 1: Pitch Cat. 11: Deficit	Using Mismatch Negativity (MMN) to investigate pre-attentive pitch change detection in amusics	Tones synthesized in piano timbre. Standard tone 1047 Hz (C6), deviant tones 25 cents or 200 cents higher or lower in pitch CR: Neutral	MMN: 10 amusic adults, 8 matched controls. Instruction: Ignore auditory stimulation while watching a silent movie with subtitles	MMN Event-related potential (ERP) components elicited by pitch changes corresponding to an eighth of a tone	No significant difference between amusics and controls. The amusic brain can process small pitch changes at a pre-attentive level of processing
27S. Rochette & Bigand (195-198) Auditory training in severely deaf children Cat. 10: Training Cat. 11: Deficit	To evaluate a training program that includes numerous nonlinguistic stimuli that tap into several means of cognitive processing	4 categories of auditory stimuli: environmental sounds, music, voices, and abstract sounds CR: Western	4 profound and 2 severely deaf children, mean age 9 y, interacted with games on a sounding platform. After 20 weeks of training, four tasks: identification, discrimination, Auditory Scene Analysis (ASA), memory	Accuracy and processing times for tasks. Comparison of test 1 before training, test 2 just after training, and test 3 6 months later	Children gained benefits of auditory training over a rather short period. Auditory training had a positive side effect on a phonetic discrimination test, for which there was no training

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
28S. Ross & Marks (199-204) Absolute pitch in children Cat. 1: Pitch Cat. 9: Child development	To test for Absolute Pitch (AP) in children with minimal musical experience	1) For note naming: 30 sinus tones and 30 piano tones from the range of C2-C7. For nonmusical AP test: 2a) A sinus tone followed by a silent interval. 2b) A sinus tone followed by randomly generated interfering tones CR: Neutral	2 children, aged 5 years, supposed to have AP. 15 control children, age 5-15 y. Tasks: 1) Name notes. 2) Reproduce the target tone by adjusting the knob of a digital sine function generator. Repeat testing of the two AP children after 5 years	Hypothesis: The salient identifying feature of AP is the ability to encode durable representations of the chroma of periodic stimuli	Data suggest that while the ability to <i>name</i> notes is dependent on learned associations, AP can be a result of the ability to <i>encode</i> meaningful representations of chroma independent of experience
29S. Schlaug et al. (205-208) Training- induced neuroplasticity in young children Cat. 9: Child development Cat. 10: Training	To investigate whether instrumental musical training would alter the development of interhemispheric connections through the corpus callosum (CC)	Private instrumental lessons CR: Western	MRI scanning before and after 30 months of instrumental training. 31 children, mean age 6.5 y. 18 attending music lessons: 11 piano, 7 string instruments. 13 controls: no training	Four areas of CC that could plausibly be affected by musical training since they contain fibers projecting to sensory and motor cortical regions	Early, intensive, and prolonged skill learning leads to significant structural changes in the anterior midbody of the CC, which connects premotor and supplementary motor areas of the two hemispheres
*30S. Strait et al. (209-213) Musical experience and neural efficiency Cat. 6: Infant sound Cat. 8: Musicians Cat. 19: Emotion	To understand how musical experience influences subcortical processing of emotionally salient sounds	An emotionally charged complex vocal sound – an infant's unhappy cry CR: Neutral	Recording of Auditory Brainstem Response (ABR). 30 adults, ages 19-35 years. Groups: 15 musicians with more than 10 years of consistent musical training. A subgroup: 11 musicians who began musical training before 7 years of age. 15 Nonmusicians	The effect of musical experience, probably a sharpening of subcortical auditory processing, resulting in fine neural tuning to acoustic features important for vocal communication	Musical training engenders subcortical efficiency that is connected with acoustic features integral to the communication of emotion

Part IV. Musical Memory: Music is Memory (31-42)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
31. Schulkind (216-224) Is memory for music special? Cat. 14: Memory	To address two questions: 1) Do cultural beliefs about the mnemonic power of music stand up to empirical test? 2) Can theories designed to explain memory for non-musical stimuli be applied to musical stimuli?	<i>Recorded music:</i> Different kinds of music in different studies, e.g. 1) Popular music 1935-1994. 2) Classical or popular music used as background for memory tests CR: Western, Western popular	Review of the literature on memory for music: 1) Memory for popular music across the life span 2) Memory for music in dementia 3) Music as a mnemonic device 4) Theoretical approaches to evaluating whether memory for music is special	To discuss the reliability of cultural beliefs about musical memory, and the reliability of various kinds of studies	Although the question of whether memory for music is special remains open, the unique structure of musical stimuli strongly suggests that memory for music is indeed special
32. Thiessen & Safran (225-233) Melody and lyric learning by infants Cat. 9: Child development Cat. 14: Memory	To assess whether infants show evidence of reciprocal facilitation between melody and lyrics when learning simple songs	Two strings of 5 digit names: 9-7-3-1-5 and 6-2-8-0-4 a) spoken in an adult register b) each of the strings was sung using different melodies, the second one more tonal CR: Western	40 infants, 6-8 months. Half in the spoken condition, half in the sung condition. Headturn Preference Procedure including familiarization period and test period. Two experiments	Do infants, like adults, capitalize on complexity, or instead do they benefit from simplified input?	Infants learned lyrics more easily when they were paired with a melody than when they were presented alone. Similarly, they learned melodies more easily when paired with lyrics
*33. Bigand et al. (234-244) Local features and familiarity judgments in music Cat. 13: Recognition Cat. 14: Memory	Musically untrained participants were asked to differentiate famous from unknown musical excerpts that were presented in normal or scrambled ways	<i>Recorded music:</i> 12 well-known and 12 relatively unknown pieces of classical music, duration 11-26 sec, were cut in a random way into fragments of 250, 350, 550, and 850 msec, and linked in a scrambled way. 24 spoken texts scrambled in a similar way CR: Western	49 musically untrained undergraduate students (France) in two groups. 1) "Bottom-up" started by listening to all the scrambled pieces that had 250 ms fragments, then 350, 550, 850, and whole excerpt. 2) "Top-down": Reverse order	To evaluate the minimal length of time necessary for participants to make a familiarity judgment. And to assess the contributions of local and global features to object identification. Discussion of identification of words, objects, faces, and music	Familiarity judgments for both music and spoken texts can be made on the basis of excerpts as short as 250 msec. Suggestion: The color of sound, i.e. timbre, harmonic style, voicing, and orchestration provides a very fast route for accessing musical memory traces

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
34. Samson et al. (245-255) Emotional power of music in memory disorders Cat. 11: Disorder Cat. 14: Memory Cat. 19: Emotion	To assess the influence of emotion on memory for music in 1) normal participants 2) patients with intractable Temporal Lobe Epilepsy (TLE) 3) patients with Alzheimer's disease AD)	<i>Recorded music:</i> 1 & 2) 28 nonfamiliar musical excerpts eliciting sadness, peacefulness, fear, and happiness. 3a) 3 popular songs with lyrics, 3 excerpts of film music, 3 short stories. 3b) 8 excerpts of film music, half "happy", half "sad", and 8 10-line poems. CR: Western, Western popular	1) 10 normal nonmusicians. Task: identify emotion by multiple-choice 2) 8 patients suffering from TLE, same task 3a) 6 AD patients: After 10 exposure sessions, Task: "Do you know this?" 3b) 13 new AD patients: After 8 exposure sessions, same task	2) Depth electrode recordings: Whether patients with medial TLE would present a deficit in recognizing emotionally arousing material. 3) Whether the feeling of familiarity will be higher with musical than with verbal materials	2) Recognition of scary music was impaired in TLE patients. 3) Patients with AD, despite their severe explicit memory and language difficulties, can create new musical representations in conceptual memory
35. Peretz et al. (256-265) Musical lexical networks Cat. 13: Recognition Cat. 14: Memory	To identify the neural correlates of the major processing components involved in the recognition of a familiar tune	Synthesized piano sound: a) 28 familiar instrumental melodies, 8.5 sec. b) 28 unfamiliar melodies: retrograde adaptations of the familiar melodies. c) 28 random sequences of tones taken from the melodies CR: Western	9 women (Quebec) with little musical education. fMRI scanning of BOLD response to a) b) c), and silence in randomized order. After scanning, familiarity judgment task on a) mixed with b) in random order	Comparison of cerebral responses to familiar versus unfamiliar music	Comparing familiar music to unfamiliar music, we found focal and bilateral activation in the Superior Temporal Sulcus (STS) with a right-hemisphere bias. This region probably contains musical lexical networks
36S. Akiva-Kabiri et al. (266-269) Music-length effect in tonal pitch memory Cat. 14: Memory	To investigate the nature of musical working memory	Pairs of isochronous tone sequences in C major. (SMI) Four categories: Short and slow, short and fast. Long and slow, long and fast. CR: Western	8 subjects without musical training. Same / different task	Whether musical working memory can be explained by the classical explanation of the word length effect in the verbal domain	Recognition of musical information is affected by both number of items and rate of presentation. Long sequences are better recognized with faster presentation. Word length effect does not explain results
37S. Gosselin et al. (270-272) Impaired memory for pitch in amusia Cat. 11: Deficit Cat. 14: Memory	To assess the possibility that individuals suffering from congenital amusia have pitch memory deficits	1) Two single tones separated by a) a retention interval b) 6 distractor tones. 2) Two sequences of 1, 3, or 5 tones (SMI) CR: Neutral	9 amusics, 9 controls. Same / different task	Interference and length effects on pitch retention accuracy	Amusics' performance on both tasks impaired relative to controls. Results confirm the presence of a pitch memory problem in congenital amusia

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
38S. Grimaud et al. (273-277) Acoustic short-term memory for pitch Cat. 1: Pitch Cat. 14: Memory	To characterize acoustic short-term memory (ASTM) at the functional and neuronal level by the use of fMRI and MEG	Two sequences of tones separated by a silent retention interval. Varying memory load: 1, 3, or 5 tones in sequence. (SN/I) CR: Neutral	Without regard to musical training or ability: 1) fMRI: 15 subjects. 2) MEG: 7 subjects. Same / different task	To identify brain areas that responded in an increasing fashion with increasing memory load	Both analyses revealed brain activations that varied with memory load in the vicinity of secondary auditory cortex, Brodmann area (BA) 22 and superior parietal cortex (BA 5/7)
39S. Groussard et al. (278-281) Neural correlates underlying musical semantic memory Cat. 13: Recognition Cat. 14: Memory	Using PET imaging to determine the neural substrates that underlie musical semantic memory, using different tasks and stimuli	1) Oboe timbre: 2,5 sec monophonic melodies. 2) Flute timbre: 5 sec monophonic sequences 3) Flute timbre: First part of familiar melodies. CR: Western	PET imaging during tasks: 1) Familiar or not? N = 9 2) Familiar or not? N = 12 3) N = 12 Decide whether the second part of melody matched the first. All tasks followed by reference tasks	Semantic memory: the ability to identify familiar melodies. Episodic memory: the ability to recognize a musical excerpt for which the context of its former encounter (when, where, how) can be recalled	Clinical and neuroimaging data suggest that the musical lexicon (and musical semantic memory) is sustained by a temporo-prefrontal network involving right and left hemispheres
40S. Pecenka & Keller (282-286) Auditory imagery and musical synchronization Cat. 14: Auditory imagery Cat. 17: Sensory-motor	To investigate the contribution of auditory imagery abilities to basic sensorimotor synchronization (SMS) processes in musicians	Target tones: 3 complex tones, base frequencies 261, 392, 523 Hz. Probe tones: Chosen randomly between 200 and 1200 Hz. CR: Neutral	20 musicians, varying degree of experience. Tasks: A) Adjust probe tone to match target, or compare probe and target pitch. S) Three beat-tapping tasks	A) Auditory imagery acuity S) Sensorimotor synchronization (SMS)	Auditory imagery and SMS abilities were positively correlated with one another and with musical experience. SMS ability only partially mediated by musical ability
41S. Tew et al. (287-290) Melody representation in infants Cat. 1: Melody Cat. 9: Child development	To compare melodic encoding in auditory cortex in infants and adults using Electroencephalography (EEG)	Tones synthesized in grand piano timbre. 4-tone melodies presented in 20 transpositions. 80% Standard melodies, 20% Deviant: last note raised by a semitone CR: Western	5 nonmusician adults. 17 infants, mean age 6,3 months watched silent movie or puppet show during recording of EEG	Mismatch negativity (MMN) response to pitch changes in infants and adults	Both infants and adults showed cortical response to a change in relative pitch. Differences: Adults showed a right, frontally negative MMN, infants exhibited a slow positive wave
42S. Vanstone et al. (291-294) Preservation of memory for tunes and lyrics Cat. 11: Deficit Cat. 14: Memory	4 studies of elderly persons with distinctive patterns of memory for tunes and lyrics of songs, in contrast to neurologic impairments: deafness, right-hemisphere stroke, and Alzheimer's Dementia	<i>Recorded music:</i> 1) Familiarity Decision test for Tunes (FDT): 10 familiar melodies, 10 foils. 2) Familiar lyrics test (FLT) analogous to FDT. 3) Lyrics prompt test (LPT): Spoken lyrics from familiar tunes. CR: Western	4 cases and 90 elderly healthy controls. After Mini-Mental Status Examination (MMSE), performance of tasks: 1 & 2) Indicate familiarity or not. 3) Sing tune after listening to spoken lyrics	Retained memory for tunes and lyrics in spite of impairments: profound deafness (age 90), right-hemisphere stroke (age 77), severe Alzheimer (age 85), moderate Alzheimer (age 83)	Results suggest that memory for tunes and lyrics may be particularly resistant to the ravages of neurological disorder. Discussion of models of brain organization for musical memory

Part V. Emotions and Music: Normal and Disordered Development (43-55)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
43. Saccuman & Scifo (297-307) MRI and auditory processing in infancy Cat. 9: Child development	To review studies that have used MRI techniques to elucidate the anatomic and functional correlates of auditory processing in infancy	No particular musical material, many different studies CR: ---	Review of 86 studies. Concise overview of techniques. Structural MRI, functional fMRI, Diffusion Tensor Imaging (DTI): Directionality of tissue water diffusion	The hemispheric specialization for the processing of complex auditory stimuli in infants. Volume of gray matter, myelinated and unmyelinated white matter	MRI has been successfully used from the first hours after birth, providing informative data on auditory processing and its anatomic underpinnings
44. Brattico & Jacobsen (308-317) Subjective appraisal of music Cat. 19: Emotion, preference	To review studies on the neural determinants of subjective affective processes of music, contrasted with early automatic processes linked to the objective universal properties of music	Review of a variety of studies, including classical, pop and rock music. One study by Brattico et al.: Simple 5-chord cadences, Western style. Last chord conventional, blatantly deviant, or ambiguous (SNII) CR: Western, Western popular	Review of 71 studies. The study by Brattico et al: EEG: Event-Related Potentials (ERP) elicited by "disliked" and "incorrect" stimuli	The evaluative judgments of music by subjects according to its aesthetic and structural values. Music-specific emotions felt by listeners, and conscious liking. Influence of socio-cultural context	The study by Brattico et al. suggests a neural dissociation between cognitive and affective judgments
*45. Heaton & Allen (318-325) Musical experience in autism Cat. 11: Disorder Cat. 19: Preference	To discuss musical ability, understanding and affinity in children and adults diagnosed with Autism, Down syndrome and Williams syndrome	<i>Recorded music:</i> Various studies. One study by Heaton et al.: Classical instrumental extracts CR: Western	Heaton et al. study: Participants with autisms and Down syndrome. Task: Match music with drawings representing feeling states and movement states	Autistic adults have extremely diverse motivations for listening to music	Intellectual impairment in handicapped listeners does not appear to limit individual benefits from the experience of listening to music
*46S. Allen et al. (326-331) Experience of music in autism spectrum disorder (ASD) Cat. 11: Disorder	To examine the nature of the personal experiences of music in high-functioning adults on the autism spectrum	<i>Recorded music:</i> Classical and popular music selected by participants CR: Western, Western popular	Semi-structured interviews with 12 adults, ages 21-65, 9 with Asperger's syndrome, 3 with autism	Development of musical interests. Motivations for engaging with music. Characteristics of chosen music. Use of descriptive terms, especially valency terms versus arousal terms	ASD persons use music in several ways similar to typically developing people: mood change, self-management for depression, and social affiliation. Descriptions: Almost no valency terms. Arousal terms prominent, excitement or exhilaration is a desired state

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
47S. Boso et al. (332-335) Musical taste in persons with severe autism (Italy) Cat. 11: Disorder Cat. 19: Preference	To explore whether autistic persons judge pleasant and unpleasant music in an unusual manner	<i>Recorded music:</i> 1) 3 popular songs, often presented on radio and TV versus environmental sounds (sea, wind, fire) 2) 3 excerpts of pleasant versus 3 excerpts of unpleasant music CR: Western	11 ASD adults, mean age 27 years. Absence of language. Controls: 1) 6 subjects. 2) 5 subjects. Mean age 29 years	Time spent 1) in the familiar music condition versus the environmental sounds condition. 2) In the pleasant music condition versus the unpleasant music condition	Both groups preferred the musical task and the pleasant music condition. No difference detected. Autistics share with healthy people the preferences for pleasant music
48S. Dellachetie et al. (336-341) Musical emotion and intracranial recordings Cat. 11: Deficit Cat. 2: Consonance / Dissonance	Single-case study: To investigate event-related potentials (ERPs) recorded by intracranial Electroencephalography (EEG) in an epileptic patient	Organ or synthesizer sounds: 48 3-tone dissonant chords, composed of minor and major seconds. 48 consonant sounds: 24 major, 24 minor triads CR: Western	One 35-year old epileptic patient, nonmusician. Recording of ERPs in 1) auditory areas, 2) orbito-frontal cortex, 3) amygdala and anterior cingulate gyrus	ERPs: Differences between consonant and dissonant chords, and between major and minor chords	Sequential involvement of brain structures in implicit emotional judgment of musical dissonance. ERPs: 1) 200 msec. 2) 500-1000 msec. 3) 1200-1400 msec. Major/minor changes induced ERPs only in orbitofrontal cortex.
49S. Drapeau et al. (342-345) Recognition of emotions in Dementia of the Alzheimer Type (DAT) Cat. 11: Deficit Cat. 19: Emotion	To assess emotional recognition from nonverbal mediums of communication (face, voice, music) in mild DAT	<i>Recorded music:</i> 56 novel instrumental clips from the film genre, intended to induce happiness, sadness, fear, and peacefulness CR: Western, W. popular	7 patients with mild DAT. 16 elderly matched controls. Musical Task: Rate expressed emotion on a 10-point scale. Also Facial Expressions Task, and Prosody Task	Preservation of emotional recognition from face, voice, and music	In DAT patients, emotional recognition from voice and music was well preserved. Only emotional recognition from the face was impaired
50S. Eggermann et al. (346-350) Social feedback on emotion Cat. 7: Culture Cat. 19: Emotion	To investigate whether music-induced emotional effects can be manipulated by social feedback	<i>Recorded music:</i> 23 music excerpts selected to represent four emotional characters: negative or positive valence, low or high arousal CR: Western	3315 participants on web. All listened to 5 randomly chosen excerpts. Task: After each excerpt, rate induced emotions by moving sliders on screen between 1) "unpleasant" and "pleasant". 2) "calming" and "arousing"	Visitors were randomly directed to 1) control group or 2) group presented with manipulated social feedback during music listening: display of information about preceding ratings	Feedback significantly influenced participants' ratings in the manipulated direction compared to the group without feedback

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
51S. Grewe et al. (351-354) Chills and individual emotional peaks Cat. 18: Bodily impact Cat. 19: Emotion	To discuss a new approach that uses chills as indicators of individual emotional peaks: Combination of subjective response, Skin conductance response (SCR) and Heart Rate (HR)	<i>Recorded music:</i> Seven musical pieces of Mozart, Bach, and Puccini CR: Western	Collection of chill samples of 95 listeners in response to the music. Ratings of the intensity of subjective feelings were recorded and synchronized to measurements of SCR and HR in the range of msec.	Chills seem to consist in a strong feeling response combined with a measurable bodily reaction: goose bumps elicited by the peripheral nervous system	Subjective intensity as well as physiological arousal (SCR, HR) revealed peaks during chill episodes. Results suggest that chills are a reliable indicator of individual emotional peaks
52S. Müller et al. (355-358) Expert versus lay aesthetic judgment of music Cat. 2: Harmony Cat. 8: Musicians	To analyze the process of making aesthetic judgments of music, focusing on the differences between music experts and laypersons	180 five-chord, 3 sec piano sequences. Ending chords sounded congruous, ambiguous, or incongruous relative to the established harmonic context. CR: Western	EEG: Event-Related Potentials (ERP). 16 music experts, 16 laypersons. 360 trials. Visual cue indicated task: 1) Beautiful? 2) Correct? Response: Yes or No	Differences between groups: The depth of analytical processing as revealed by analyses of ERP: The P2 component and the Early Right Anterior Negativity	ERP data indicate differences between experts and laypersons at three different processing stages: Cue presentation; 3rd to 4th chord; Last chord
53S. Nakahara et al. (359-362) Emotion-induced cardiac response to musical performance Cat. 18: Bodily impact Cat. 19: Emotion	To investigate the effects of emotions evoked by music on Heart Rate (HR) and Heart Rate Variability (HRV) during piano playing compared to listening to the same music	<i>Task material:</i> Bach: Well-Tempered Clavier: Prelude Vol I, no. 1 (35 bars of music) played on the piano. Subsequently, listening to one's own performances CR: Western	13 active classical pianists. Tasks: 1) Play the music expressively. 2) Play the same music without emotions 3) Listen to 1 4) Listen to 2)	Electrocardiogram: Measuring HR and HRV. Analyses of data indicating vagal and sympathetic nerve activities	Performance provided a stronger effect of emotion-linked modulation in HR and HRV than listening. Reciprocal modulation of sympathetic and parasympathetic nervous activities involved
54S. Sutherland et al. (363-367) Social influences on emotions responses to music Cat. 7: Culture Cat. 19: Emotion	To investigate whether listening to music in a group setting influenced the emotion felt by listeners	<i>Recorded music:</i> 10 pre-selected music excerpts shown in pilot tests to evoke strong emotional responses. 7 classical, 2 film music, 1 new age. CR: Western, Western popular	2 testing sessions: Alone, and in a group. Emotional reactions measured by a) questionnaires b) Skin Conductance Response (SCR) c) Button press for chill	Differences between emotional response listening alone, and listening in a group	Participants did not experience more chills when listening to music in a group than when listening alone
55S. Yoshie et al. (368-371) Stress responses in a piano competition Cat. 18: Bodily impact	To examine the effects of psychological stress on performance quality, autonomic responses, and upper extremity muscle activity in skilled pianists	<i>Task material:</i> Participants played a solo piece of their own choice a) in the rehearsal condition, alone in a practice room. b) in the competition condition, in front of audience and judges CR: Not indicated	Measurements of 1) Tension-Anxiety (Profile of Mood States) 2) Heart Rate (HR) 3) Sweat Rate (SR) 4) Electromyographic activity (EMG) of arm-related muscles	Differences between rehearsal and competition conditions	In the competition condition: Increased levels of subjective anxiety, autonomic arousal, and EMG activity. Increased activation of the sympathetic division of the autonomic nervous system

Part VI. Listening to and Making Music Facilitates Brain Recovery Processes (56-65)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
*56. Koelsch (374-384) Music therapy and neuroscience Cat. 12: Therapy Cat. 18: Bodily impact	Brief overview of factors contributing to the effects of music-therapeutic work. Review of neuroscientific studies using music to investigate emotion, perception-action mediation ("mirror function"), and social cognition	Different kinds of musical material. CR: One study: Western non-tonal	Comprehensive review of various studies. 53 references. Technologies: PET, fMRI, EEG, MEG	Music listening and music production activate a multitude of brain structures involved in cognitive, sensori-motor, and emotional processing. Modulation of (1) Attention (2) Emotion (3) Cognition (4) Behavior (5) Communication	It is likely that the engagement of these processes by music can have beneficial effects on the psychological and physiological health of individuals, although the mechanisms underlying such effects are currently not well understood
57. Schlaug et al. (385-394) White-matter plasticity in chronic Broca's aphasia Cat. 11: Deficit Cat. 12: Recovery, therapy	To test whether melodic intonation therapy (MIT) for aphasic patients administered in an intense fashion would lead to changes in white-matter tracts, particularly the Arcuate Fasciculus (AF)	<i>Task material:</i> MIT: (1) Melodic intonation (singing) using two pitches, to exaggerate the normal melodic content of speech. (2) rhythmic tapping of each syllable, using the patient's left hand. CR: Neutral	6 patients with nonfluent aphasia due to left-hemisphere stroke, and relatively preserved comprehension. Structural MRI with Diffusion Tensor Imaging (DTI) before and after 75 therapy sessions	Recovery through the right hemisphere. Possible effect of tapping the left hand, which may engage a right-hemispheric sensorimotor network. Connections between the temporal and the frontal lobes	All patients showed a significant increase in the absolute number of fibers in the right AF. Several studies have shown that motor and linguistic cortical functions are closely linked
58. Altenmüller et al. (395-405) Neural reorganization induced by music-supported therapy Cat. 12: Therapy, recovery Cat. 17: Sensory-motor	To assess whether a new treatment of music-supported therapy (MST) leads to neural reorganization and motor recovery in patients after stroke	<i>Task material:</i> MST: Exercises on a MIDI piano and an 8-pad electronic drum set. Beginning with 1 tone, systematically increased to songs of 5-8 tones. Instructor plays first, patient repeats. CR: Western	32 patients received MST plus conventional treatment. 30 patients only conventional treatment. EEG recordings, and behavioral tests of motor functions	EEG: Therapy-induced changes in Event-Related Desynchronization / Synchronization (ERD / ERS)	MST leads to marked improvements of motor function after stroke. These are accompanied by electrophysiological changes indicating a better cortical connectivity
59. Thaut et al. (406-416) Neurologic music therapy and cognitive rehabilitation Cat. 12: Therapy, recovery	To examine the immediate effects of neurologic music therapy (NMT) on cognitive functioning and emotional adjustment with brain-injured persons	<i>Task material:</i> Training exercises based on interactive group improvisations with a focused functional content: a) emotional adjustment b) executive function c) attention d) memory CR: Neutral	31 treatment participants, 23 controls. Treatment: 4 sessions on 4 different days. Pre/post assessments by means of well-established tests	Assessment of a) depression, anxiety, hostility, sensation seeking, positive affect. b) mental flexibility. c) attention. d) memory. Auditory Verbal Learning Test	Treatment participants showed improvement in executive function and overall emotional adjustment, and lessening of depression and anxiety seeking and anxiety

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
60S. Bernardi et al. (417-421) Rhythm cueing of cognitive functions Cat. 4: Rhythm Cat. 10: Training	To investigate the interaction between rhythm cueing and cognitive programming of complex actions in a patient suffering from ideomotor apaxia (IA), an impairment of high-level voluntary motor control	Rhythm cueing consisting of an isochronous metronome-like square wave tone. The speed of rhythm was changed flexibly with the training CR: Neutral	A 32 year-old woman, suffering from a hemiparesis, was asked to learn complex novel motor sequences involving the left upper limb, with or without rhythm cueing	To compare efficiency of training with or without rhythm cueing	Both sets of training increased the patient's accuracy, but rhythm cueing was significantly more effective
61S. Brandes et al. (422-425) Music programs to remedy burnout Cat. 11: Deficit Cat. 12: Therapy	To test whether specially designed receptive music programs and protocols might reduce the symptoms of burnout syndrome	<i>Recorded music:</i> Two specifically designed music programs, P1 and P2, called Individualized Music-Focused Audio Therapy (I-MAT). Plus a program consisting of unspecific nature sounds (PN). CR: Western	Randomized Controlled Trial (RCT). Participants, suffering from burnout, listened to a program twice daily for 30 min, 5 days per week, for 5 weeks. P1: n=45, P2 n=40. PN n= 26. Control group n=39	Comparison of music intervention groups P1 and P2 with Placebo group PN and Control group, a waiting list group which received no listening program during the intervention period	Two specific music programs significantly reduced burnout symptoms after 5 weeks. The effects were maintained over a long time period
62S. Forsblom et al. (426-430) Music listening in stroke rehabilitation Cat. 11: Deficit Cat. 12: Recovery	To gain more insight into the therapeutic role of music listening in stroke rehabilitation	<i>Recorded music:</i> Music selected by patients CR: Western, Western traditional, Western popular	Two interview studies. 1) 20 patients listened to self-selected music at least 1 hour a day for 2 months. 2) A participatory action research study involving nurses	Interviewing stroke patients about the subjective emotions and cognitions evoked by music listening, and nurses about the clinical use of music listening	Results suggest that music listening can be used to relax, improve mood, and provide both physical and mental activation during the early stages of recovery from stroke
63S. Norton et al. (431-436) Melodic intonation therapy Cat. 11: Deficit Cat. 12: Therapy	To gain insight in the effect of Melodic Intonation Therapy (MIT) on language recovery in patients with nonfluent aphasia	Singing short phrases, from 2-3 to 5 or more syllables, on two pitches matching the phrases' natural prosody CR: Neutral	The patient repeats words and phrases sung by the therapist. Individual training sessions, instituting the use of <i>Inner Rehearsal</i> and <i>Auditory-Motor Feedback Training</i>	<i>Inner Rehearsal:</i> Slowly tapping the patient's hand while humming the melody, then softly sing the words. <i>Auditory-Motor Feedback Training:</i> Patients listen as the therapist sings the target, and learn to compare their own output as they repeat the phrases	We share observations and additions to the protocol that aim to enhance MIT's benefit, and the rationale that supports them

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
64S. Petersen et al. (437-440) Musical ear training after cochlear implantation Cat. 10: Training Cat. 11: Deficit	To evaluate the behavioral and neurologic effects of musical ear training on Cochlear Implant (CI) users' speech and music perception. 3 and 6 months training in playing, singing, and listening	Test stimuli: Melodies in pure tones f3 to c5. Rhythm patterns: Sampled sound of cowbell for "call", woodblock sound for "response" in same/different task CR: Western	Speech tests: 1. repeat words correctly. 2. identify "sad" or "happy" sentences. Music tests : 1. Melody and rhythm. 2. Pitch-ranking. 3. Timbre recognition	PET scanning to detect regional cerebral blood flow (rCBF) in auditory brain areas with relation to music and speech. Scan and test procedures before training, and after 3 and 6 months	The goal is to find and work out musical methods to improve CI users' auditory capabilities and, in a longer perspective, provide a strategy for improving speech understanding
65S. Särkämö et al. (442-445) Amusia and cognitive defects after stroke Cat. 11: Deficit	To study the relationship between musical and cognitive deficits by testing Middle Cerebral Arterial (MCA) stroke patients for amusia and for memory, verbal and visuospatial abilities	Test material: A shortened version of the Montreal Battery of Evaluation of Amusia (MBEA): Subtests of scale, contour, interval, rhythm, meter, and memory. Synthesized piano tones CR: Western	53 patients were studied 1 week after stroke. On the basis of their performance on the MBEA scale and rhythm subtests. 32 were classified as amusic and 21 as non-amusic. Plus examination using an extensive neuropsychological testing battery	Amusics' deficits in executive functioning, working memory and learning, verbal expression and comprehension, and visuospatial cognition and attention	Acquired amusia is a common deficit after an acute MCA stroke in the left or right hemisphere, esp. if it affects the frontal lobe and auditory cortex. Domain-general attention, executive, and working memory processes are associated with amusia

Part VII. Music, Language, and Motor Programming: A Common Neural Organization? (66-76)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
66. Fadiga et al. (448-458) Broca's area in language, action, and music Cat. 17: Sensory-motor	To review research showing that the inferior frontal gyrus (IFG) and the ventral premotor cortex (PMv) are activated for tasks other than language production	No particular musical material CR: ---	Review of literature. 87 references	The involvement of IFG and PMv in language comprehension, action execution and observation, and music execution and listening. Possible relationship to mirror neuron system.	Broca's area (the posterior part of the IFG) may be a center of a brain network encoding hierarchical structures regardless of their use in action, language and music
67. Patel et al. (459-469) Synchronization to musical beat in animals Cat. 4: Meter Cat. 17: Sensory-motor	To discuss: What kind of animals can synchronize to musical rhythms, and what are the key methodological issues for research in this area?	Reference to the author's experiment with a cockatoo bird which exhibits genuine synchronization to a musical beat at several different musical tempi CR: Neutral	Review of literature. 49 references	Hypothesis: Beat Perception and Synchronization (BPS) builds on the brain circuitry for vocal learning. i.e. learning to produce complex acoustic communication signals based on imitation	The study of animal synchronization to music may have broader significance, e.g. for the understanding of Parkinson's disease, because BPS has a powerful impact on the human motor system

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
68. Palmer et al. (470-480) Neural correlates of contextual effects Cat. 13: Expectation Cat. 15: Structure	To investigate neural responses to timbral, temporal, and melodic accents as they coexist in a longer melodic context	Melodic tones: piano timbre. Timbre deviants: steel guitar. 6 Melodies of 17 isochronous tones systematically combining a) ascending-descending patterns. b) no, one, or two temporal accents. c) no, or one timbral deviant tone CR: Western	EEG: Event-related potential responses (ERPs) to melodies. 16 musically trained young adult listeners. Task in order to ensure attentive processing: Indicate timbre changes at the end of each trial	Detection accuracy and ERPs were measured for the accent manipulations. Grand average group data for Mismatch Negativity (MMN) and P300 responses	Listeners' neural responses to musical structure changed systematically as sequential predictability and listeners' expectations changed across the melodic context
69S. Lidji et al. (481-484) MMN to vowel and pitch Cat. 1: Pitch Cat. 6: Phonemes	To investigate whether vowel and pitch changes are processed as integrated or separated units at an early preattentive level indexed by the Mismatch Negativity (MMN) in sung stimuli	Standards: two synthesized vowels sung on C3 (130 Hz) and C#3 (138 Hz). Deviants: pitch height, vowel identity, or both CR: Neutral	EEG: Event-Related Potentials (ERP) recorded from 12 nonmusicians watching a silent movie, while sequences of repetitive standard sounds and rare deviants were presented through headphones	Whether Mismatch Negativity (MMN) responses produce additive effects when manipulated simultaneously in a single stimulus (double deviant)	MMN to vowel and pitch deviants did not show significant additivity. Suggestion: vowel and pitch are processed by shared neural substrates at the preattentive level
70S. Neuhaus et al. (485-489) ERP study on musical form perception Cat. 15: Musical form	To investigate how consecutive phrase patterns in the musical form types AAB and ABAB are conjoined perceptually	150 8-bar piano melodies in C, E and Ab major. Half of them were of type AAB, half type ABAB CR: Western	EEG: Event-Related Potentials (ERP) recorded from 16 nonexpert listeners. Task: to evaluate whether adjacent or nonadjacent patterns are related to each other	Grand average ERPs for form types AAB and ABAB. Especially an anterior N300	73% of melodies evaluated as "hierarchical". ERP data show that brain responses are strongly affected by form type, but do not correlate with the rating decisions
71S. Nguyen et al. (490-493) Tonal language processing in amusia Cat. 6: Language Cat. 11: Deficit	To examine the transfer of deficit between music and language by examining the effects of impaired musical pitch perception on the discrimination of lexical tones	98 words spoken by a female native speaker of Mandarin Chinese, with 1 of 4 possible tones: level, mid-rising, dipping, and high-falling tone CR: French/Chinese	20 amusic and 20 control French-speaking participants listened to pairs of words, half using same tone, half using different tones. Task: Judge same or different	To assess whether amusic individuals would be able to discriminate pitch variations in an unfamiliar language	Even if the amusic group performed significantly below the control group, there was a high degree of overlap between the scores obtained by amusics and controls

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
72S. Sammler et al. (494-498) Musical and linguistic syntax processing Cat. 2: Harmony Cat. 6: Language	To investigate the co-localization of musical and linguistic syntax processing in the human brain	German language: 132 correct, 132 incorrect, 66 filler sentences. Music: 144 regular, 144 irregular 6-chord sequences (SNr) CR: Western	Intracranial ERP: 9 patients undergoing invasive EEG monitoring during evaluation for epilepsy. Attention was not focused on syntactic violations	Localization of neural generators of the early potentials elicited by syntactic errors in music and language. Generators identified by Brain Surface Current Density (BSCD) mapping	Data confirm a co-localization of the early detection of musical and linguistic syntactic errors within the bilateral superior temporal gyrus
73S. Sevdalis & Keller (499-502) Self-recognition in action perception Cat. 16: Audiovisual	To investigate self-recognition in point-light displays depicting actions performed in synchrony with music	<i>Recorded music:</i> 3 Musical excerpts from drum and bass, folk and jazz CR: Western popular	14 adults with reflective markers attached to the head and the main joints were recorded executing dancing, walking, and clapping in synchrony with music	Subsequently, participants were required to watch point-light displays, with or without music, of themselves or another participant. Task: Identify "self" or "other"	Recognition accuracy was better than chance for all actions. It was best for the relatively complex dance actions. The presence of music did not affect accuracy
74S. Sonnadara et al. (503-507) Spatial properties of perceived pitch Cat. 1: Pitch Cat. 13: Localization	To investigate the influence of pitch on reaching movements	1) Two monaural pure tones, 500 and 1000 Hz presented via one loudspeaker. 2) Same tones presented via 4 loudspeakers hung in the vertical or the horizontal plane 3) Nine diotic pure tones 250-1250 Hz presented over headphones CR: Neutral	10-14 kinesiology students. 1) Respond as quickly as possible to a tone by button press. 2) Move a pointer to indicate perceived location of a tone. 3) as 2, with nine different diotic tones	1) Reaction time for high and low tones 2 and 3) Error in endpoint placement	Data suggest a relationship between perceived pitch and perceived location of tones, with higher tones being placed either higher or further to the right, and lower tones placed lower or to the left
75S. Trehub et al. (508-511) Detecting cross-modal cues to identity Cat. 16: Audiovisual	To test infants 6-8 months of age on their ability to link dynamic cross-modal cues to the identity of unfamiliar speakers and singers	Audio-recording of a mother singing a song to her infant, followed by silent videos of a) the previously heard singer b) another person, singing infant-directed versions of another song. Similar recordings of infant-directed speech. CR: Western	48 infants heard a 30 sec sample of infant-directed speech (test 1) and infant-directed song (test 2) from one woman, after which they were tested with two silent videos, including one from the previously heard speaker	Cumulative looking time provided an index of infants' interest in the person depicted in each video	Infants looked significantly longer at the video of the person heard previously, which indicates that they can match auditory and visual cues to the identity of unfamiliar persons

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
76S. Wigley et al. (512-515) Motor timing and literacy Cat. 4: Timing Cat. 6: Language	To investigate the relationship between a motor-rhythmic measure of ability (synchronous tapping) and purported linguistically processing measures	A steady beat presented at ~1,3 Hz (inter-stimulus interval of 750 msec) (SNII) CR: Neutral	88 kindergarten children, mean age ~4 years. Four individual testing sessions. Task after training: tapping in synchrony on a temple block. Plus tests for Rapid Automated Naming (RAN) and Phonological Awareness (PA)	Relationship between tapping precision and literacy precursor skills : Rapid Automated Naming (RAN) and Phonological Awareness (PA)	Significant association between synchronous beat tapping skill and RAN, which is associated with fluent reading ability. No difference on the PA measure

Part VIII. New Directions: Cochlear Implants (77-79)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
77. Galvin et al. (518-533) Music Perception with Cochlear Implants Cat. 11: Deficits	To present experiments that directly measure Cochlear Implant (CI) users' melodic pitch perception using a melodic contour identification (MCI) task	Synthesized tones. 1) 9 Melodic contours: 3-tone complex: fundamental (F0), 1st harmonic (F1), 2nd harmonic (F2). 2) Same melodic contours: 3-tone complex and spectral envelopes of 6 instruments. 3. Same melodic contours: 3 target instruments: organ, violin, piano. Masker instrument: piano, "flat" contour CR: Western	1) 11 CI users, 9 Normal-hearing (NH) subjects listened to randomly selected melodic contours. Task: Identify contour shape by button click. 2) 8 CI users, 8 NH subjects. Same test method as 1). 3) 7 CI users, 7 NH subjects. Same test method. Task: Identify contour shape of target instrument in the presence of masker instrument. 4) Training experiment	Better understanding of the effects of CI processing on music perception in order to improve the design of CI devices and, in turn, to improve CI users' music perception and appreciation	1) NH 95 % correct, CI 53% correct. Large inter-subject variability. 2) CI users' MCI performance was significantly affected by instrumental timbre: simple harmonic structure provides the best performance. 3) the presence of a competing instrument significantly affects performance. 4) A short period of training can improve melodic pitch perception. Verbal cues are not critical for song identification by CI users. Music is more engaging and memorable for children with CI than it is for adult CI users. Limitations of current CI technology do not exclude rewarding musical experiences, especially for children
78. Trehub, Vongpaisal, and Nakata (534-542) Children with Cochlear Implants Cat. 11: Deficits	To present and discuss studies of music in the lives of deaf children with cochlear implant (CI)	<i>Recorded music:</i> a) Familiar songs in original version 1) instrumental version 2) synthesized piano version b) TV theme songs in 1) original version 2) instrumental version 3) synthesized flute version CR: Western, Japanese	a & b) Summaries of tests comparing CI users with normal hearing (NH) subjects, and comparing child and adolescent CI users. Typical task: Identify the target song from choices depicted on a monitor	CI users' ability to identify songs in instrumental versions without words. Differences between users who acquired CI as infants, and users who acquired CI later in life	

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
79. Kraus et al. (543-557) Experience-induced Malleability in speech and Music Cat. 1: Pitch Cat. 3: Timbre Cat. 4: Timing Cat. 11: Deficit Cat. 16: Audiovisual	To present studies of auditory brain stem responses (ABR) to pitch, timbre and timing in different groups of subjects: a) Musicians and non- musicians. b) Speakers of English and of Mandarin Chinese, in which tone contour has semantic meaning. c) Auditory-Processing Disorder (APD) in learning- impaired population. Cochlear Implant (CI) users	Examples of material: a) <i>Recorded music</i> : Audiovisual paradigm: Same material presented audio- visually (AV), auditory alone (A), and visually alone (V) b) 3 Mandarin tone contours: level, rising, and dipping CR: Western, Chinese	Review of various studies. 80 references. Technology: The auditory brain stem response (ABR), a highly replicable far-field potential recorded from surface electrodes placed on the scalp, reflects the acoustic properties of the sound stimulus with remarkable fidelity. (p. 544) c) clinical tool: Biological Marker of Auditory Processing (BioMARK)	Subcortical representation of pitch, timbre and timing. Differences between defined groups of subjects. Malleability affected by lifelong experience and short- term training	Musically trained subjects have enhanced subcortical representations of pitch, timbre and timing. Subcortical processes are dynamic and not hardwired. Auditory sensory processing interacts with visual and motor influences and is influenced by language and music experience. Likely top-down influence on auditory processing by exten-sive circuitry of efferent fibers that descend from the cortex to the cochlea

The Neurosciences and Music IV: Learning and Memory. Conference June 9-12, 2011 at Edinburgh, Scotland, UK.
A survey of presentations based on the conference abstracts and personal notes

Contents:		Number of presentations
Workshop 1:	Experimental methods	4 (1-4)
Workshop 2:	Social / real world methods	4 (5-8)
Symposium 1:	Mechanisms of rhythm and meter learning over the life span	3 (9-11)
Symposium 2:	Impact of musical experience on cerebral language processing	4 (12-15)
Symposium 3:	Cultural neuroscience of music	6 (16-21)
Symposium 4:	Memory and learning in music performance	5 (22-26)
Symposium 5:	Mind and brain in musical imagery	4 (27-30)
Symposium 6:	Plasticity and malplasticity in health and disease	5 (31-35)
Symposium 7:	The role of music in stroke rehabilitation: Neural mechanisms and therapeutic techniques	6 (36-41)
Symposium 8:	Music: A window into the world of autism	4 (42-45)
Symposium 9:	Learning and memory in musical disorders	4 (46-49)

Information about the presentations is not complete, as merely abstracts of the papers were available at the time of compiling the present survey.
The survey presents, in brief and schematic form, available information about each presentation:

Title as indicated in the conference abstracts. Category of investigation
Aim of the study
Musical material applied as stimuli in the study, and Cultural references of the Musical material.
Technology and Procedure
Main focus of interest
Conclusion

Recurrent abbreviations: EEG: Electroencephalography. MEG: Magnetoencephalography.
PET: Positron Emission Tomography. fMRI: functional Magnetic Resonance Imaging. MRI: Magnetic Resonance Imaging.
CR: Cultural reference. *SNI: Source not indicated*

Workshop 1: EXPERIMENTAL METHODS (1-4)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
1. Amir Lahav New imaging methods and auditory protection for neonates Cat. 9: Child development	Review of recent imaging methods used to study brain development in extremely vulnerable preterm infants < 32 weeks gestation		fMRI	The implementation of a newborn-friendly imaging protocol, protection from scanner noise and the need for obtaining high-resolution images	
2. Laurel Trainor Musical experience, plasticity and maturation: issues in measuring developmental change using electro-physiology (EEG) and magneto-encephalography (MEG) Cat. 9: Child development	Changes in brain processing with age and specific experience can be studied noninvasively in infants and young children using EEG and MEG		EEG, MEG	EEG and MEG can be analyzed with a wide variety of techniques, including traditional time-waveform analyses, frequency analyses (e.g., beta and gamma band oscillations) and machine learning algorithms	
3. Sandra Trehub Current behavioural methods with infants Cat. 9: Child development	A number of behavioral measures will be outlined, both those that have been used in published research and those that could be used profitably in the future			Neural measures, which are becoming increasingly popular in infancy, are often uninterpretable in the absence of behavioral measures	Measures have to be repeatable and reliable. Be vigilant about validity and reliability, e.g. of the "head-turning procedure"
4. Nadine Gaab Current fMRI methods with children Cat. 9: Child development	Review of useful pediatric imaging and analyses tools and presentation of a pediatric neuroimaging protocol with guidelines and procedures that have proven to be successful to date in young children and infants		fMRI	Various strategies and techniques as a means to ensure comfort and cooperation of young children during neuroimaging sessions	Play therapy, behavioral approaches and simulation, the use of mock scanner areas, basic relaxation and a combination of these techniques have all been shown to improve the participant's compliance and thus MRI data quality

Workshop 2: SOCIAL / REAL WORLD METHODS (5-8)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
5. Stefanie Uibel Education through music: The model of the Musikkindergarten Berlin Cat. 7: Culture Cat. 10: Training	Kindergarten in which music is used as the central education medium during every child's day. Examples from our experiences over the last six years	Children experience music in all its different aspects and in its unique capability as a transfer medium into all the other educational areas		Method, ambition and experimental ground is not only education in or with music, but 'education through music'	
6. Maria Majno From "El Sistema" to other models: learning and integration through collective music education Cat. 7: Culture Cat. 10: Training	The presentation takes its clue from the model of the Venezuelan nationwide project "El Sistema", and will survey a number of projects aiming at the exchange between social, educational, cultural and artistic contributions of such networks	The unprecedented and unequalled success of "Sistema" is based on its qualities as a vehicle of social integration aiming at the prevention of endemic crime by offering an alternative "system" to children		To distill the principles for higher efficiency, accessibility, stability and visibility of results	
7. Katie Overy Making music in a group: synchronisation, imitation and shared experience Cat. 7: Culture Cat. 17: Sensory-motor <i>Articles: Molnar-Szakacs & Overy (2006). Overy & Molnar-Szakacs (2009)</i>	I will outline the SAME (Shared Affective Motion Experience) model of musical experience and propose that the effects of music are due to the co-occurrence of motor, emotional and social facets of music	McCartney: Hey Jude. England football supporters in Portugal 2004		I suggest that the human mirror neuron system provides a possible clue: it suggests that when we hear music, we do not only hear abstract patterns of sound – we can also hear the expressive, human motor acts behind those sounds	
8. Nigel Osborne Music as a therapeutic resource for PTSD children in conflict zones Cat. 11: Disorder Cat. 12: Therapy	Based on experiences of using music as a therapeutic intervention for traumatised children in zones of conflict and post-conflict, the paper draws some clear connecting lines joining neuroscience research and therapeutic practice			Neurophysiological symptoms, including chronic raised tone in the sympathetic division of the autonomic nervous system, leading to raised heart rate, higher blood pressure, irregularities in breathing, dysregulation of movement repertoires	Consistent evidence linking PTSD to specific neurophysiological symptoms

Symposium 1: MECHANISMS OF RHYTHM AND METER LEARNING OVER THE LIFE SPAN (9-11)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
9. J. Devin McAuley Neural bases of individual differences in beat perception: implications for rhythm learning Cat. 4: Rhythm Cat. 17: Sensory-motor	To present a framework for considering the neural and behavioral bases for individual differences in rhythm perception, with an emphasis on beat induction			For some individuals, perception of a beat in music is very difficult. Individuals have the potential to engage in distinct beat-based and interval-based modes of timing that involve different neural circuitry We will reconsider these empirical data in the light of the question whether these hierarchical representations are emergent (a structural property of the stimuli themselves), explicitly learned (a result of musical training), or implicitly learned (a result of mere exposure to music)	A key finding from this research is that engaging in a beat-based timing mode involves activation of a network of subcortical and cortical motor areas that are also involved in rhythm production
10. Henkjan Honing Is hierarchy in rhythm perception learned or emergent? Cat. 4: Rhythm Cat. 10: Training	In an earlier study we showed that hierarchical representations for rhythms are formed pre-attentively in the human auditory system. We currently investigate whether the pre-attentive perception of hierarchical structure in an ambiguous rhythm can be influenced by priming				
11. Erin E. Hannon Rhythm learning through listening: effects of perceptual experience on children's and adults' comprehension of unfamiliar rhythms Cat. 4: Rhythm Cat. 7: Culture <i>Articles: Hannon & Trehub (2005), Hannon et al. (2011)</i>	The present work uses a simple behavioral task to examine the ease with which listeners of various ages acquire unfamiliar or foreign metrical structures after passive exposure	Cross-cultural: Western and Bulgarian rhythms	Test before and after a two-week period of at-home exposure to recordings of traditional, complex-meter folk music from Bulgaria	American children's (4-12 years) and adults' (18 years or older) discrimination of simple, familiar (Western) rhythms and moderately complex, unfamiliar (Bulgarian) rhythms	Across sessions, the asymmetry declined dramatically for the youngest children, but minimally for older children and adults. Implications for "sensitive periods" in music learning

Symposium 2: IMPACT OF MUSICAL EXPERIENCE ON CEREBRAL LANGUAGE PROCESSING (12-15)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
12. Nina Kraus, Dana Strait, A. Parbery-Clark Musical training shapes functional brain networks for selective auditory attention and hearing speech in noise Cat. 6: Language Cat. 13: Attention	To investigate the ability of the nervous system to lock on to patterns in a target signal (i.e., the characteristics of a speaker's voice; statistical regularities) and suppress competing noise			Brain networks associated with auditory attention and working memory sharpen the neural encoding of a target signal, highlight patterns, suppress competing sounds and enhance perceptual performance	We provide evidence that sustained musical experience confers cognitive, perceptual and biological advantages that undergird the hearing and neural encoding of speech in background noise throughout the life span
13. Daniele Schön Music training for the development of speech segmentation Cat. 6: Language Cat. 10: Training	We compared learning based on speech sequences to learning based on sung sequences. Then we studied how linguistic and musical information are learned using a sung material		Coupling behavioral methods to EEG recordings and comparing musicians with nonmusicians	Adults and infants can use the statistical properties of syllable sequences to extract words from continuous speech. Moreover, such a statistical learning ability can also operate with non-linguistic stimuli such as tones	1) Performance is better with sung compared to spoken material. 2) Using sung material, the linguistic structure is better learned than the musical structure. Musical expertise facilitates learning of both linguistic and musical structures
14. Martin Meyer Brain responses to rapidly changing acoustic modulations in spoken language vary as a function of musical expertise Cat. 6: Language Cat. 8: Musicians	To determine to what extent musical expertise leads to altered neural mechanisms underlying the perception of rapidly changing temporal information available in the auditory speech signal, such as the voice onset time in stop consonants		Event-related brain potential study: Native speakers of German, musicians and non-musicians, were presented with voiced and unvoiced CV syllables as well as with non-speech noise analogues	Proficient musicians transfer their auditory skills to the language domain, in particular when supra- segmental modulations are decoded. Do transfer effects also occur at the subsyllabic segmental level?	Strong evidence that musical expertise facilitates the processing of sub-segmental cues in the speech signal by altering the functional organization of the human auditory system
15. Aniruddh Patel Presented by M. Oechslin Why would musical training benefit the neural encoding of speech? The OPERA hypothesis Cat. 6: Language Cat. 10: Training	Evidence suggests that musical training benefits the neural encoding of speech. This presentation offers a hypothesis specifying why, and under what circumstances, such benefits occur			The "OPERA" hypothesis proposes that such benefits are driven by adaptive plasticity in speech-processing networks, and that this plasticity occurs when five conditions are met	The five conditions are: 1) Overlap in brain networks 2) Precision of processing 3) Emotion elicited by music 4) Repetition 5) Attention

Symposium 3: CULTURAL NEUROSCIENCE OF MUSIC (16-21)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
16. Laurel Trainor, David W. Gerry and Andrea Unrau Effects of learning on musical enculturation in infancy Cat. 7: Culture Cat. 10: Learning	In recent work we have examined infant learning in detail by controlling exposure	1) Training in Western rhythmic structures versus no training 2) Melodies in guitar timbre versus marimba timbre 3) Music classes versus background music	Comparison of two groups after a period of training or exposure	Just as infants learn the language(s) in their environment, they learn the specific musical systems to which they are exposed. This enculturation occurs to a large extent without formal training	Together these studies show that musical acquisition is not simply on a genetically determined timetable, but is greatly affected by the particular learning experiences of the individual
17. Peter Vuust Practiced musical style shapes auditory skills Cat. 7: Culture Cat. 8: Musicians <i>Articles: Vuust et al. (2011, 2012)</i>	We aimed at tackling the role of musical style on modulating neural and behavioral responses to changes in musical features	Sound features of six different types: pitch, timbre, location, intensity, slide, rhythm	EEG: Using a novel, fast and musical sounding multi-feature MMN paradigm, we measured the mismatch negativity (MMN), a preattentive brain response	MMN response to six types of musical feature change in musicians playing three distinct styles of music (classical, jazz, rock/pop) and in non-musicians	Jazz musicians had larger MMN-amplitude than all other experimental groups across the six different sound features, indicating a greater overall sensitivity to auditory outliers
18. Mari Tervaniemi, T. Tupala and Elvira Brattico Expertise in folk music alters the brain processing of Western harmony Cat. 2: Harmony Cat. 7: Culture Cat. 8: Musicians	We suggest a neuroplasticity of harmony processing in Finnish folk musicians derived from their long-term exposure to both Western and non-Western music	Incongruous chords violating the rules of chord succession crystallized in Western harmony theory	EEG	Incongruous chords violating the rules of chord succession crystallized in Western harmony theory generate an early right anterior negativity (ERAN) in the inferior frontal gyrus of the human brain	The morphology of the ERAN to a mildly incongruous chord embedded in the musical cadence was altered in musicians trained in Finnish folk music
19. Edward Large Neurodynamics of tonality Cat. 1: Scales <i>(Online only in the conference proceedings)</i>	A new theory of musical tonality is proposed, which treats the central auditory pathway as a complex nonlinear dynamical system			As networks of auditory neurons resonate to musical stimuli, stability and attraction relationships develop among frequencies, and these dynamic forces correspond to feelings of stability and attraction among musical tones	A canonical model of phase-locked neural oscillation predicts complex nonlinear population responses to musical intervals that have been observed in the human brainstem. This observation provides support for the theory

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
20. Steven Demorest, Lee Osterhout and Ramesh Gangolli ERP responses to cross-cultural music expectancy violations Cat. 1: Melody Cat. 7: Culture	We examined listeners' sensitivity to expectancy violations across different cultures using Event Related Potential (ERP) methodology	US-born and Indian-born subjects heard a series of 30 melodies taken from Western folk melodies and 30 from Indian ragas.	ERP responses to musical violations. Each melody was presented randomly in blocks by culture and was heard in both its original and violated form	The P600 response found in previous work in both music and language: Variation based on the cultural background of the listener	Preliminary results: Western listeners were sensitive to expectancy violations within their own culture, but showed no significant response to violations within the Indian music context
21. Patrick Wong, Alice Chan, and Elizabeth Hellmuth Margulis The bimusical brain Cat. 7: Culture	Investigation of the effects of passive exposure on our nervous system without active use. Evaluation of how the brain acquires multiple symbolic systems by studying listeners who have exposure to more than one musical system	Western and Indian music	fMRI study: listeners who had been exposed to Western-only (mono-musicals), and both Indian and Western musical systems (bimusicals) since childhood made tension (affective) judgment on Western and Indian music	Effects predominantly driven by between-music differences in temporal regions in the mono-musicals and by between-music differences in limbic regions in the bimusicals	Connectivity analysis of networks via structural equation modeling (SEM) showed a higher degree of connectivity and larger differentiation between the music conditions within the bimusicals

Symposium 4: MEMORY AND LEARNING IN MUSIC PERFORMANCE (22-26)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
22. Virginia Penhune Sensitive period effects for musical training Cat. 9: Child development Cat. 10: Training	Comparing the performance of early- (before age seven) and late-trained (after age seven) musicians who were matched for training and experience on a variety of tasks of musical skill	Auditory and visual rhythm reproduction		A sensitive period: a time during development when experience has a differential effect on later behaviour and on brain development	The results demonstrate that early musical training can have long-lasting effects on adult music performance, and that early training may also be related to specific changes in brain structure

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
23. Peter Pfordresher Effects of musical training on the role of auditory feedback during music performance Cat. 10: Training Cat. 17: Sensory-motor	To discuss research concerning the importance of auditory feedback, the sounds one creates, to perform the. Specifically to consider the basis of audio-motor associations that lead to effects of altering auditory feedback			Recent results challenge the notion that auditory-motor associations in music performance are based on learned, task-specific associations. These may have a more abstract basis, general to a broad range of motor tasks	Recent research suggests that the neural network underlying auditory-motor associations includes the inferior frontal gyrus and the cerebellum, both of which serve a broad range of motor and perceptual tasks
24. Amir Lahav Seeing what you hear and hearing what you do: audiovisual interactions in music learning and rehabilitation Cat. 10: Learning Cat. 16: Audiovisual	To describe studies of how the action-recognition system responds to sound in the context of music learning and rehabilitation		Two groups of non-musicians were trained to play piano music by ear; one group received uninterrupted audiovisual feedback, while the other group only heard, but could not see their hand on the keyboard	fMRI studies with a similar task support the hypothesis of a "hearing- doing" neural system that is highly dependent on the individual's motor repertoire and gets established rapidly	Subjects who were deprived of visual information showed significantly poorer auditory recognition of pitches from the musical piece they had learned
25. Caroline Palmer Contextual influences on performers' memory retrieval processes Cat. 8: Musicians Cat. 14: Memory	I describe a formal, graded model of distributed contextual memory retrieval of real-time music performance, based on the primary feature of incremental planning		A series of experiments with highly skilled and less skilled performers in which the model accounts for patterns of serial ordering errors, speed/accuracy tradeoffs, etc.	Performers have access to a subset of contextual sequence events that have formed strong inter-connections, during practice, with the event currently being performed	Model applications account for memory activation that is distributed incrementally among tones
26. Maria Herrojo Ruiz Error prediction and action control during piano performance in healthy and dystonic pianists Cat. 11: Deficit Cat. 17: Sensory-motor	To present findings that shed new light on the neural mechanisms which might implement motor prediction by means of forward control processes, as they function in healthy pianists and in their altered form in patients with musician's dystonia		EEG studies of the neural underpinnings of error detection during the retrieval of music from memory	A negative event-related potential (ERP) triggered in the posterior frontomedial cortex (pFMC) 70 ms before performance errors (incorrect keypress) was reported	This ERP component, termed pre-error related negativity (preERN), was assumed to reflect processes of error detection in advance. The present paper aims to examine that interpretation and address further questions

Symposium 5: MIND AND BRAIN IN MUSICAL IMAGERY (27-30)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
27. Andrea Halpern Dynamic aspects of musical imagery Cat. 13: Anticipation Cat. 14: Memory, imagery <i>Article: Lucas, Halpern et al. (2010)</i>	To review two recently published studies which illustrate the dynamic aspects of musical imagery		1) A behavioral study that examined the ability to make emotional judgments about both heard and imagined music in real time. 2) A neuroimaging study on the neural correlates of music that is about to be played, or "anticipatory imagery"	The ways in which musical imagery allows us not just to remember music, but also to use those memories to judge temporally changing aspects of the musical experience. Brain areas: Basal Ganglia, Cerebellum, Pre-Motor Area	We found activation of several sequence-learning brain areas, some of which varied with the vividness of the anticipated musical memory
28. Peter Keller Mental imagery in music performance Cat. 13: Anticipation Cat. 14: Memory	To review the results of a series of studies that support the hypothesis that imagery facilitates multiple aspects of music performance. This work focuses specifically on anticipatory auditory and motor imagery		1) Several behavioral tasks involving intonation judgments. 2) Electrophysiological measures fMRI	Processes that are assumed to entail running internal simulations that trigger mental images of upcoming actions	It is proposed that anticipatory imagery enables thorough action planning, and movement execution that is characterized by efficiency, temporal precision, and biomechanical economy
29. Petr Janata and Ana Navarro Cebrian Acuity of mental representations of pitch Cat. 13: Expectation Cat. 14: Memory	To present studies of the effects of mental expectations on performance of precise musical pitch			Singing in one's mind or forming expectations about upcoming notes both require that mental images of one or more pitches will be generated	Multiple memory systems contribute to the formation of accurate mental images for pitch, and the functionality of each is affected by musical training
30. Robert J. Zatorre Beyond auditory cortex: working with musical thoughts Cat. 13: Recognition	To illuminate the neural and cognitive mechanisms that permit one to transform and manipulate existing representations to create new ones			Investigating two kinds of musical tasks, one requiring recognition of transposed melodic patterns, the other requiring recognition of temporally reversed melodic patterns	Converging evidence that such tasks recruit areas outside of traditionally defined auditory cortex, implicating in particular the intraparietal sulcus region

Symposium 6: PLASTICITY AND MALPLASTICITY IN HEALTH AND DISEASE (31-35)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
31. Stefan Koelsch and Katrin Schulze The functional architecture of working memory for tones and phonemes in non-musicians and musicians Cat. 8: Musicians Cat. 14: Memory	To provide a review on fMRI studies on tonal and verbal Working Memory, dealing with the neuroarchitecture of verbal and tonal WM, as well as with functional plasticity of tonal and verbal WM due to musical training		fMRI	Differences between musicians and non-musicians in the recruitment of specific WM components only for verbal (such as the right insular cortex) WM or only for tonal WM (such as basal ganglia and cerebellum)	Whereas nonmusicians appear to rely on vocal-articulatory coding for verbal as well as for tonal information, musicians appear to recruit additional sensorimotor codes for the rehearsal of tonal information
32. Gottfried Schlaug, Gus Halwani, Andrea Norton, Sarah Marchina, Psyche Loui Singing: when it helps, when it hurts, and when it changes brains Cat. 5: Song Cat. 17: Sensory-motor	To investigate the effects of singing for the integration and adaptive training of auditory and sensorimotor processes		MRI: A study of professional singers compared to otherwise matched occasional singers	Differences in gray- and white matter of auditory-motor regions which play a critical role in the mapping and feedback/feedforward control of sounds to articulatory actions. Region of interest: The Arcuate fasciculus (AF)	The between-group differences were correlated with the intensity and duration of training, suggesting that the auditory-motor system that supports vocal communication can adapt to performance requirements
33. Lutz Jäncke The adapting sensory-motor system of musicians Cat. 10: Training Cat. 17: Sensory-motor	To describe some main principles how the motor system adapts to the tremendous amount of practicing a music instrument			Effects of training in professional musicians and in nonprofessional subjects: 1) Optimization of motor control. 2) The motor system changes its grey and white matter architecture	1) The neurophysiological changes are present after short practice sessions. 2) The neuroanatomical changes happen to take place after at least several weeks of practice
34. Christo Pantev Tinnitus: the dark side of the auditory cortex plasticity Cat. 11: Deficit Cat. 12: Recovery	To illuminate the development of a treatment for reducing tinnitus loudness via reversing maladaptive auditory cortex reorganization		Exposing chronic tinnitus patients to self-chosen, enjoyable music, which was modified ('notched') to contain no energy in the frequency range surrounding the individual tinnitus frequency	Attracting lateral inhibition to the brain area generating tinnitus	The regular and enjoyable music training reverses unprofitable cortical reorganization to a certain degree by means of the focused strengthening of auditory inhibitory neuronal networks

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
35. Eckart Altenmüller, Laurent Bouliet, Hans-Christian Jabusch, Andre Lee The maladaptating sensory-motor system of musicians: dystonia as a syndrome of dysfunctional brain plasticity Cat. 11: Deficit Cat. 17: Sensory-motor	To present new results of an effective new treatment strategy applying a relearning strategy in musician's suffering from musician's cramp or focal dystonia: the loss of control and degradation of skilled movements when playing an instrument		fMRI studies in patients suffering from embouchure and hand dystonia, compared to healthy musicians	Risk factors: Prolonged practice, high workload concerning fine motor activity, need of extremely precise temporo-spatial control and reproducing "classical" music in contrast to improvising musicians	Musicians with dystonia showed a distorted topographical representation of the lips or the hand in the sensory and motor cortex, a defective inhibition in basal ganglia and cortical motor networks, and subtle structural abnormalities in the basal ganglia

Symposium 7: THE ROLE OF MUSIC IN STROKE REHABILITATION: NEURAL MECHANISMS AND THERAPEUTIC TECHNIQUES (36-41)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
36. Teppo Särkämö Rehabilitative effects of music listening on the recovering brain Cat. 11: Deficit Cat. 12: Recovery	To present a randomized controlled trial (RCT, n = 60) about the longterm effects of music on stroke recovery <i>Articles:</i> <i>Särkämö et al. (2008)</i> <i>Forsblom et al. (2010)</i>		Qualitative patient interviews, voxel-based morphometry (VBM) analyses of MRI data, and magnetoencephalography (MEG)	The potential psychological and neural mechanisms underlying the effects of daily music listening	Daily music listening enhanced the recovery of memory, attention, and auditory encoding as well as preventing depression and confusion during the early post-stroke stage
37. David Soto Improving visual neglect through pleasant music Cat. 11: Deficit Cat. 12: Recovery <i>(Not in the proceedings)</i>	The effect of musically-induced emotion upon visual neglect, i.e. reduced awareness of visual stimuli in the contralateral side of space relative to a brain lesion		fMRI: Visual tasks performed under preferred music conditions, compared to unpreferred music or silence	Visual neglect patients can show enhanced visual awareness when visual tasks are performed under preferred music conditions	Preferred music enhanced activity in emotional areas of the orbitofrontal cortex and the cingulate gyrus
38. Antoni Rodríguez-Fornells Music-supported therapy induced plasticity in the sensorimotor cortex in chronic stroke patients Cat. 11: Deficit Cat. 12: Recovery	Music-Supported Therapy (MST) has been developed in order to improve the use of the affected upper extremity after stroke		fMRI and Transcranial Magnetic Stimulation to investigate the physiological mechanisms underlying the effects of MST	Motor amelioration will occur because music-supported training involves precise auditory feedback and may promote auditory-motor coupling	Behavioral motor improvement accompanied by signs of neuroplastic reorganization in the sensorimotor cortex of chronic patients

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
39. Takako Fujioka Multimodal functional cortical reorganization and its spatio-temporal pattern after music-supported stroke rehabilitation Cat. 11: Deficit Cat. 12: Recovery	We have examined the effects of music-supported motor rehabilitation on functional cortical reorganization in our case-based study		Over a 1-month period we probed somatosensory, motor, and auditory memory functions using various MEG mapping techniques before and after the intervention of music playing	We hypothesize that multimodal neural activities underlying musical timing processing encourage cortical reorganization in wide areas of a brain damaged by stroke	Post-intervention Improvements in movement of the paretic hand as well as massive multimodal shifts from abnormal to normal cortical response patterns in somatotopic maps and auditory evoked responses
40. Raymond MacDonald, van Wijck, Knox, Dodds, Cassidy, Alexander Making music after stroke: using musical activities to enhance arm function. Cat. 11: Deficit Cat. 12: Recovery	This presentation will focus upon using musical participation to enhance arm function recovery after stroke		Music technology, appropriate for use by people with different upper limb impairments after stroke	Stroke is one of the most disabling long term conditions in the UK and loss of arm function is particularly common	Music technology can be utilised to develop creative activities that are enjoyable and enhance the rehabilitation process
41. Concetta Tomaino Effective music therapy techniques in the treatment of non-fluent aphasia Cat. 11: Deficit Cat. 12: Therapy	This presentation will introduce working guidelines for music therapy for aphasia		Different techniques emphasizing rhythm, pitch, memory, and vocal/oral motor components dealing with different symptoms	Various benefits of singing have been identified: strengthened breathing and vocal ability, improved articulation and prosody of speech	The efficacy of each component is enhanced or diminished by the choice of music and the way it is interactively delivered

Symposium 8: MUSIC: A WINDOW INTO THE WORLD OF AUTISM (42-45)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
42. Pamela Heaton, Rory Allen, Francesca Happe, Anna Jarvinen-Pasley, Jennifer Mayer, Jessica Ward Why are musical skills preserved in autism? Cat. 1: Pitch Cat. 11: Disorder	Potential explanations for uneven development across functional domains in infants diagnosed with autism will be proposed and future directions for the study of music in autism will be outlined			Whilst research has shown that infants who are subsequently diagnosed with autism fail to "attend" to speech, such inattention does not appear to generalize to music	Experiments conducted with verbally able children and adults with autism have revealed a heightened sensitivity to pitch in music and environmental sounds

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
43. Krista L. Hyde Brain and behavioral correlates of auditory processing in autism spectrum disorders Cat. 11: Disorder	To present recent findings of brain and behavioral differences in auditory perception in Autism Spectrum Disorders (ASD) with respect to current theories of atypical sensory perception in ASD		The combination of behavioral and brain imaging methods of function and structure is critical to understand the neural mechanisms underlying ASD phenotypes	How atypical auditory perception in ASD is reflected at the level of both brain structure and function	The study of such brain-behavioral relationships may lead to the identification of neurobiological markers in ASD. In turn, the findings from this work may guide earlier and improved biologically based interventions in ASD
*44. I. Molnar-Szakacs, T. Wong, R. Brezis, M. Wang, L.S McKay, E.A. Laugeson, W. Wu, K. Overy, J. Piggot The neural correlates of emotional music perception: an fMRI study of the SAME model of musical experience Cat. 11: Disorder Cat. 17: Sensory-motor <i>Articles: Overy et al. (2009) Molnar-Szakacs et al. (2006) (Not in the proceedings)</i>	The Shared Affective Motion Experience (SAME) model of music perception holds that emotion in music is perceived not only as an auditory signal, but also as intentional, hierarchically organized sequences of expressive motor acts behind the signal	No passive stimuli. Multi-sensory activity such as clapping, tapping, marching, dance	We studied the neural correlates of emotional music perception in high-functioning children with Autism spectrum Disorder (ASD) (mean age 12 years) and age-matched controls using 3T functional Magnetic Resonance Imaging (fMRI)	The human Mirror Neuron System (MNS) allows for co-representation and sharing of affective musical experience between agent and listener	Support for the SAME model of affective musical experience, whereby recruitment of the neural systems of embodiment and emotion in the children allows them to experience and understand the expressive dynamics of heard sound gestures through emotional music
45. Catherine Wan, Loes Bazen, Lauryn Zipse, Andrea Norton, Jennifer Zuk, Jennifer Batore, Gottfried Schlaug Using Auditory-Motor Mapping Training (AMMT) to facilitate speech output in non-verbal children with autism Cat. 11: Disorder Cat. 17: Sensory-motor	Auditory-Motor Mapping Training treatment data from a series of completely nonverbal children with autism will be presented, as well as diffusion-tensor imaging results showing abnormalities in language-related tracts. These brain abnormalities may be associated with therapeutic outcomes		Recently, our laboratory has developed a novel intonation-based intervention called Auditory-Motor Mapping Training (AMMT), which trains the association between sounds and articulatory actions with the goal of facilitating speech output in nonverbal children with autism	Although up to 25% of children with autism are non-verbal, there are very few interventions that can reliably produce significant improvements in speech output	AMMT capitalizes on the inherent musical strengths of children with autism, and offers activities that they intrinsically enjoy. It also engages and potentially stimulates a network of brain regions that may be dysfunctional in autism

Symposium 9: LEARNING AND MEMORY IN MUSICAL DISORDERS (46-49)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
46. Simone Dalla Bella, Alexandra Tremblay-Champoux, Isabelle Peretz and Magdalena Berkowska Memory disorders and vocal performance Cat. 14: Memory Cat. 17: Sensory-motor	The role of memory in vocal performance has been paid relatively little attention. To fill this gap, I will report recent findings with participants suffering from congenital amusia (typically impaired in vocal performance), and from unimpaired individuals		Participants were asked to produce from memory a well-known melody or to imitate a model melody (in some conditions, at the unison)	The ability to sing in tune and in time is underpinned by a complex system (the "vocal sensorimotor loop") involving several functional components, such as perceptual mechanism, sensorimotor integration, motor control, and memory systems	The results point to memory as a relevant source of impairment in poor singing, and to imitation as a useful aid for poor singers
47. Lauren Stewart, Susan Anderson, Graham Welch, Evangelos Himonides and Karen Wise Congenital amusia: is there potential for learning? Cat. 10: Learning Cat. 11: Deficit	To describe a small-scale study which used a broad-brush approach of targeted interventions, in an attempt to facilitate change in both music perception and vocal production in five individuals diagnosed with congenital amusia		The training was conducted by a professional singing teacher, and used elements designed to enhance singing technique, vocal health and efficiency, musical understanding, pitch perception and production	Understanding which aspects of the disorder, if any, are subject to change, constrains psychological theorizing about the nature of the disorder and has implications for remediation programmes	The close observations made by the teacher over a sustained period of time provided new insights about areas of difficulty and potential routes of compensation for those with the disorder

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
48. Psyche Loui, Charles Li and Gottfried Schlaug Behavioural and neural correlates of normal and disordered music learning ability Cat. 10: Learning Cat. 11: Disorder	Drawing on a combination of music theory, cognitive science, and structural neuroimaging, we investigated the effect of tone-deafness on music learning		Tone-deaf individuals and matched controls underwent diffusion tensor imaging (DTI) and a series of behavioral tests that assessed their learning of a new artificial musical grammar, based on the Bohlén-Pierce scale, an alternative musical system that adheres to basic psychoacoustic principles of consonance and dissonance, but is completely unfamiliar to all participants	Behavioral results showed significantly below-normal learning performance in tone-deaf subjects. Furthermore, DTI data showed reduced volume of the arcuate fasciculus in tone-deaf subjects, and significant correlations between learning and tract volume in the right inferior arcuate fasciculus	These findings show that the acquisition of musical structure depends crucially on white matter connecting right hemisphere brain regions responsible for sound categorization and production
49. Isabelle Peretz and Jenny Saffran Learning speech but not musical sounds in congenital amusia Cat. 10: Learning Cat. 11: Disorder	Background for the investigation: Individuals who suffer from congenital amusia have experienced lifelong difficulties in processing of music. The deficit can be traced down to an impairment in fine-grained pitch discrimination. Their language abilities appear intact. One possible account for this dissociation between music and speech is that amusics lack of normal exposure to music because of their lifelong history of musical failures		A group of 11 adults with congenital amusia, and their matched controls, were exposed to a continuous stream of syllables or tones for at least 21 min. Their task was to try to identify words or motifs, defined by transitional probabilities	Amusics might be able to acquire basic musical abilities if given appropriate exposure	The results show that amusics can learn novel words as easily as controls whereas they systematically fail on musical materials. Thus, limited exposure cannot fully account for the musical disorder

3.05 Musical material NM I

The Neurosciences and Music I - Conference 2002, publication 2003: Mutual Interactions and Implications on Developmental Functions

Cerebral organization 1-29

Brain sciences versus music 30-44

Music and development 45-61

Musical material – NM I and related material	Number of papers	Papers no. (One paper may include several kinds of material)
Source not indicated		
	16	1 6 11 14 15 16 22 24 25 28 37 38 43 44 51 61
Synthesized material		
Pure tones = sinus tones	11	2 3 10 11 19 21 30 45 49 55 59
Synthesized tones, clicks	15	2 4 5 10 13 17 20 23 29 32 35 40 47 49 52
Noise	3	3 18 19
Acoustic material		
Acoustic instruments: violin and trumpet 1, drum 1, violin and piano 1 tend	3	11 49 55
Singing voice	0	
Phonetic sounds, Language	6	2 26 45 51 60 61
Animal sounds	2	30 42
Environmental sounds	1	4
Recorded music		
Specified recorded music	7	8 9 18 41 46 48 58
Unspecified recorded music	1	57
Material for tasks		
	1	27

3.05 Musical material NM II

The Neurosciences and Music II - 2005: From Perception to Performance

Ethology / Evolution 1-5

Development, Education 20-27

Performance 36-43

Music and language 6-10

Music therapy 28-31

Emotion 44-53

Mental representations 11-19

Disorders 32-35

Musical material NM II and related material	Number of papers	Papers no. (One paper may include several kinds of material)
Source not indicated		
	7	6 8 13 19 22 43 45
Synthesized material		
Pure tones = sinus tones	3	15 16 36
Synthesized tones, clicks	13	1 11 14 15 21 23 32 35 40 42 48 50 51
Noise	5	1 7 9 16 33
Acoustic material		
Acoustic instruments: wind and percussion 1	1	19
Singing voice	3	7 11 24
Phonetic sounds, Language	5	6 7 10 23 24
Animal sounds	2	2 3
Environmental sounds	0	
Recorded music		
Specified recorded music	9	12 17 20 25 46 47 49 52 53
Unspecified recorded music	2	13 33
Material for tasks		
	5	17 18 27 38 39

3.05 Musical material NM III

The Neurosciences and Music III – 2008, publication 2009: Disorders and Plasticity

Rhythm 1-9 Singing 10-15 Training 16-30
 Memory 31-42 Emotions 43-55
 Recovery 56-65 Music, language, motor 66-76 Cochlear implants 77-79

Musical material NM III and related material	Number of papers	Papers no. (One paper may include several kinds of material)
Source not indicated		
	9	1 2 5 36 37 38 44 72 76
Synthesized material		
Pure tones = sinus tones	9	4 8 15 16 18 22 28 64 74
Synthesized tones, clicks	18	16 20 23 25 26 35 39 40 41 48 52 60 64 65 68 69 77 78
Noise	0	
Acoustic material		
Acoustic instruments	7	7 9 17 18 27 70 78
Singing voice	4	27 32 63 75
Phonetic sounds, Language	9	19 30 33 34 42 71 72 75 79
Animal sounds	0	
Environmental sounds	3	27 47 61
Recorded music		
Specified recorded music:	3	19 33 51
Unspecified recorded music:	14	31 34 42 45 46 47 49 50 54 61 62 73 78 79
Material for tasks		
	11	10 11 12 13 21 24 53 55 57 58 59

3.05 Musical material	NM I	NM II	NM III	NM IV
	Interaction Development	Perception Performance	Disorders Plasticity	Learning Memory
Musical material and related material	Papers 2002	Papers 2005	Papers 2008	Not available
Total number of papers:	61	53	79	
Source not indicated	16	7	9	
Synthesized material				
Pure tones = sinus tones	11	3	9	
Synthesized tones, clicks	15	13	18	
Noise	3	5	0	
Acoustic material				
Acoustic instruments	3	1	7	
Singing voice	0	3	4	
Phonetic sounds, Language	6	5	9	
Animal sounds	2	2	0	
Environmental sounds	1	0	3	
Recorded music				
Specified recorded music	7	9	3	
Unspecified recorded music	1	2	14	
Material for tasks	1	5	11	

Musical material NM I NM II NM III: Artificial stimuli, Acoustic sounds, and Recorded music.

Artificial stimuli in NM I NM II and NM III

23 studies apply sinus tones as stimuli, 46 studies apply synthesized material. Some noteworthy papers are the following:

Investigations and discussions related to sinus tones

Sinus tones, NM I

Tervaniemi and Huotilainen (NM I no.2, pp. 29-39) and Trainor et al. (NM I no. 55, pp. 506-513) find evidence that sinus tones and musical tones evoke different cortical responses.

Griffiths et al. (NM I no. 3, pp. 40-49) employ rippled noise instead of sinus tones to evoke the perception of pitch.

Lopez et al. (NM I no. 10, pp. 124-130) state in their introduction that "the need for quantifiable data implies the use of experimental protocols that necessarily address only specific aspects of music."

Jones (NM I no. 30, pp. 218-233) strongly recommends studies of naturalistic musical sounds.

Sinus tones, NM II

Tramo et al. (NM II no. 15, pp. 148-174) discuss sinus-tone and harmonic-tone pitch perception in the auditory cortex.

Sinus tones, NM III

Tervaniemi (NM III no. 18, pp. 151-156) reviews MEG and EEG studies which show different responses to sinus tones and to instrumental tones.

Investigations and discussions related to synthesized material

Synthesized material, NM I

Vignolo (NM I no. 4, pp. 50-57) reports studies employing environmental sound as well as synthesized tones.

Roads (NM I no. 35, pp. 272-281) discusses the microtemporal properties of synthesized and acoustic sounds.

Krumhansl (NM I no. 47, pp. 414-428) has conducted an ecological survey of initial melodic patterns in a corpus of Western melodies.

Synthesized material, NM II

Schneider et al. (NM II no. 40, pp. 387-395) discuss two different modes of pitch perception in groups of musicians, related to their musical instrument preference.

Synthesized material, NM III

Palmer et al. (NM III no. 68, pp. 470-480) have investigated the ERP responses to timbres in different contexts, which influence the listener's expectations.

Acoustic instruments in NM I NM II and NM III

11 papers apply the sounds of acoustic instruments, three in NM I, one in NM II, and seven in NM III. Some noteworthy investigations are the following:

Acoustic instruments, NM I

Münste et al. (NM I no. 11, pp. 131-139) apply a real drum sequence in a mismatch negativity study of temporal deviance from a pattern of regular beats. The response of drummers is compared to the response of nonmusicians.

In a MEG study, Pantev et al. (NM I no. 49, pp. 438-450) investigate the cortical responses for violin and trumpet tones in violinists, trumpeters, and nonmusicians.

In an EEG study, Trainor et al. (NM I no. 55, pp. 506-513) investigate auditory evoked potentials in response to sinus tones, violin tones, and piano tones. The responses of adult musicians and nonmusicians as well as children with or without musical experience are compared.

Acoustic instruments, NM III

Dennis et al. (NM III no. 7, pp. 84-88) apply snare drum sounds in a study of children with impaired rhythmic abilities.

Tervaniemi (NM III no. 18, pp. 151-156) reviews MEG and EEG studies of responses to sinus tones and instrumental tones in musicians and nonmusicians.

Trehub et al. (NM III no. 78, pp. 534-542) investigate song identification in children with cochlear implants, comparing familiar songs and TV theme songs in original version, instrumental version, and synthesized version.

Singing voice in NM I NM II and NM III

Seven papers report the use of singing voice, 0 in NM I, 3 in NM II, and 4 in NM III.

Some characteristic applications are the following:

Singing voice, NM II

Schön et al. (NM II no. 7, pp. 71-81) apply spoken words, sung words, vocalises and noise in studies of musical and linguistic processing in song perception.

Tillmann (NM II no. 11, pp. 100-110) applies musical material played with instrumental timbres or sung with artificial syllables in a study of implicit tonal knowledge in nonmusicians.

In an EEG study of the effect of music on learning and memory, Thaut et al. (NM II, no. 24, pp. 243-254) apply words presented in spoken form or in a song.

Singing voice, NM III

Thiessen & Safran (NM III no. 32, pp. 225-233) investigate melody and lyric learning in infants by comparing spoken and sung material.

Norton et al. (NM III no. 63, pp. 431-436) report observations of Melodic Intonation Therapy for aphasia patients, a rehabilitation method based on singing short phrases on two pitches.

Trehub et al. (NM III no. 75, pp. 508-511) have investigated 6-8 months old infants' recognition of singing voices and faces.

Recorded music NM I NM II and NM III

19 studies apply specified recorded music as material,¹ 17 studies apply unspecified recorded music. Noteworthy papers which apply specified recorded music are the following:

Recorded music, NM I

Demorest and Morrison (NM I no. 8, pp. 112-117). An fMRI study of cultural differences based on excerpts from A. Scarlatti: *Sonata Terza* and a traditional Chinese piece, *Liu Qin Niang*. The excerpts were matched for tempo, texture, and instrument type.

De Poli (NM I no. 9, pp. 118-123). A study of expressive intentions in music performance, based on live recordings of different styles, including Mozart's Concert for clarinet K. 622.

Dalla Bella & Peretz (NM I no. 18, pp. 166-169). A study of amusic persons' ability to tap in synchrony with recordings of real music versus noise bursts.

Plantinga & Trainor (NM I no. 58, pp. 520-521). A study of infants' long-term memory representations for the pitch of familiar melodies.

Recorded music, NM II

Janata (NM II no. 12, pp. 111-124). An fMRI study of attentive listening to polyphonic music, applying an excerpt from Schubert's trio in Ab major for violin, cello and piano, op. 100.

Sloboda et al. (NM II no. 25, pp. 255-261). An investigation of emotional communication in expressive live recordings of melodies played by a professional violinist. The live recordings were compared to synthesized versions of the same melodies, which are test pieces in the Montreal Battery for the Evaluation of Amusia.

Bigand et al. (NM II no. 46, pp. 429-437). A study of fast emotional responses to music, based on 27 excerpts of classical music by R. Strauss, J.S. Bach, Mozart, Brahms, Scarlatti, Schumann, Shostakovich, Wagner, Liszt, Prokofiev, Beethoven, Mendelssohn, Chopin, W.F. Bach, Haydn, Schubert, Stravinsky, and Schoenberg.

Grewe et al. (NM II no. 49, pp. 446-449). A study of strong emotional experiences arousing "chills", applying music of seven different styles: Mozart, Bach, Pop music, Film music, Cello-Rockband, Death Metal, and Bossa Nova.

Recorded music, NM III

Wong et al. (NM III no. 19, pp. 157-163). A study of Western and Indian listeners' responses to excerpts of Western music by J. Stamitz and G.B. Sammartini, and Indian music by N. Banerjee and U.R. Shahn.

Bigand et al. (NM III no. 33, pp. 234-244). A study of fast recognition of music, based on 20 excerpts of familiar and unfamiliar classical music by Bach, Rossini, Mozart, Brahms, Dvorak, Ravel, Shostakovich, Bizet, Schubert, R. Strauss, Söderman, Olson, Rebel, Berwald, Kraus, Bengtsson, Norman, Scriabin, Beethoven, Alfvén, and Wagner.

Grewe et al. (NM III no. 51, pp. 351-354). A study of strong emotional and physiological responses to Mozart's *Requiem*, The motet *Unser Leben ist ein Schatten* by Johann Bach (1604-1673), and Puccini's *Requiem*.

¹ Specifications are indicated in the survey of Cultural references, appendix 3.07.

3.06 Categories of investigation NM I

The Neurosciences and Music I - Conference 2002: Mutual Interactions and Implications on Developmental Functions

Cerebral organization 1-29

Brain sciences versus music 30-44

Music and development 45-61

Categories of investigation – NM I	Number of papers	Papers no. (A paper may belong to several categories)		
A1. Neural correlates of sound				
1. Pitch, melody, scales	14	2 3 5 6 10 11 14 20 24 29	30 44	47 59
2. Harmony, consonance / dissonance	7	1 6 15 16 21 28		52
3. Complex sounds: acoustic tones 1, timbre 1, roughness 1, spectrally rich sound 1, inharmonic 1, complex synthesis 2	7	2 13 19 21	35 39	55
4. Timing, tempo, rhythm, meter	9	5 12 17 18 22	32 38 40	48
A2. Neural correlates of vocal sound				
5. Song	0			
6. Phonetic sounds, language, infant sounds, animal sounds	8	2	30 42	45 51 54 60 61
B. Culture, development, training				
7. Cultural influence, cultural differences	7	8 12 23 26		46 48 60
8. Musicians versus non-musicians or different musicians	13	10 11 22 25	31 37 38 44	50 51 55 56 61
9. Child development	5			45 46 52 57 58
10. Training effect, learning	6	27		49 50 53 54 56
C. Deficits, disorders, therapy, recovery				
11. Deficits, disorders	8	4 13 16 18 20 24	38 43	
12. Therapy, recovery	0			
D. Attention, memory				
13. Attention, expectation, anticipation, recognition, localization	4	1 4	43	47
14. Memory, auditory imagery	3		42 43	58
15. Musical form and structure	1		37	
E. Embodiment, motion, emotion				
16. Audiovisual integration	1	25		
17. Sensory-motor processing, motion, entrainment	4	27	35 40	49
18. Bodily impact	2	7	41	
19. Emotion, feeling, mood, preference	0			
20. Musical expression	1	9		
21. Creative projects				
	4		33 34 36 39	

3.06 Categories of investigation NM II

The Neurosciences and Music II - Conference 2005: From Perception to Performance

Ethology / Evolution 1-5

Development, Education 20-27

Performance 36-43

Music and language 6-10

Music therapy 28-31

Emotion 44-53

Mental representations 11-19

Disorders 32-35

Categories of investigation – NM II	Number of papers	Papers no. (A paper may belong to several categories)
A1. Neural correlates of sound		
1. Pitch, melody, scales	5	4 5 15 19 21
2. Harmony, consonance / dissonance	7	1 4 6 23 50 51 52
3. Complex sounds: acoustic instruments 0, timbre 0, noise 2	2	1 9
4. Timing, tempo, rhythm, meter	3	21 38 42
A2. Neural correlates of vocal sound		
5. Song	2	7 43
6. Phonetic sounds, language, infant sounds, animal sounds	5	2 3 6 10 23
B. Culture, development, training		
7. Cultural influence, cultural differences	0	
8. Musicians versus non-musicians or different musicians	6	8 16 39 40 41 46
9. Child development	1	3
10. Training effect, learning	4	10 22 26 27
C. Deficits, disorders, therapy, recovery		
11. Deficits, disorders	7	25 32 33 34 35 36 45
12. Therapy, recovery	4	28 29 30 31
D. Attention, memory		
13. Attention, expectation, anticipation, recognition, localization	3	11 12 13
14. Memory, auditory imagery	5	13 14 24 37 47
15. Musical form and structure	0	
E. Embodiment, motion, emotion		
16. Audiovisual integration	2	16 39
17. Sensory-motor processing, motion, entrainment	4	17 18 42 43
18. Bodily impact	2	12 49
19. Emotion, feeling, mood, preference	10	20 44 45 46 47 48 49 50 52 53
20. Musical expression	2	25 53
21. Creative projects		
	0	

3.06 Categories of investigation NM III

The Neurosciences and Music III – Conference 2008: Disorders and Plasticity

Rhythm 1-9 Singing 10-15 Training 16-30
 Memory 31-42 Emotions 43-55
 Recovery 56-65 Music, language, motor 66-76 Cochlear implants 77-79

Categories of investigation – NM III	Number of papers	Papers no. (A paper may belong to several categories)
A1. Neural correlates of sound		
1. Pitch, melody, scales	10	10 13 15 26 28 38 41 69 74 79
2. Harmony, consonance / dissonance	3	48 52 72
3. Complex sounds: acoustic instruments 0, vibrato 1, timbre 1	2	15 79
4. Timing, tempo, rhythm, meter	11	1 2 3 4 5 8 9 60 67 76 79
A2. Neural correlates of vocal sound		
5. Song	4	10 11 12 13
6. Phonetic sounds, language, infant sounds, animal sounds	7	11 25 30 69 71 72 76
B. Culture, development, training		
7. Cultural influence, cultural differences	4	12 19 50 54
8. Musicians versus non-musicians or different musicians	5	6 18 22 30 52
9. Child development	7	23 24 28 29 32 41 43
10. Training effect, learning	11	16 17 18 19 20 21 24 25 27 29 60 64
C. Deficits, disorders, therapy, recovery		
11. Deficits, disorders	23	2 7 14 26 27 34 37 42 45 46 47 48 49 57 61 62 63 64 65 71 77 78 79
12. Therapy, recovery	7	56 57 58 59 61 62 63
D. Attention, memory		
13. Attention, expectation, anticipation, recognition, localization	5	33 35 39 68 74
14. Memory, auditory imagery	13	21 23 31 32 33 34 35 36 37 38 39 40 42
15. Musical form and structure	2	68 70
E. Embodiment, motion, emotion		
16. Audiovisual integration	2	73 75 79
17. Sensory-motor processing, motion, entrainment	7	1 2 8 40 58 66 67
18. Bodily impact	4	51 53 55 56
19. Emotion, feeling, mood, preference	10	30 34 44 45 47 49 50 51 53 54
20. Musical expression	1	
21. Creative projects	0	

3.06 Categories of investigation NM IV

The Neurosciences and Music IV – Conference 2011: Learning and Memory

Experimental Methods 1-4	Social / Real World Methods 5-8	Rhythm and Meter Learning 9-11
Music and Language 12-15	Cultural Neuroscience 16-21	Memory, Learning, Performance 22-26
Musical Imagery 27-30	Plasticity and Malplasticity 31-35	Stroke Rehabilitation 36-41
Autism 42-45	Learning, Memory, Disorders 46-49	

Categories of investigation – NM IV	Number of papers	Papers no. (A paper may belong to several categories)
A1. Neural correlates of sound		
1. Pitch, melody, scales	3	19 20 42
2. Harmony, consonance / dissonance	1	18
3. Complex sounds: acoustic instruments, timbre, noise	0	
4. Timing, tempo, rhythm, meter	3	9 10 11
A2. Neural correlates of vocal sound		
5. Song	1	33
6. Phonetic sounds, language, infant sounds, animal sounds	4	12 13 14 15
B. Culture, development, training		
7. Cultural influence, cultural differences	9	5 6 7 11 16 17 18 20 21
8. Musicians versus non-musicians or different musicians	5	14 17 18 25 31
9. Child development	5	1 2 3 4 22
10. Training effect, learning	13	5 6 10 13 15 16 22 23 24 34 47 48 49
C. Deficits, disorders, therapy, recovery		
11. Deficits, disorders	17	8 26 32 35 36 37 38 39 40 41 42 43 44 45 47 48 49
12. Therapy, recovery	8	8 32 36 37 38 39 40 41
D. Attention, memory		
13. Attention, expectation, anticipation, recognition, localization	5	12 27 28 29 30
14. Memory, auditory imagery	6	25 27 28 29 31 46
15. Musical form and structure	0	
E. Embodiment, motion, emotion		
16. Audiovisual integration	1	24
17. Sensory-motor processing, motion, entrainment	10	7 9 23 26 33 34 35 44 45 46
18. Bodily impact	0	
19. Emotion, feeling, mood, preference	0	
20. Musical expression	0	
21. Creative projects	0	

3.06 Categories of investigation	NM I	NM II	NM III	NM IV
	Interaction Development	Perception Performance	Disorders Plasticity	Learning Memory
Categories of investigation	Papers 2002	Papers 2005	Papers 2008	Papers 2011
A1. Neural correlates of sound				
1. Pitch, melody, scales	14	5	10	3
2. Harmony, consonance / dissonance	7	7	3	1
3. Complex sounds	7	2	2	0
4. Timing, tempo, rhythm, meter	9	3	11	3
A2. Neural correlates of vocal sound				
5. Song	0	2	4	1
6. Phonetic sounds, language, infant sounds, animal sounds	8	5	7	4
B. Culture, development, training				
7. Cultural influence, cultural differences	7	0	4	9
8. Musicians versus non-musicians or different musicians	13	6	5	5
9. Child development	5	0	7	5
10. Training effect, learning	6	4	11	13
C. Deficits, disorders, therapy, recovery				
11. Deficits, disorders	8	7	23	17
12. Therapy, recovery	0	4	7	8
D. Attention, memory				
13. Attention, expectation, anticipation, recognition, localization	4	3	5	5
14. Memory, auditory imagery	3	5	13	6
15. Musical form and structure	1	0	2	0
E. Embodiment, motion, emotion				
16. Audiovisual integration	1	2	2	1
17. Sensory-motor processing, motion, entrainment	4	4	7	10
18. Bodily impact	2	2	4	0
19. Emotion, feeling, mood, preference	0	10	10	0
20. Musical expression	1	2	1	0
21. Creative projects	4	0	0	0

3.07 Cultural references NM I

The Neurosciences and Music I – Conference 2002: Mutual Interactions and Implications on Developmental Functions

Cerebral organization 1-29

Brain sciences versus music 30-44

Music and development 45-61

Cultural references – NM I Papers no.

Neutral or not indicated: 23 7 11 13 16 17 19 21 29 31 32 33 34 36 38 39 40 44 45 50 56 57 59 61

Western major-minor: 29 1 2 3 4 5 6 8 9 10 12 14 15 18 20 22 23 24 25 27 28 37 43 47 49 51 52 53 54 55

Specified music:

8: Excerpts from A. Scarlatti: *Sonata Terza in C minor for Treble Recorder, Strings and Basso Continuo*.

9: Mozart: Clarinet Concerto K. 622

10: Mozart: *Twinkle Little Star*, Bach: *Two-part invention no. 8*18: Ravel: *Bolero*

37: Bach, Haydn and Mozart minuets. Extracts from four sonatas by Haydn.

Western popular: 4 18 41 46 48

Specified music:

18: Bee Gees: *Stayin' alive*

41: Relaxing music excerpts from Enya, Vangelis, and Yanni

46: Instrumental excerpts from TV programs: *E.R.*, *Friends*, *Jeopardy*, *Law & Order*, *The Simpsons*, *X-files*48: 6 French songs: *Milord*, *On cherche un Auguste*, *Flamandes*, *Comme*, *Besoin de personne*, *Comédie*

Western traditional: 3 18 46 58

18: Instrumental folk music 46: English folk melodies

58: Two English folk songs, *The Country Lass* and *The Painful Plough*

Western non-tonal: 2 35 37

35: Electronically synthesized tones made up of streams or clouds of sonic particles

37: Specially composed canons in the style of Webern

Cross-cultural: 7 8 9 23 26 46 48 60

8: Western classical and Chinese music: Excerpts from A. Scarlatti and a traditional Chinese piece, *Liu Qin Niang*.

9: Western classical and African-American scores: Performances by professional musicians

23: Western, Thai, and Turkish scales

26: Thai and Chinese language: Syllables of two tonal languages

46: Responses by Western and Japanese children. English folk melodies, instrumental excerpts from TV programs

48: 6 Tunisian songs: *Maftoun*, *Ya Kassi*, *Ain*, *Ya meziana*, *Sultan*, *Aghrab*, plus 6 French songs, specified above

60: Early infant sounds by Italian and Moroccan babies

Animal sounds: 2 30 42

30: Monkey communication (Coo sounds)

42: Bird songs

3.07 Cultural references NM II

The Neurosciences and Music II – Conference 2005: From Perception to Performance

Ethology / Evolution 1-5
Development 20-27
Performance 36-43

Music and language 6-10
Music therapy 28-31
Emotion 44-53

Mental representations 11-19
Disorders 32-35

Cultural references – NM II Papers no.

Neutral or not indicated: 25 1 2 3 4 5 8 9 15 16 19 27 28 29 30 31 34 35 36 37 38 40 41 42 43 44

Western major-minor: 28 6 7 10 11 12 13 14 17 18 20 21 22 23 24 25 26 32 33 39 45 46 47 48 49 50 51 52 53

Specified music:

12: Schubert Piano trio, excerpt

17: Mozart: Sonata facile

20: Mozart: String Quintet in D major K. 593, last movement 10 min.

46: Twenty-seven classical excerpts, specified in Bigand et al. (2005)

47: Thirty J.S. Bach piano pieces

49: Mahler: Symphony no. 2, 4th movement "Urlicht", three excerpts

52: Six Bach chorales containing unexpected harmonies

53: Stravinsky: Clarinet piece

Western popular: 4 13 20 46 49

Specified music:

13: Favorite CDs, self-selected, not specified

20: Blur: *Country House*. Mark Morrison: *Return of the Mack*. PJ & Duncan: *Stepping Stone*

46: Pop/rock, not specified

49: 7 Different musical styles: Mozart, Bach, Pop music, Film music, Cello-Rockband, Death Metal, and Bossa Nova.

Western traditional: 0

Western non-tonal: 0

Cross-cultural: 0

Animal sounds: 2

2: Songs of whales, seals, and birds

3: Songs of birds, whales, dolphins, and seals. Ape drumming

3.07 Cultural references NM III

The Neurosciences and Music III – Conference 2008: Disorders and Plasticity

Rhythm 1-9 Singing 10-15 Training 16-30 Memory 31-42
Emotions 43-55 Recovery 56-65 Music, language, motor 66-76 Cochlear implants 77-79

Cultural references – NM III Papers no.

Neutral or not indicated: 28 1 2 3 4 5 6 7 8 14 15 16 26 28 30 37 38 40 43 55 57 59 60 63 66 67 69 74 76

Western major-minor: 40 10 11 12 13 17 18 20 21 22 23 24 25 27 29 31 32 33 34 35 36 39 41 42 44
45 46 47 48 49 50 51 52 53 54 58 61 62 64 65 68

Specified music:

19: Excerpts from Bach Partitas. Excerpts of symphonies by J. Stamitz and G.B. Sammartini

33: Familiar excerpts: Bach, Rossini, Mozart, Brahms, Dvorak, Ravel, Shostakovich, Bizet, Schubert, Strauss.

Unfamiliar excerpts: Söderman, Olson, Rebel, Berwald, Kraus, Bengtsson, Norman, Scriabin, Beethoven, Alfvén.

Training items: Wagner, Mendelssohn, Schmelzer, Rubenson.

51: Mozart: From *Requiem: Lacrimosa, Rex Tremendae, Confutatis, Tuba Mirum, Dies Irae*.

Bach: *Motet, Unser Leben ist Schatten*. Puccini: *Requiem*.

46, 62: Music selected by participants

Western popular: 11 9 31 34 44 46 47 49 54 62 73 78

Specified music:

9: Variants of a rhythmic rock pattern.

31: Popular music 1935-1994.

73: Three excerpts from Drum and Bass, Folk, Jazz

78: TV theme songs

46, 62: Music selected by participants

Western traditional: 1 62

62: Music selected by participants

Western non-tonal: 1 56

56: Excerpts from piano pieces by Arnold Schönberg and Anton Webern

Cross-cultural: 4 19 71 78 79

19: Western: Excerpts of J. Stamitz and G.B. Sammartini. Indian: Excerpts of N. Banerjee and U.R. Shkan

71: Words spoken in a tonal language, Mandarin Chinese. Four tone contours; level, mid-rising, dipping, high-falling.

78: Western and Japanese TV theme songs

79: Mandarin Chinese language: Three tone contours; level, rising, and dipping

Animal sounds: 0

3.07 Cultural references	NM I	NM II	NM III	NM IV
	Interaction Development	Perception Performance	Disorders Plasticity	Learning Memory
Cultural references	Papers 2002	Papers 2005	Papers 2008	Not available
Total number of papers	61	53	79	
Neutral or not indicated	23	25	28	
Western major-minor	29	28	40	
Western popular	4	4	11	
Western traditional	3	0	1	
Western non-tonal	2	0	1	
Cross-cultural	7	0	4	
Animal sounds	2	2	0	

A survey of music applied in music therapy research, as reported in AAU PhD dissertations 2002-2008.

All dissertation texts could be retrieved 27 July 2012 from the website <http://www.mt-phd.aau.dk/phd-theses/> , except Rolvsjord (2007), which is documented in book form (2010).

In the survey, features which appear relevant for a discussion of music types reported in neuroscience and music therapy research are marked in **bold type**.

MT 1. Cochavit Elefant (2002) *Enhancing communications in girls with Rett syndrome through songs in music therapy*.

In a study of song preferences in girls with Rett syndrome, Cochavit Elefant applies 18 pre-composed children's songs, sung with guitar accompaniment by the investigator (p. 83, 91, 200).

Full scores of songs are provided in Appendix VIII, 9 pages.
16 songs are in major tonality, one in minor tonality, one is a chant.

Important musical features for determining preferences are the following:

Tempo, accelerando, ritardando, fermata, pauses, upbeat introductions and syncopation (pp. 204-208).

Rhythmic grouping, melody, dynamic variability, vocal play with sounds (pp.209-217)

MT 2. Ulla Holck (2002) *"Kommunikalsk" samspil i musikterapi. Kvalitative videoanalyser af musikalske og gestiske interaktioner med børn med betydelige funktionsnedsættelser, herunder børn med autisme*.

["Commusical" interplay in music therapy. Qualitative video analyses of musical and gestural interaction with children with severe functional limitations, including children with autism.]

Ulla Holck describes and analyzes interactive interplay between the therapist and children with severe functional limitations. The interplay includes song, melody, rhythm, movement, **gesture, and facial expressions** (pp. 402-403).

Holck provides transcriptions and microanalyses of three sessions:

A: **Interactive drumming with vocal sounds and song, movements and facial expressions.** (Transcriptions pp. V-XXXI).

B: The child **jumps on a trampoline, utters a few words and sounds, smiles often.**
The therapist plays the piano, sings and talks, and **communicates with big smiles and facial expressions.**
(Transcriptions pp. XXXII-XI).

C: The child **sings, jumping on a ball.** The therapist **sings tones and glissandi**, speaks, and plays a repeated vamp-chord progression on guitar. (Transcriptions pp. LXII-LXXVI)

MT 3. Trygve Aasgaard (2002) *Song creation with children with cancer. Process and meaning.*

Trygve Aasgaard describes the creation, development and use of 19 songs in music therapy with children suffering from leukemia or other types of cancer. The aim was to improve the children's quality of life by expressing and communicating their life stories.

The children created the texts.

The investigator created 14 songs, one together with patient, one together with patient's father. Four songs were pre-composed, one a traditional children's song.

Notations of the songs and texts are provided in Appendix 2, pp. 256-274.

All 19 songs were in major/minor tonality.

Some songs adopted a specific popular style:

Heavy rock, blues, rock, quasi reggae, swinging, cha-cha, disco style.

MT 4. Christian Gold (2003) *Effectiveness of individual music therapy with mentally ill children and adolescents: A controlled study.*

Christian Gold summarizes types of music reported by music therapy researchers (pp. 50-51):

Free or structured improvisations, permitting **supportive, stimulating, or challenging interventions.**

Well-known songs, which **establish secure frameworks**, and permit the expression of moods and feeling. Play songs, which can help children to **mirror themselves and focus their play.**

Structured musical activities used to **improve coordination or concentration.**

Furthermore, Gold points out particular kinds of music described in various studies:

Very loud and shifting rhythms (p. 51).

Music used to **express aggressive sounds and to experiment with the voice** (p. 53).

Games and body movement together with musical activities (p. 55).

Rock music (p. 245) Mozart (p. 247)

MT 5. Hanne Mette Ochsner Ridder (2003) *Singing dialogue. Music therapy with persons in advanced stages of dementia.*

Hanne Mette Ochsner Ridder has used a large repertory of familiar songs as a means of entering dialogue with persons suffering from dementia. The investigator sings with the participants, and often includes improvisations in the musical communication. The songs **focus attention, and provide structure and stability**. Songs are also used to **regulate the arousal of the participant** as a preparation for the **dialogue**.

A complete list of songs used in regulation and dialogue is provided in Appendix B, pp. 307-312. Ridder lists 206 songs and 32 improvisations. The songs are all in major/minor tonality. 200 songs are in Danish, two in Danish Jutlandic dialect, three in English, one in Swedish. The repertory consists of Danish community songs, folk songs, popular songs, psalms, children's songs, and songs from revues and movies.

Six songs are structure- songs used as cues to indicate the course of the session: beginning, middle and end.

Four structure songs are traditional, in major/minor tonality (Appendix A, pp. 303-306). Two structure songs are African. One is rhythmic, pentatonic, allegro, the other one melodic, adagio, with **calling phrases** (p. 98).

MT 6. Felicity Baker (2004) *The effects of song singing on improvements in affective intonation of people with traumatic brain injury.*

Felicity Baker reports her work with four persons suffering from traumatic brain injury. She employed a song-singing program in 15 music therapy sessions with the purpose of improving the affective intonation of the clients' monotonal speaking voices. With each client, Baker worked with three client-preferred songs in pitch-matching tasks:

Subject B (p. 151)	<i>I heard it through the grapevine</i> (Creedence Clearwater Revival) <i>Comfortably numb</i> (Pink Floyd) <i>Under the bridge</i> (The Red Hot Chili Peppers)
Subject C (p. 172)	<i>Heavy heart</i> (You Am I) <i>You're the voice</i> (John Farnham) <i>Waltzing Matilda</i> (Traditional Australian song)
Subject D (p. 190)	<i>Layla</i> (Eric Clapton) <i>Bad Moon Rising</i> (Creedence Clearwater Revival) <i>Sunday, Bloody Sunday</i> (U2)
Subject E (p. 210)	<i>Cecilia</i> (Simon and Garfunkel) <i>Knockin' on heaven's door</i> (Guns n' Roses) <i>Better man</i> (Pearl Jam)

MT 7. Rudy Garred (2004) *Dimensions of Dialogue. An Inquiry into the Role of Music and of Words in Creative Music Therapy*.

Rudy Garred's thesis is a philosophical inquiry on the use of music and words in creative music therapy. Garred discusses music from sessions with three clients. No. 1 and 2 are his own clients.

- 1) A spontaneous song in F major, which **induces joy and laughter** in a 14-year old girl, who suffers from Rett syndrome, and has no functional language (p. 134, 156).
- 2) A simple rhythm figure on two tones initiates a piano improvisation with a 15-year old girl with autism. Several subsequent improvisation sessions lead to a pivotal moment. Client and therapist play grooves on djembe-drums, and a particular initiative from the therapist elicits a moment of **intense eye contact** (pp. 183-184).
- 3) A slow, hymn-like melody in E major arouses interest in a withdrawn male client suffering from Down's syndrome. In a following session, the client plays the drum, improvising with the therapist, who invents **dancing syncopated melodies and cross-rhythms** (Ansdell 1995, 202-206)

MT 8. Lars Ole Bonde (2004, Defense 2005) *The Bonny method of guided imagery and music (BMGIM) with cancer survivors*.

Lars Ole Bonde 's study of BMGIM therapy with cancer patients proposes grounded theories concerning the relationship between the music and the participants' experience. The 75 music selections from the BMGIM repertory included in the study encompass baroque, classical, romantic and impressionist music by the following composers:

Albinoni, Bach, Beethoven, Berlioz, Bizet, Boccherini, Brahms, Canteloube, Cesnokov, Copland, Corelli, Debussy, Delius, Duruflé, Dvorak, Elgar, Fauré, Gorecki, Gounod, Grieg, Haydn, Holst, Liadov, Mahler, Marcello, Massenet, Mendelssohn, Mozart, Pachelbel, Puccini, Ravel, Respighi, Rodrigo, Schmidt, Schostakovich, Schumann, Sibelius, Strauss, Stravinsky, Tschaikovsky, Vaughan Williams, Vivaldi, Wagner, Walton and Warlock, plus a Russian chant and a Russian folk song.

The selections are listed in Appendix 8.1, pp. 504-509.

All selections are in major/minor tonality, or have affinity to tonality.

MT 9. Jos De Backer (2004, Defense 2005) *The transition from sensorial play to musical form by psychotic patients in a music therapeutic process.*

Jos De Backer has investigated an important aspect of music therapy with psychotic patients. He examines the transition from **monotonous, repetitive or incoherent sensorial play** to the creation of **musical form, related to a symbolizing process**.

De Backer proposes the following criteria and descriptions (pp. 270-273):

Criteria of sensorial play:

1) there is no anticipation (sensed by the presence of an inner sound) of a musical beginning and ending. This is represented in the music by endless play or by abrupt termination of the music. 2) there is almost no musical development. The content and style of the music is repetitive, unchanging and/or fragmented. 3) the structure is limited and rigid, with a lack of dynamic variability. 4) the individual notes and melodic and/or rhythmic fragments are not related to each other.

Musical aspects of sensorial play:

1) random playing (tonal and atonal). 2) repetitive and/or fragmented play. 3) significant lack of phrasing. 4) significant lack of dynamics. 5) significant lack of variation. 6) an absence of silence in the music.

Criteria of musical form:

1) the play begins with an "anticipating inner sound or silence." 2) the patient is able to end an improvisation independently with post resonance. 3) silence is an important aspect for structuring the play. 4) the patient can incorporate and use musical parameters in a stable way. 5) there is a clear musical development in the improvisation. 6) there is an inner structure.

Musical aspects of form:

1) pulse and phrasing are present. 2) rhythmic and melodic themes are present. 3) dynamic variability in the play is present. 4) melody is embedded in a harmonic structure. 5) the patient is able to vary and re-introduce musical fragments. 6) single notes and melodic and/or rhythmic fragments are related to each other. 7) there is intertwining within the timbre of both players.

De Backer describes the process of his work with two patients in great detail.

Marianne, suffering from depression, improvises with metallophone, piano and kalimbaphone (pp. 115-179)

Adrian, a shy and frightened client, improvises with metallophone, xylophone, cymbal, and especially piano. The improvisations are frequently interrupted by Adrian's insistence to play Beethoven's *Für Elise*. (pp. 181-264).

MT 10. Jinah Kim (2006) *The effects of improvisational music therapy on joint attention behaviours in children with autistic spectrum disorder*

Jinah Kim has investigated the effects of music therapy in children with Autistic Spectrum Disorder by comparing two different conditions, improvisational music therapy and free play.

The sessions included a period of free play with a large array of toys, and a period of improvised musical interaction between child and therapist.

The following instruments were available (pp. 66-67):

An upright piano, a standing cymbal, a 20 inch timpani drum, a diatonic alto xylophone, a chroma harp.

A pair of paddle drums, four different colored toy handbells, three different color tone bars, a small guiro, a pair of egg shakers, a pair of finger cymbals.

A pair of Nordoff-Robbins horns, a pair of whistles and bird call, two pairs of beaters.

MT 11. Inge Nygaard Pedersen (2006, Defense 2007) *Counter transference in music therapy. A phenomenological study on counter transference used as a clinical concept by music therapists working with musical improvisation in adult psychiatry.*

In her interview-based study of counter transference in music therapy, Inge Nygaard Pedersen reports different kinds of improvised interplay between client and therapist using piano, metallophone, xylophone, percussion and voice.

Some notable features of the improvisations reported in interviews are the following:

A wall of sound, fragmented sounds (p. 74)

Tiny movements or impulses of feelings and sensations (p. 79)

Chaos and structure, good and bad energies, **automatic and intentional playing** (pp. 82-84)

One-note improvisation on the piano (p. 148)

MT 12. Helen Odell-Miller (2007) *The practice of music therapy for adults with mental health problems: The relationship between diagnosis and clinical method.*

Helen Odell-Miller has investigated different approaches and techniques in music therapy related to adult psychiatry. She provides a list of music therapy techniques, as reported by the participants in the study:

- 1) Singing composed songs
- 2) Free improvisation with minimal talking
- 3) Free improvisation and talking/interpretation
- 4) Free improvisation with structures such as turn taking or play rules
- 5) Theme-based improvisation
- 6) Activity-based music therapy
- 7) Song writing
- 8) Musical role play / Musical psychodrama / Art and psychodynamic movement
- 9) Receptive music using live music
- 10) Receptive music using recorded music
- 11) Guided imagery and music
- 12) Music for relaxation as part of a music therapy programme.

MT 13. Randi Rolvsjord (2007) *Blackbirds Singing. An Explorational study of resource-oriented music therapy in mental health care.* Book publication:

Randi Rolvsjord (2010) *Resource-oriented music therapy in mental health care.*
Gilsum, NH: Barcelona Publishers.

In two case studies, Randi Rolvsjord reports the use of pre-composed songs and songs created with the client.

Songs sung with Maria (pp. 93-95):

Angel (Sarah McLachlan).
A Place Nearby (Lene Marlin)
That's What Friends Are For (Sager & Bacharach).
Yesterday (Lennon & McCartney)
Your Song (Elton John)
Can You Feel the Love Tonight? (Walt Disney soundtrack)
Dancing Toward Spring (Rolf Løvland)
I Will Always Love You (Whitney Houston)

Songs sung with Emma:

Pop, musical and gospel, including
I Will Light a Thousand Candles (p. 128)
Blackbird (p. 141)
Streets of London (p. 163)

Rolvsjord has created 32 songs on the basis of Emma's lyrics (p. 149).

11 of these songs, all in major/minor tonality, are notated in an appendix (pp. 263-282).

MT 14. Karin Schou (2008) *Music therapy for post operative cardiac patients.*

Karin Schou has investigated the effect of music listening and guided relaxation for patients after a cardiac operation. She compared three groups, a Guided Relaxation with Music group, a Music Listening group, and a Control group, which was not offered music.

Participants in the first two groups chose to listen to a preferred genre of relaxing music. They could choose between Easy listening, Classical, Specially composed music, and Jazz.

Schou applied four programmes consisting of music from the preferred genres (pp. 129-131):

Titles	Sources
<i>1: Easy listening</i>	
1 Norge, Kaare: Song for Guy 3:55	Here Comes the Sun, #4. RecArt 5941032
2 Norge: (Everything I do) I do it for you 3:25	Here Comes the Sun, #5
3 Rowland, Mike: Magic Moment 6:01	Within the Light, #2. Oreade ORE 5287-2
4 Norge: Why worry 4:16	Here Comes the Sun, #6
5 Rowland: Listen to your Heart 4:56	Within the Light, #3
6 Norge: Jesus to a child 4:47	Here Comes the Sun, #12
7 Rowland: Believe and See 3:34	Within the Light, #4
8 Rowland: Take my Hand 4:13	Within the Light #5
<i>2: Classical</i>	
1 J.S. Bach: 3rd Suite: Air 5:12	Bonde et al. (2001), CD #25
2 Pachelbel: Canon in D 7:11	Bonde et al. (2001) CD #22
3 Warlock: Capriol Suite (Pieds en l'air) 2:18	Music for the Imagination (MFI), Supportive CD #6
4 Mascagni: Cavalleria rusticana: Intermezzo 3:41	Naxos 8.660022, CD #11
5 Massenet: 7th Orchestral Suite: Sous Les Tilleuls 4:57	MFI. Positive CD #6
6 Shostakovich: 2nd Piano Concerto (Andante) 6:40	MFI: Supportive CD #12
7 Grieg: Cradle song 4:00	MFI: Creative CD #5
<i>3: Specially composed</i>	
1 Eje, Niels: Deep Woods & Village (excerpt) 13:06	Fairy Tales, #1 Gefion Records, GFO 20136
2 Eje, Niels: Enchantment 8:44	The Journey, #4 Gefion Records, GFO 20132
3 Eje, Niels: Secret Path (excerpt) 5:34	Fairy Tales, #2
4 Eje, Niels: Midnight Sun 8:11	Northern Light, #3 Gefion Records, GFO 20138
<i>4: Jazz</i>	
1 Danielsson, Lars: Forever You 4:03	Forever You, #1. Stunt Records 03192
2 Morricone, Andrea: Cinema Paradiso (love theme) 3:36	Ulf Wakenius 2003
3 Metheny, Pat: Two for the Road 5:17	Beyond the Missouri Sky, #11. Verve 537 130-2
4 Ryuichi Sakamoto: Bibor No Azora 5:25	Charlie Haden & Pat Metheny 1997
5 Webb, Jim: The Moon is a Harsh Mistress 4:05	Beyond the Missouri Sky, #4
6 Trad. Arr. by Metheny & Haden: He's Gone away 4:18	Forever You, #7
7 Morricone, Andrea: Cinema Paradiso (love theme) 3:36	Beyond the Missouri Sky, #6
8 Danielsson, Lars: Forever You 4:03	Beyond the Missouri Sky, #8
	Beyond the Missouri Sky, #11
	Forever You, #1

Erik Christensen

The Musical Timespace

*An Investigation of the Listening Dimensions
in Music*

A concise version 2012

*based on excerpts from the edition published by
Aalborg University Press 1996*

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 urgent; 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*

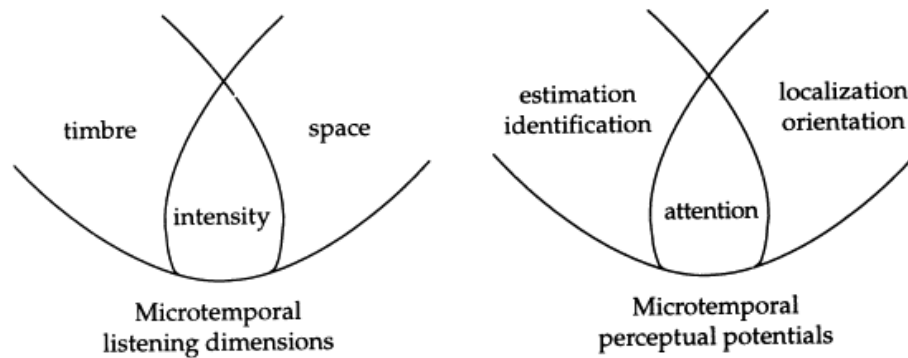


Fig. 1.1. Microtemporal listening dimensions

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 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 working memory permits 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 working 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.

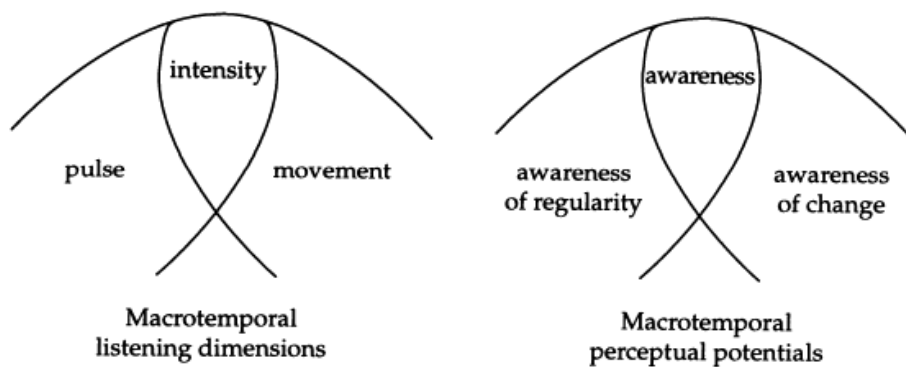


Fig. 1.2. Macrotemporal listening dimensions

The basic listening dimensions in music

It is proposed that five properties of sound; intensity, timbre, pitch, movement and pulse, constitute the basic listening dimensions in music. Intensity is the prerequisite of sound, and the fundamental dimension of listening. Timbre is the basis for identification of sounds. Pitch is a property of musical sounds. Intensity, timbre and pitch are microtemporal dimensions of sound, perceived instantly. Movement and pulse are macrotemporal dimensions of sound, evoking the experience of time.

The proposed basic dimensions of listening are displayed in the graphic model Fig. 1.4., which reflects that pitch and pulse are related to regularity in sound, and timbre and movement are related to change in sound.

It is the objective of the subsequent chapters to investigate the dimensions of listening in music that explores the natural continuum of sound, which is not divided in to discrete steps, and which encompasses noise as well as tones.

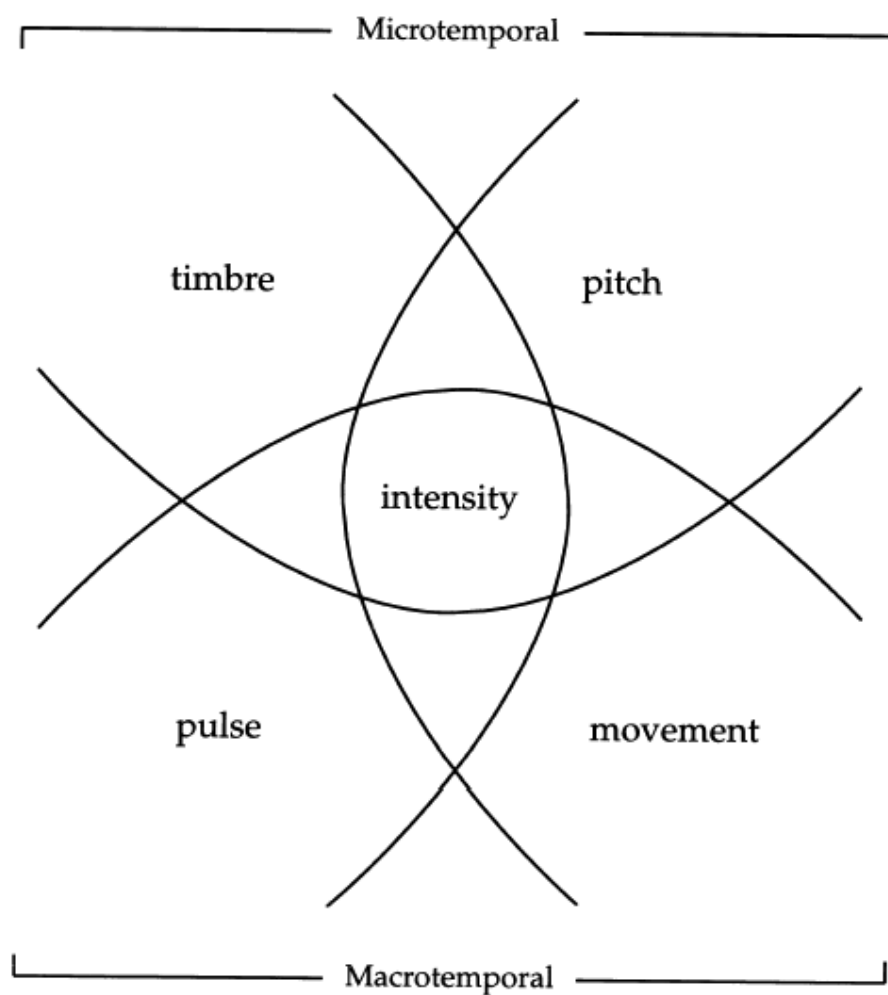


Fig. 1.4. The proposed basic listening dimensions in music

The temporal continuum

In the graphic model, *pitch* is placed opposite *pulse*, reflecting the fact that pitch 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. When a regularity in a sound spectrum is prominent, its frequency is heard as a pitch height.

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 working 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 such as 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.

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), ending 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

0'00-1'32:

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.

2'26-2'54:

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.

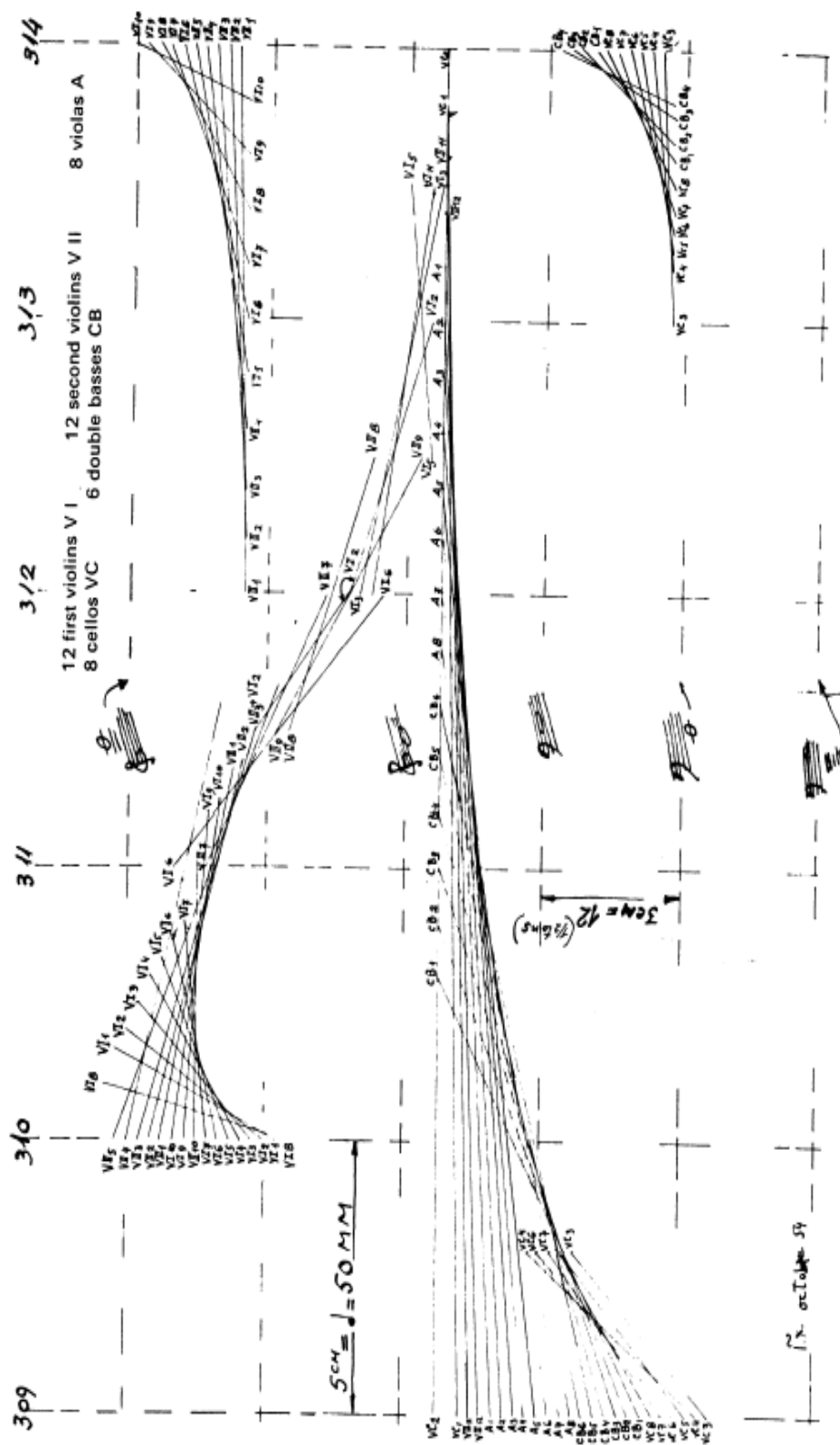
In the preface of the score, Xenakis explains the title *Metastasis* as "dialectic transformation", and states some new ideas introduced by this work:

- (1) The normal orchestra is totally divided: 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*.



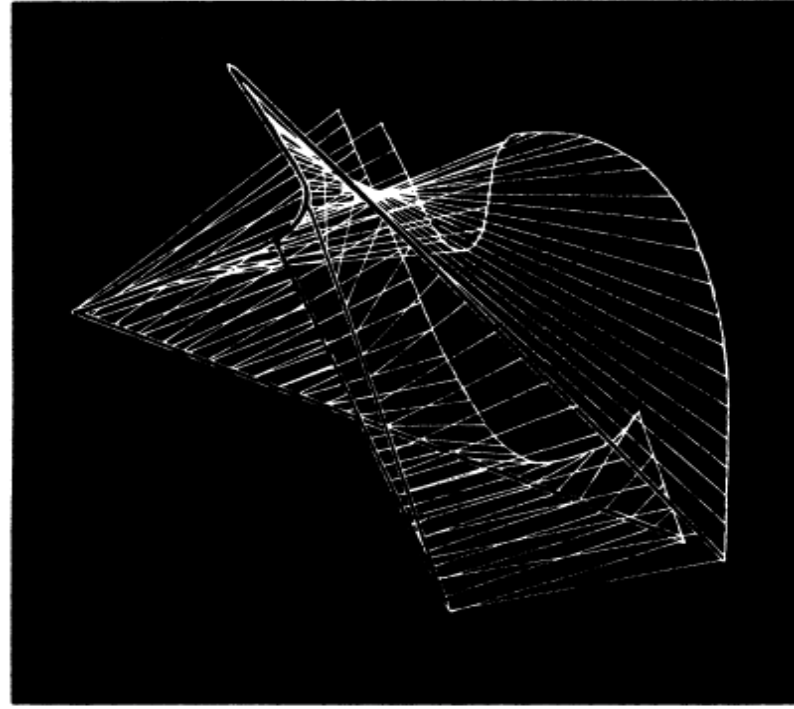


Fig. 2.2. First model of Philips Pavilion

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.

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 électronique* were heard from 350 loudspeakers in the curved walls. After the exhibition, the Pavilion was demolished.

Atmospheres - A vibrating space of timbre and movement

The composition of events, states and transformations is 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 contrabassoon, 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

<p>0'00 Sound emanates "out of nowhere", gradually changing in color, nearly disappearing... 0'53</p> <p>0'53 ... emerging, vibrating and growing, 1'18 being illuminated, 1'26 approaching, 1'45 brightening ... shimmering, 2'00 dissolving ...</p> <p>2'15 ... gently oscillating, 2'30 darkening ... 2'50 thinning out</p> <p>2'56 ... trembling, 3'16 rising towards a high extreme ... 3'50</p> <p>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</p> <p>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</p> <p>6'35 Blowing; faint trembling, 6'53 strands of light, 7'06 waves of glittering sound spectra, 7'34 darkening, disappearing ... 8'33.</p>

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.

***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

<i>Chapters and Interludes</i>	<i>Timing</i>	<i>Duration</i>
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:

0'00-1'15:

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:

2'32-3'00:

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/Kaczynsky, 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.

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.

Pitch: Investigation of the pitch continuum, pitch movement, pitched and unpitched sounds.

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.

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.

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 working memory is constantly active, retaining auditory images of musical events for a short while. The retention in 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.

Retention of musical form is the effect of a variable and rather unpredictable interaction between working 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 working 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 working 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 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.

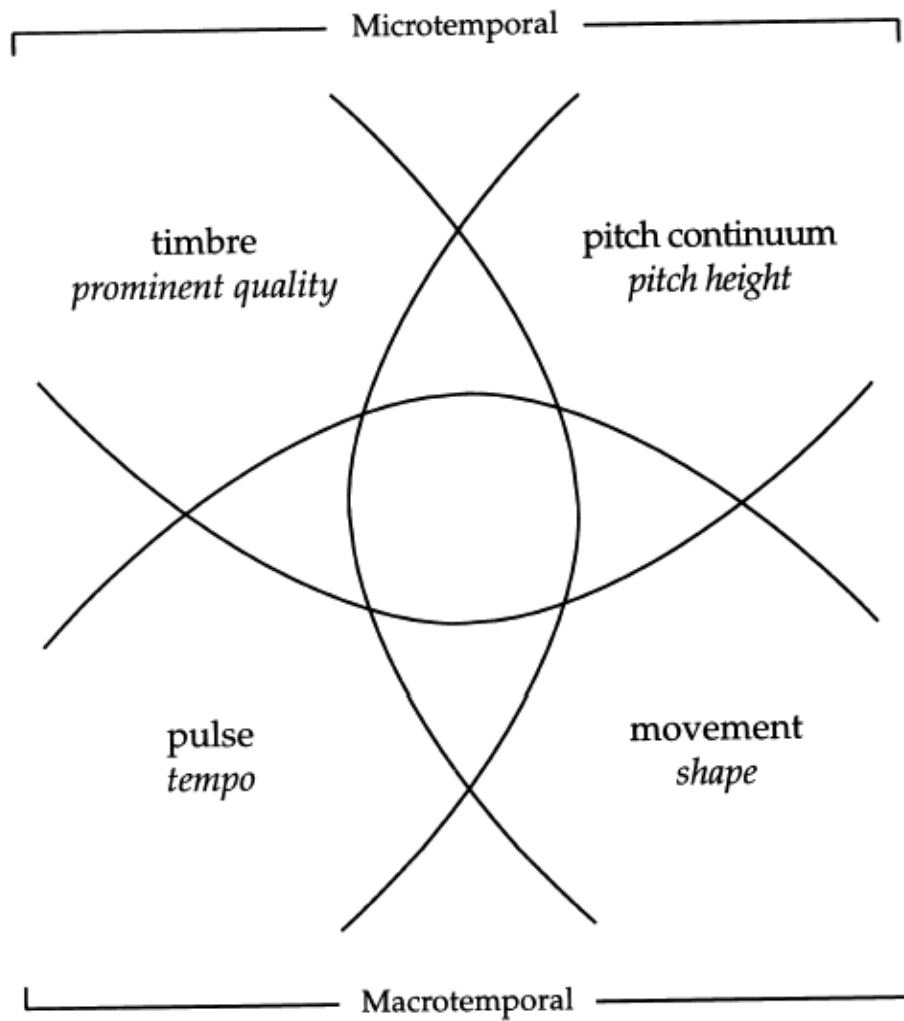


Fig. 3.1. Memorized representations of listening dimensions

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.

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.

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.

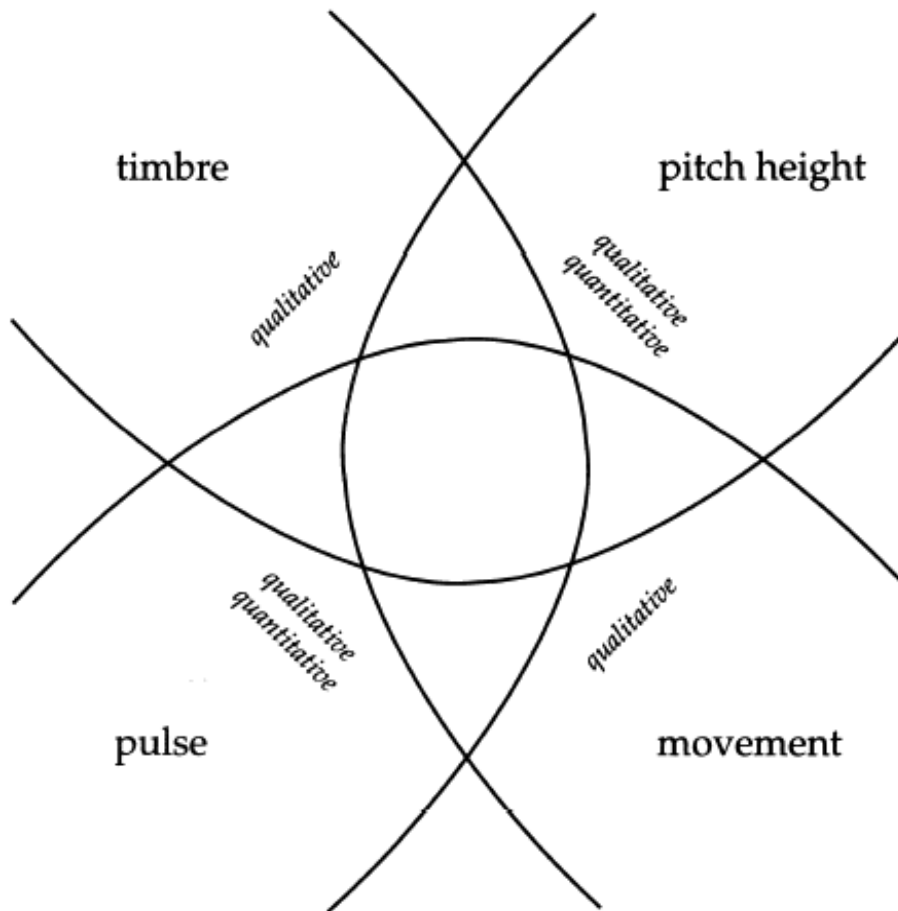


Fig 3.2. Qualitative and quantitative potentials of listening dimesions

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, experiential 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 time 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.

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.

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).

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

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 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 4'18, 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.

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.

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 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*.

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

<i>Spatial quality is predominant</i>	<i>Spatial- temporal qualities are present</i>	<i>Temporal quality is predominant</i>
no tempo or very slow tempo	variable salience of tempo	clearly marked tempo
<i>The time of being prevails</i>	<i>The time of movement and events prevails</i>	<i>The time of pulse prevails</i>
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 timespace. 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.

5

Microtemporal listening dimensions: Timbre, Harmony and Pitch

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*.

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 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, 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. Attentive listening provides evidence that every violin produces its own particular sound, and that 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 question, "What is it?". The simultaneous 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.

Jean-Claude Risset 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.

Contemporary research has demonstrated the limitations 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*.

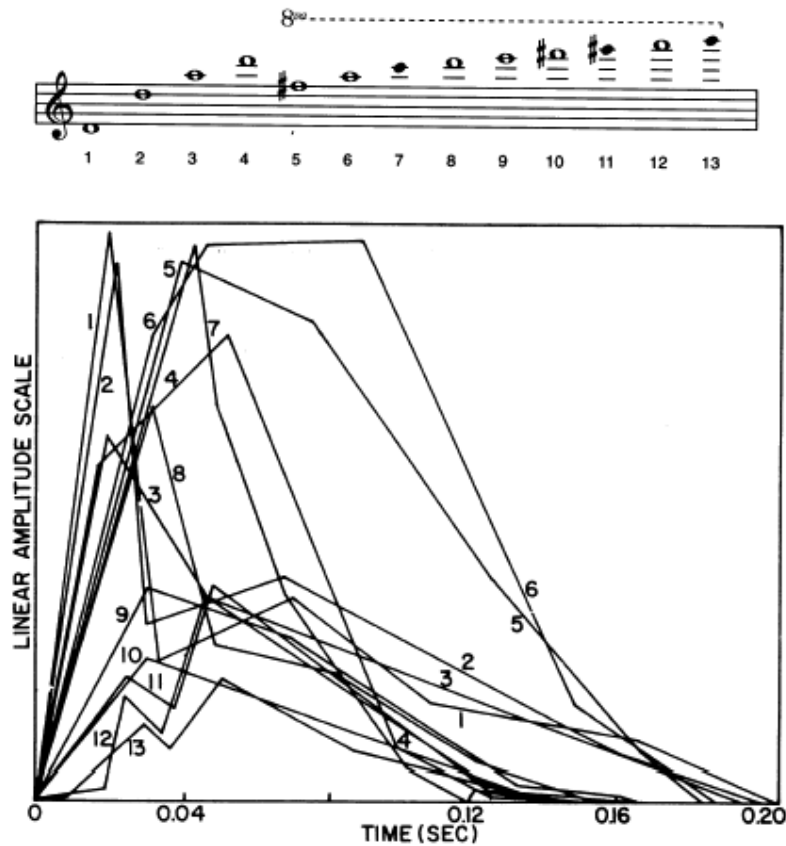


Fig 5.1. Line-segment functions that approximate the evolution in time of 13 harmonics of a D4 trumpet tone lasting 0.2 sec. (Risset & Mathews, 1969)

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.

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

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 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*.

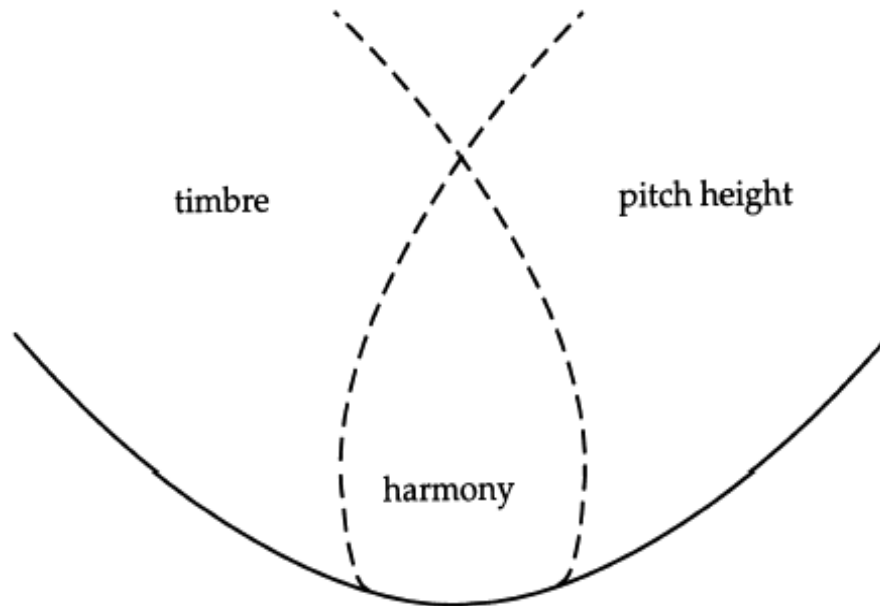


Fig. 5.3. The microtemporal timbre-harmony-pitch height continuum

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.

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

In the third movement of his *Second String Quartet* (1968), György Ligeti has composed transitions between regularity and irregularity.

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 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.

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 working 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 arises as a secondary listening dimension between the basic dimensions movement and pulse. Harmony 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.

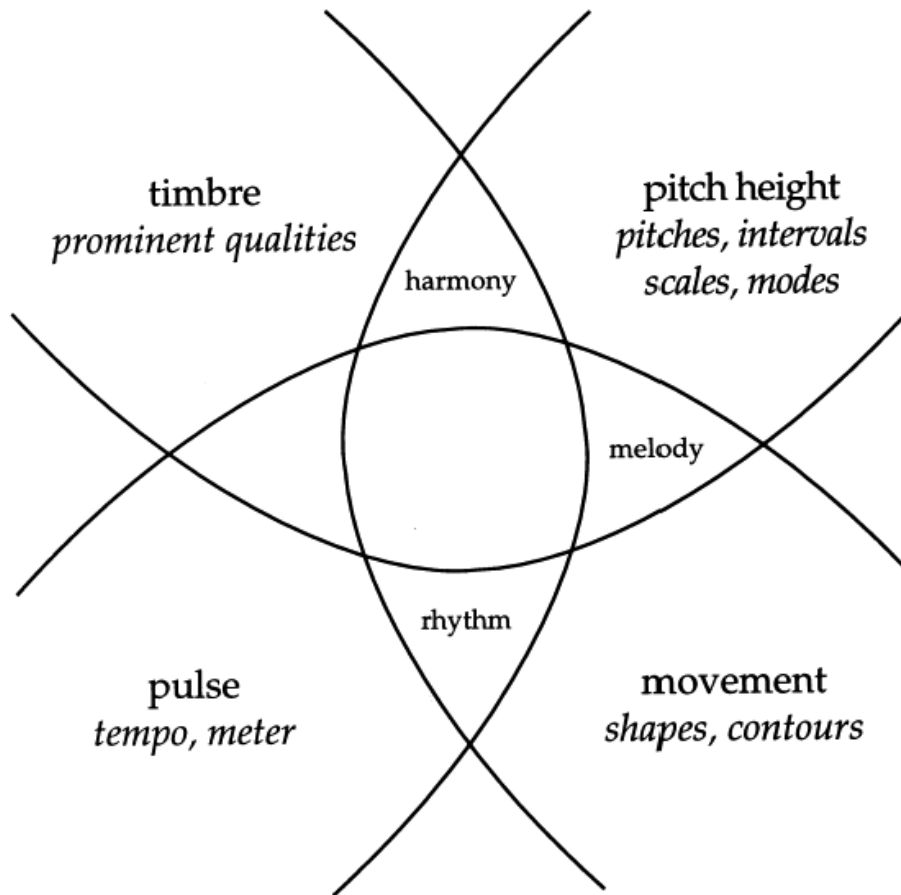


Fig. 6.5. Five basic and three secondary listening dimensions.
Memorized representations are indicated in italics.

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

The musical score is a transcription of Coleman Hawkins' 'Body and Soul', specifically the three A sections. It is written in a key signature of three flats (B-flat major/D-flat minor) and a 4/4 time signature. The score is presented in two staves: a bass staff (bottom) and a treble staff (top). The music is characterized by complex rhythmic patterns, including many triplets and sixteenth-note runs. Dynamic markings are used throughout to indicate volume changes, including *p* (piano), *mp* (mezzo-piano), *pp* (pianissimo), *mf* (mezzo-forte), *f* (forte), *ff* (fortissimo), and *dim.* (diminuendo). The score is divided into measures, with measure numbers 4, 7, 10, 13, 15, 57, 60, 62, and 64 marked at the beginning of their respective lines. The notation includes various musical symbols such as beams, slurs, and articulation marks.

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 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. 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.

- (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.

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.

Throughout the solo, the movement towards the final climax is a process of spatial expansion.

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.

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.

Music is a multivariable complex of temporal and spatial relations, movement and pulse, rise and fall, segregation and fusion of timbres, 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.

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. 13-14. 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 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 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*.

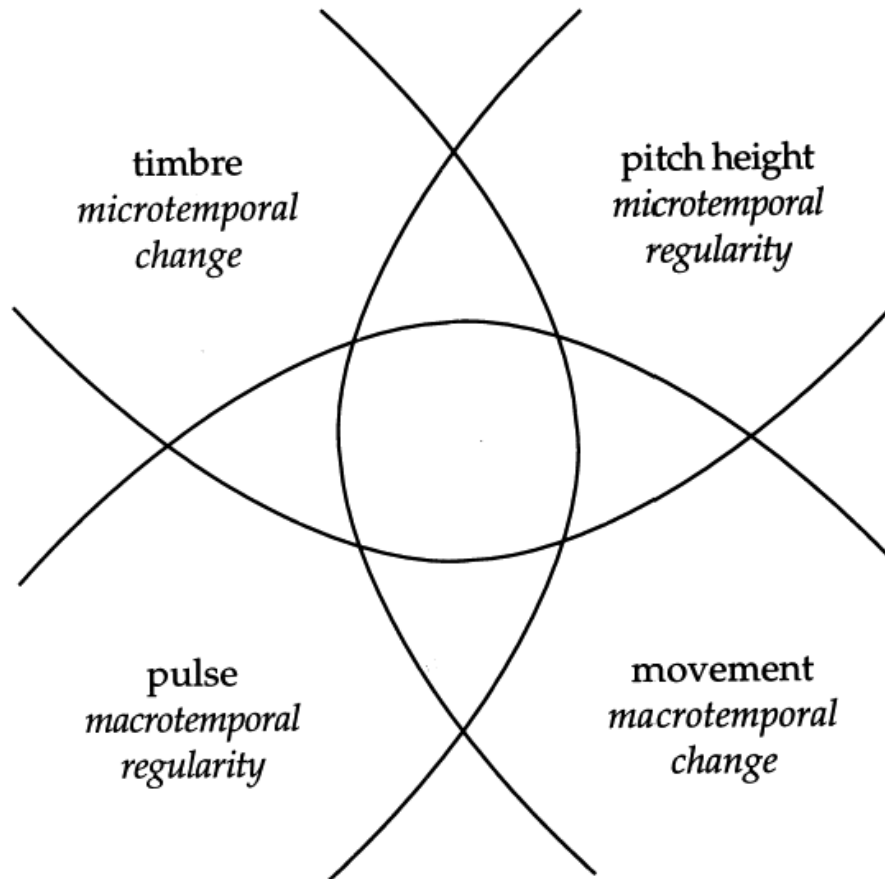


Fig. 6.12. Change and regularity

Density 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 transparency, focusing and diffuseness, and differences in intensity.

Flow, expansion and emotion

Continuum - An expanding flow of timbral-harmonic colors

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 range 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 rhythmic 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 sound-streams 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 continues 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 accompanied by pulsating keyboard noise, 3'54 stops, reverberates, 3'56 disappears.

This music is a flow of sound in continuous transformation. The fast, incessant 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.

György Ligeti

Continuum

Prestissimo *

The image shows the first page of the musical score for György Ligeti's 'Continuum'. It consists of seven systems of piano staves, each with a treble and bass clef. The music is written in a single melodic line across both staves of each system. The tempo is marked 'Prestissimo *'. The score is characterized by extremely dense, rapid sixteenth-note passages that create a continuous texture. Vertical dashed lines are placed throughout the score to provide a visual structure, as there are no traditional bar lines or a fixed meter. The key signature is one flat (B-flat), and the time signature is not present.

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.

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. 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 may call forth a strong emotional response in the listener, experienced as a climax when the total range of the soundspace is expanded towards the limits of pitch perception.

The final model of nine listening dimensions

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 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 *col legno* and *sul ponticello* effects of stringed instruments.

In the model *Fig. 8.1*, Micromodulation is included as the ninth listening dimension.

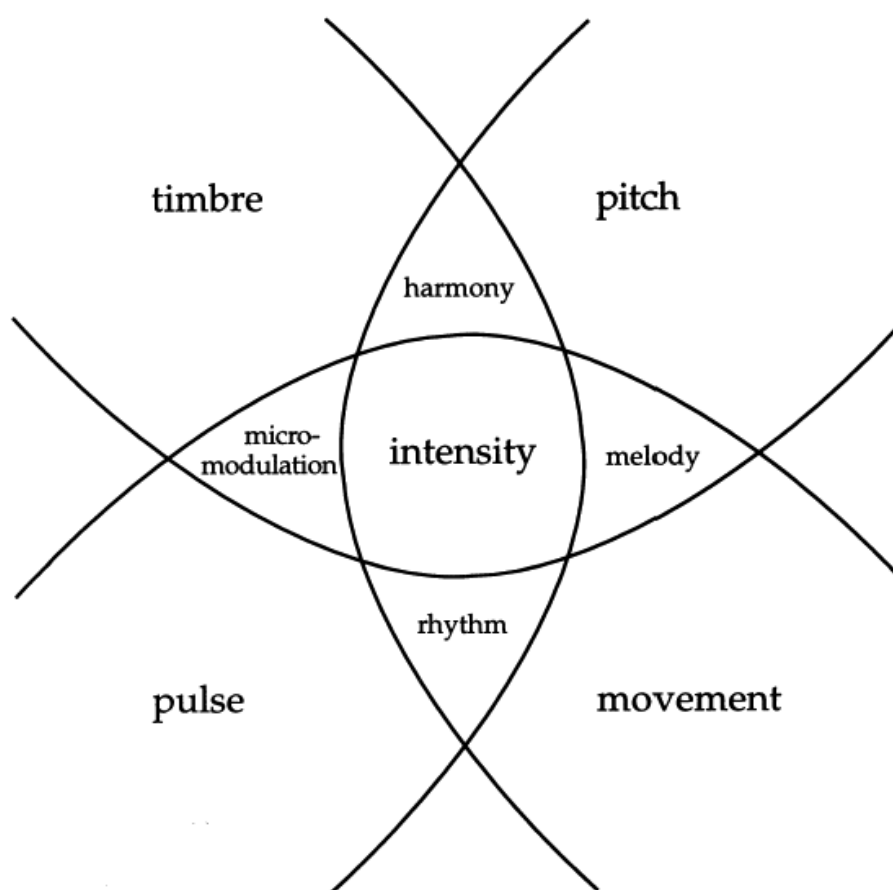


Fig. 8.1. Nine listening dimensions

Vibrato, tremolo, interference, distortion

Various kinds of micromodulation are heard in the music of Xenakis, Ligeti, Lutoslawski, and Coleman Hawkins, discussed in the previous chapters. Some examples are the following;

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.

A section of Xenakis' *Metastasis*, 1'37-2'18 in 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*.

Metastasis, 1'37-2'18

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)

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.

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.

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."

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 vibrato, 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.

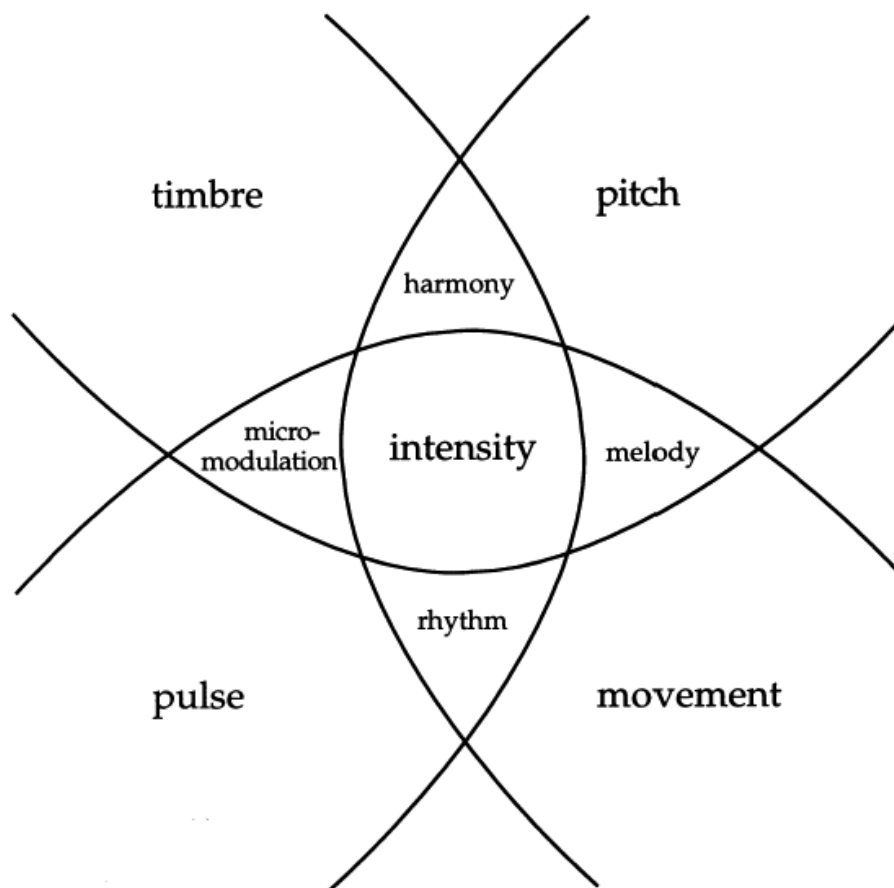


Fig. 8.1. Nine listening dimensions

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Bartok: An Evening in the Village (2'50)

A sky with northern lights. Dancing pixies or elves appear. I am turning the pages of a fairy-tale book. Northern lights again, an arch swings across the sky, shadows with a golden rim. A court jester jumps in, fooling about, dressed in red and green. The sky darkens, clouds are gathering. A beam of light calls forth memories of a candle flame in a Picasso painting.

Corigliano: Voyage (8'00)

Another image of a sky with a full moon, beams radiate in circles, like an impressionistic painting. A luminous boat floats on the surface of the ocean.

(What do you feel in your body?)

I feel warm and vibrating, filled with delight. I remember a painting by Van Gogh – undulating cornfields. Now it is quiet, the light of dawn appears, golden and pink surfaces and stripes of light, more and more – again, it is like a book of fairy tales. A new and simple clarity, gentle sounds on a delicate background. 5'08 The light changes, a few clouds appear and some dark bushes. I am an observant eye in the landscape, I am a large eye that grows out of a hillside, watching a blue-grey space of diffuse beauty. The end of the piece is like a sunset.

Messiaen: The Garden of Love's Sleep (10'30)

(Emotional) This music calls forth intense memories of my first great love. I have heard this piece many times, and I know the composer's intention: it is a story of a loving couple sleeping on a riverbank, lulled by gentle nocturnal birdsong. Nevertheless, the music seems novel to me. A golden clarity, and a silvery percussion which I have not noticed before. 4'41 A fullness of sound and rising sunbeams, a yearning – this music is about fulfilled love, and also about longing for love... I have not heard that flute before, it is a colleague of the flute in the previous piece, soaring as a golden track of light in a dark blue sky. *(Are you soaring yourself?)* – Yes...

8'15 I recall meeting the composer and his wife in Copenhagen, a touching memory.

It is unbelievable that there is so much music, like a woven texture of thick and thin woollen threads. There are so many layers, I feel a freedom, being allowed to lean against so many different threads in the spatial texture. 10'30, end of the piece: I have never noticed that metal timbre before.

Tavener: Lament (2'15)

This is very strange – I recall a metal sculpture I saw on a journey as a very young man – a large sculpture made out of the tails of aeroplanes - I think it was placed in front of the NATO headquarters in Brussels. And I hear gentle metallic sounds, like droplets

Pärt: Da pacem Domine (5'30)

A large church – and the Heavens which open up. I recall paintings of angels... a wonderful softness, like the radiating moonbeams in a previous piece. Like Hildegard von Bingen's painting which is an opening into a woman...

There is a large group of people – I don't know if they grieve or rejoice – but there is not very much sorrow. I see faces of women and apostles with beards

Tormis: Lullaby (2'45)

Another book of fairy tales for children. A forest in the night, arches of light through the forest. A Star-Sun is shining in the top of a tall tree. Women are dancing, hand in hand, to and fro, they remain there, they are not going anywhere.

(How do you feel the music?)

Life-giving, radiant – I cannot wish for anything better...

