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NORTHWESTERN UNIVERSITY

CONSISTENCY OF TEMPO JUDGMENTS AS A MEASURE OF TIME EXPERIENCE IN MUSIC LISTENING

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

for the degree

DOCTOR OF PHILOSOPHY

Field of Academic Studies and Composition -
Music Education

By

Eleni Lapidaki

EVANSTON, ILLINOIS

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I dedicate this work to him.

---

[1] W. H. Auden, *A Thanksgiving* [E. Mendelson (Ed.), W. H. Auden. Collected Poems, 1976, p. 671].

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

What we must do in our music is to expand the scale and range of tempi. It opens a completely new dimension for listening because a person who experiences this music becomes as much slower and as much faster in his reactions and experiential time as the music. This expands man and also his awareness of what music can be.

Karlheinz Stockhausen [Cott, 1973, p. 193]

One of the more fascinating and mysterious aspects of time in general is that clock time and psychological time can be quite independent from one another (Friedman, 1990; Ornstein, 1969). Most of us have at some time or other had the experience of a stressful situation that we are certain took hours to unfold; yet, when we looked at our watch, we found that only a few minutes had actually elapsed. We often relate to similar experiences as we perform or listen to music. For example, our feeling that a musical composition goes fast or slow does not necessarily directly correspond with the objective measurement of time by the metronome (Fraser, 1966, Gabrielsson, 1986).

The rapid development of a cognitive outlook in experimental psychology has, among other things, underlined the need for a reconsideration of time experience. At the same time only a handful of prominent psychologists have been concerned with the issue of time which is thoroughly anchored in music, one of the so called *temporal arts* (Cooper & Meyer, 1960; Fraisse, 1956, 1982; Kramer, 1988; Lerdahl & Jackendoff, 1983; Longuet-Higgins & Lee, 1984; Povel, 1985; Sloboda, 1983, 1985). Yet, most studies on musical time deal primarily with rhythm and meter and how they are perceived and often overlook musical tempo. Rhythm and meter can be structured, grouped, notated, and imagined

without exact measurement. Nevertheless, as soon as they are listened to, they gain concrete dimension in a fixed period of time, at a certain tempo. In other words, the rhythmic and metric order of a musical composition cannot be realized and, thus, measured without the parameter of tempo. These observations support the belief that a closer study of tempo perception is warranted. This will help us gain greater insight into the nature of the musical experience.

This study on the consistency of tempo judgments during the listening process is based on the premise that music has the ability to create different kinds of time: subjective (psychological, virtual) versus objective (real, clock) time. The musical parameter of tempo will be examined as a specific unifying relationship in conscious musical experience between the subjective pace of the flow of a musical composition and ordinary clock time or between subjectively felt and objectively measured time while listening to music.

It is somewhat surprising to find, however, that in most music psychological research, tempo is still being treated as if it were applied to a physical system, e.g., the metronome. These studies lead us to believe that subjects are not supposed to have an awareness of the tempo of music when they are listening to it. Most studies on tempo tend to deal primarily with performance practice, tempo indications, or tempo preference (Clynes & Walker, 1986; Gabrielsson, 1986). Rather than approaching the concept of tempo from the standpoint of performance practice or preference, the present study proposes to focus on the determination of correct tempo for a given musical work, the consistency of this determination over an extended period of time, and the possible effects of other variables on this determination while listening to music.

Especially now that the emancipation and manipulation of musical parameters is made possible by using digital technology that would allow for an equal differentiation of the diverse parameters, composers, music researchers and music educators are slowly but

steadily showing an increasing interest in reconsidering the historical hierarchy of musical parameters (e.g., pitch, harmony, melody, durations in rhythm and meter, timbre, and dynamics). It is hoped that if we consider the musical parameter of tempo as a new point of reference by using advanced technological tools this will attract our attention to the pace of musical time and, thus, "... open a completely new dimension for listening" (Cott, 1973, p. 193). I agree with Machover (1992, p. 7) who summarized this position as follows:

> If we rise to the challenge of using technology to explore, interpret, and communicate deeply reasoned thoughts about our complex world, then we will open doors to experiences that we cannot even imagine.

Purpose of the Study

Perception of musical time and tempo are extremely complex phenomena. Although we know their significance from general musical experience, it has been only recently that we have been able to study them in an empirical way through important technological advances. By observing objective perceptions and inferring from them the proper conclusions, research on time and tempo in music can, perhaps, yield up objectively valid and stable understandings.

The present study was designed to examine whether listeners from different age groups and musical backgrounds can set tempi in a consistent manner over an extended period of time in actual musical contexts which represent a wide range of styles, familiarity, and potential preference. It was possible by means of a computer program to manipulate the parameter of tempo, without changing the other attributes of music, such as pitch, dynamics, articulation, and timbre, and to relate it to variations in reported musical judgments about the right tempo of the composition.

Consistency of Right Tempo Judgments

It was hypothesized that listeners would demonstrate a notable consistency over a period of time, regarding the way each of them perceived how a piece of music should sound in its "right" tempo when it was presented on four separate trials. I was concerned with the temporal stability of the musical thought over a period of time observed in the listening process. Right (correct, most appropriate) tempo was thought of as a subjective unifying construct of music whose function is the meaningful (rightful) synthesis of finite juxtaposed musical elements, such as harmonic as well as rhythmic structure, texture, dissonance, melody, form, and ornamentation, among other things, in relation to real time.

Furthermore, I wanted to examine whether listeners would exhibit consistency in their perception of right tempo although the experimenter systematically changed the tempo at which each piece was first presented in every session (e.g., the initial tempo). Here the question was whether the initial tempo would influence the listener's judgment of right tempo. By means of a computer, listeners just by saying "faster" or "slower" to the experimenter who manipulated the computer accordingly, were enabled to examine the influence of tempo on the way the music sounded until they came to a point when music sounded "right" to them.

Thus, listeners were given the opportunity to explore and, finally, determine by themselves the right tempo. They were provided with the opportunity to choose the right tempo of the compositions among a vast number of tempi available to them by means of the computer, something that cannot happen when you play the music, due to motor-sensory limitations of the performer. Thereby, they were faced with the technical problem of choice making in creative thinking: to choose among the many possibilities in front of them. Moreover, listeners were given the opportunity to dive into the intricate regions of the subjective problem of saying "that's not right" or "that's right" which can be called

inspiration, intuition, insight, or revelation, but which still remains a choice (Xenakis, 1985; Lapidaki, 1990) or a mode of problem solving in the creative process (Weisberg, 1988; Webster, 1987). This clearly treats musical tempo as a topic for experimental investigation: it follows Clarke's suggestion (1985) that "it would seem desirable to study music cognition by means of some more intrinsically musical activity" (p. 209).

Musical Style

If we consider musical style as "... almost as much an expression itself as a system of expression" (Rosen, 1972, p. 21), or the composer's "primary form of self-identification" (Corbett, 1994, p. 80), or the way of cultivating a personal musical vocabulary, then tempo can be thought of as a significant 'signature' element unique to a composition's musical style, as are harmonic as well as rhythmic structure, texture, dissonance, melody, form, and ornamentation, among other things (Barry, 1990, p. 27). Brown (1979) makes the point that "period, style and even national temperament all affect the range of acceptable tempi for the performer" (p. 26).

Along these lines, it was of interest to examine the hypothesis whether the musical style of the stimulus has an effect on the consistency of tempo judgments that listeners would render with regard to the right tempo of the piece in repeated listenings. Therefore, several compositions of different styles were selected, such as Baroque (J. S. Bach), Impressionistic (C. Debussy), contemporary (M. Lapidakis), rock ballad (the Beatles), and dance music (M. Hadjidakis). Furthermore, by using substantial sections or complete musical compositions listeners could have a sense of actual musical context, in contrast with stylistically neutral or decontextualized material used in many experiments in music perception.

Musical Background

Perception of musical tempo is viewed as a function of the musical ability to create organization out of musical information. Musical abilities, however, are not innate or fixed, but subject to musical learning and experience (Davies, 1978; Shuter-Dyson & Gabriel, 1981). Therefore, the study was concerned whether the consistency in the perception of the right tempo of the music listened to was affected by the musical background of listeners, that is, by their music education and participation in specialized musical activities.

Age

Another concern of the study is to examine the degree to which the temporal stability of listeners might be influenced by their age. The question is whether age has an effect on the consistency of tempo judgments that listeners would render with regard to the right tempo of the stimulus across an extended period of time. Therefore, three age groups were selected for the study: adult (over 28 years old), adolescent (16-18 years old), and preadolescent listeners (10-12 years old). Once the age question has been answered, it might be then possible to set varied music educational standards for each age level by considering the often overlooked development of temporal perception in students and, in turn, create a more effective condition for the growth of musical experience.

Familiarity and Preference

Another assumption on which the theoretical framework of the study is based is that "... if perception can be considered as the ability to sort out and structure often complex information into coherent patterns, then the defining factors of liking and familiarity can be regarded as filters affecting choice" (Barry, 1990, p. 12). The following fundamental question central to the perception of tempo was raised: Are familiarity with the musical examples and their respective musical styles and individual preference for a particular

musical example variables affecting consistency of judgments concerning the right tempo of the stimuli? The musical stimuli were selected so as to vary widely as to their familiarity and likely preference to the listeners. The term 'preference' is understood here to reflect a listener's liking for one musical example as compared with another.

In summary, this study proposes to focus on the listener's judgment about right tempo for a given musical work and the possible effects of other variables on this determination. Specifically, the purpose of this study is to examine the consistency of right tempo judgments of various musical styles among subjects with differing musical background, age, familiarity with, and preference for selected music.

Research Questions

The following research questions were posed:

(1) Is there a consistent judgment of tempo across four separate trials of the same musical examples using varying initial tempi for each trial?

(2) Is the consistency of tempo judgment affected by the style of music?

(3) Is the consistency of tempo judgment affected by the musical background (training) of the listener?

(4) Is the consistency of tempo judgment affected by the age of the listener?

(5) Is the perception of tempo affected by the familiarity or unfamiliarity (novelty) with the individual pieces and the overall style of the music?

(6) Is the consistency of tempo judgment affected by the listener's preference / liking for a particular musical example?

Need for the Study

Musical time has not been widely recognized as an independent field of study (Kramer, 1985). Most works written on musical time deal with rhythm and meter—notated parameters, although less accurately and less completely than pitch—and how they are perceived. Yet the preoccupation with the vital concepts of rhythm and meter has led scholars to overlook other crucial issues of temporality in music, such as motion, continuity, progression, timelessness, duration, and tempo, among others. These issues must be studied if the full force of musical time is to be understood in order to gain greater insight into the nature of the musical experience.

It must be noted that most studies on tempo tend to deal primarily with performance practice and tempo indications, rather than with the listening process (Clynes & Walker, 1982; Dahlhaus, 1959; Forte, 1957; Margulis, 1984; Kravitt, 1973; Kuhn, 1974).

Empirical research on the broad subject of tempo has taken many directions. In music education there has been extensive inquiry into the effect of tempo on listener preference (Geringer & Madsen, 1987; LeBlanc, 1981; LeBlanc & Cote, 1983; Sims, 1987), on preferred tempi in music performance (Brown, 1981; Wapnick, 1980, 1987), and on discrimination of tempo changes in music listening (Kuhn, 1974; Wang, 1983). Much of this work is important in establishing a theoretical base for tempo preference and discrimination, but does not speak directly to the question of consistency of tempo judgments over an extended period of time

Investigations concerning tempo consistency in musical and nonmusical environments were performed around the first half of the century and were often referred to as "personal" tempo studies (Braun, 1927; Frischeisen-Kohler, 1933; Harisson, 1941; Miles, 1937; Mishima, 1956; Rimoldi, 1951; Wallin, 1911). Most commonly, subjects were asked either to tap a telegraph key as their response task or to use a metronome to

indicate tempo. More recently, two studies by Clynes & Walker (1982, 1986) on temporal stability in music performance are worth noting.

In addition to studies that employ traditional listening and performance tasks, of particular interest are those investigations that ask the listeners to make judgments about tempo with hardware that allowed for variable-speed control over the music stimulus. Farnswarth, Block, & Waterman (1934) designed a study that examined whether there is one tempo consistently associated with familiar waltz and fox-trot tunes. Fifty-four years later, Halpern (1988) conducted a similar study in which well-known popular songs served as stimuli. Interesting as these studies may be, they do not demonstrate whether judgments of correct tempo are consistent over a period of time, especially when subjects are presented with compositions of different musical styles.

Lapidaki & Webster (1991) conducted a study to determine whether adult musicians and nonmusicians could consistently set tempi when listening to compositions drawn from Western art music of different styles. However, this study did not assess different age groups, musical background, familiarity with, and preference for musical examples so that the role of these important variables may be more clearly understood.

In light of the dearth of information on the topic of tempo perception, the composer Arrand Parsons (as cited in Dorhout, 1979/1980) recommended the following steps for an adequate research of tempo perception:

> 1. the construction of an instrument to evaluate the ability of individuals to perceive tempo.
> 2. the investigation into the effects of maturation, sex, and musical experience upon the perceptive ability of tempo.
> 3. the investigation into possible unique qualities of tempo perception within individuals (p. 18).

The present study also placed great emphasis upon an understanding of the influence of maturation and musical education on the development of musical temporal perception, in the hope that music educators may be helped to better comprehend the

qualities of tempo in order to design activities and materials for optimum development of tempo perception within each student.

This investigation was concerned with the temporal stability of the musical thought over a period of time observed in individuals during the listening process. The main concern of the research was to determine whether there is a concept of a particular tempo represented in the mind as a consistent musical entity like pitch during the listening process. This raises the question of the existence of a potential musical ability to give over time precisely stable tempo judgments to a piece of music in conditions seemingly devoid of an external tempo reference (e.g., a score or the body interaction involved in performance). This musical ability may be referred to as *"absolute tempo,"* as being analogous to absolute pitch.

Organization of the Study

The remainder of this chapter will sketch a theoretical framework within which the study on tempo perception has been conceived based on philosophical speculations about time in general, and, in particular, time in music. Furthermore, several considerations of tempo by composers, performers, and music theorists will be reviewed, along with their possible relevance to the determination of the right tempo of a musical composition.

Chapter 2 deals with the present state of the research about tempo perception in music. It first offers a critical overview of the empirical research on the perception of musical tempo. Then it discusses the various sources that may be tapped to find out what processes underly the consistency of the temporal experience in music. There are several such sources, physiological, biological, and psychological. The present state of empirical research on the consistency of tempo perception is then considered, drawing upon research in the areas of music education and developmental psychology of music. The chapter

attempts to establish a psychological framework on which the experiment on the consistency of tempo perception that follows is based.

Chapter 3 provides a description of the design and the procedures of the experiment, which examines the consistency of right tempo judgments of pieces in various musical styles among subjects with differing ages, music backgrounds, familiarity with, and preferences for selected music.

Chapter 4 contains the report of the statistical treatment of experimental data and the discussion of the variables that may affect the consistency of tempo judgments.

Chapter 5 deals with the summary of the dissertation. Considering information accrued through this investigation, the chapter concludes with recommendations for music research and music education.

Background for the Study

> *... One lies here with time passing and wanders about it. Every sort of time trickling through the hourglass, 'time immemorial,' and 'for the time being,' and 'time out of mind'; the time of the poet, the philosopher, the pregnant woman, the calendar ...*
>
> Lawrence Durrell, *Clea*, 1961, p. 71

Tempo perception is closely associated with the experience of time of a musical composition—that is, with the way we sense "the rate of speed" of the flow of musical sounds or events when we compose, perform, or listen to music (Dürr, 1966, p. 183). Therefore, if this research is to contribute to a more comprehensive understanding of tempo as time transformed into a certain rate of speed, it should begin with an investigation of the question: What is the time of music?

The experience of time in music can only be explained in connection with what we believe time is. The nature of time is, however, a puzzling phenomenon like the riddle of

the Sphinx in Greek mythology, and a definition of time is indeed very difficult. What we call time exists in such diverse ways that we can hardly pinpoint what it is. We do not even know if it exists at all; we can only describe the attributes of our sense of time. Discussing the nature of time in a penetrating passage in his *Confessions*, which has become almost a classic in the history of philosophy, Saint Augustine (trans. 1961) wrote: "What then is time? I know well enough what it is, provided that nobody asks me; but if I am asked what it is and try to explain I am baffled" (p. 264).

If we opt to determine the time experience in music, an inseparable aspect of which is tempo, there is the temptation to solely rely on musical speculations and terminology to explain its nature. Nevertheless, it becomes clear that strict interpretations of musical terms do not tell the whole story about their essence and perceptions. This can be explained by the proposition that music is a sociocultural phenomenon that reflects human intellect as it searches, questions, infers, and reveals aspects of experience at a given moment in history (Xenakis, 1985).

Relation of the Dissertation to the Center for the Study of Education and the Musical Experience (CSEME)

Much of my thinking about musical time experience is directly linked to the work of CSEME established by Professor Bennett Reimer at Northwestern University. The common feature that unifies doctoral dissertations and other publications of this research group is that they deal with important aspects of musical experience and its cultivation. In addition, the Center research efforts emphasize the importance of aesthetics, psychology, music education, and arts education to any kind of investigation on musical experience.

During the coordinated research process for the production of the jointly authored book *On the Nature of Musical Experience* it was emphasized that the concept of time is one key idea common among several musicians and other thinkers (e.g., Thomas Clifton,

Paul Hindemith, Susanne Langer, and Igor Stravinsky, among others) who addressed the issue of musical experience. Therefore, time served as the topic for an essay, the writing of which (Lapidaki, 1992) focused my thinking on the problems that are addressed in this dissertation. In particular, the following list of research implications which the essay generated provided me with inspiration and motivation for pursuing the investigation of some of them in this study:

> (1) What musical parameters affect the perception of musical time? How does a listener perceive, encode, and process musical duration and tempo? Is temporal structure intrinsic to the music, the listener, or the performance?
> (2) Are different types of time experienced during the listening process? How does the listener perceive musical duration and tempo?
> (3) How can teaching and learning processes of music be affected by the consideration of musical time? (pp. 275-276)

In order to provide the framework within which ideas of time in music developed, I shall now turn to a brief consideration of a few of the numerous attempts philosophers have made to achieve a better understanding of time.

The Problem of Time: A Perennial Issue of Bifurcation

> *Time, according to the first theory, was the wind that blew in the world and, according to the second, it was the blow or the breathing of the things themselves. In the first, things were the victims of time, in the second, they were the perpetrators of time.*
>
> Takis Simotas (1996), *The Pit* [Trans.from the Greek by E. Lapidaki].

Philosophers have searched an answer to the riddle of time to discover the ultimate reality of life and the basic principles that govern it. The most fundamental problem that has been formulated in the course of many centuries of Western philosophical debate is the existence of various forms of dualism. These include the split between subject and object,

reality and eternity, matter and mind, body and mind, space and time, the world and experience, facts and theory, senses and consciousness, empiricism and formalism, among other forms of bifurcation. Centore (1991) argued that

> The most fundamental split of all, though, is the one between Being and Becoming, that is, between that which is eternally fixed, immutable, permanent, unchanging, nonhistorical, and isolated within itself, and that which is forever in flux, changing, temporal, developing, growing, evolving, dynamic, and implicated in everything, everywhere (p. 21).

The philosophical split between Being and Becoming has influenced inquiries about the essence of time. Since the beginning of human history, philosophers have raised the question whether time is *absolute*, that is, an inherent property of the physical environment, independent of our perception, or *relational*, that is, a mental disposition based on the way we perceive things and relationships among them (Benjamin, 1966, p. 5).

Absolute Time

Already in the pre-Socratic period, the nature of time occupied the minds of the Greek philosophers who linked time to the notion of flow, motion, change, and reality (Heraclitus) versus constancy, permanence, and immobile Eternity (Parmenides and Zeno). Heraclitus believed that reality consists of permanent flux and change. "You cannot step twice into the same river; for fresh waters are ever flowing in upon you" (as cited in Fraser, 1966, p. 8). In Buddhism the term *samsara* ("transmigration") was also used to indicate the change that overtakes all things, that is, the flow of time (Ikeda, 1985, p. 106). Plato tried to reconcile the opposition of Heraclitus' views, on the one hand, and Zeno's and Parmenides' views, on the other. Plato believed that time belongs to the phenomenal or material cosmos as a moving image of the immobile Eternity. As he pointed out in *Timaeus,* the motion of time is circular and acts according to numbers:

> But he [the creator] resolved to make a moving image of eternity, as he set in order the heaven. He made this eternal image having a motion according

> to number, while eternity rested in unity; and this is what we call time (as cited in Benjamin, 1966, p. 12).

Aristotle seems to have advanced beyond Plato in the understanding of time by introducing the concept of measurement. Aristotle considered time as a function of the motion of all material bodies in the universe and the criterion for measuring their movement. According to Gunn (1930), this presupposes that all time can be reduced to measure; thereby, time does not depend for its existence upon our perception.

Furthermore, Aristotle' s belief that time merely involves the motion of the physical universe, and that human beings are assumed to be passive observers, is embedded in early practices of timekeeping (e.g., Egyptian shadow clocks dating from the 10th to 8th century B.C., extant stone sundials dating from the 4th century B.C., the astrolabe invented by the astronomer Hipparchus in the 2nd century B.C., and early planetaria of the first century B.C.). These timekeeping devices are essentially measurements and interpretations of the motions of celestial bodies (Fraser, 1978).

Clocks are based on the same principle of physical cosmology: the motions of their hands represent the movements of atoms in visible form within a fixed, limited space at a fixed speed. Once the notion of time could be spatialized—that is, based on the movement of the sun, the earth, atoms or elementary particles—the concept of the so called *physical*, *mechanical*, or *conventional* time began to develop. Physical time as we know it today is to be considered purely *objective*, since it can measure the passing of other "times" in an external, removed from the senses, preestablished, unconditioned, unchanging, uni-dimensional way. Michon & Jackson (1985) describe this relationship of timekeeping practices to time as follows:

> Conventional time as we know it today is to be considered a surplus structure, imposed on an already existing and naively accepted temporal order in the universe: if we cannot change the rate of the flow of time, we can at least impose a deliberate structure on the ways events as >packaged< within the confines of the time we find at our disposal (p. 2).

Relational Time

All the above mentioned philosophers, however, did not distinguish time as it is in itself from our awareness of time and from events in time. Perhaps Plotinus' treatise *On Eternity and Time* provides the first attempt to insinuate the psychological aspect of time, anticipating some of the best views of contemporary philosophy. As Gunn (1930) explains, "Plotinus grasped the fact that Time must at least be accorded *the reality of being in the nature of things*, and is a necessary form of our thinking of things" (p. 30, italics in original). For the Neoplatonic philosopher, time is not merely a function of the motion of material bodies, but a function of the life of the Soul, while Eternity is the mode of the life of the full Being, which exists without change and motion. Therefore, problems of measurement would tell us nothing of the nature of time, in contrast to Aristotle's view. According to Plotinus (as cited in Sambursky & Pines, 1971):

> It [time] is not an accompaniment of Soul nor something that comes after (anymore than eternity There) but something which is seen along with it and exists in it and with it, as eternity does There... (p. 12).

Time began to pose a psychological problem from the later mediaeval philosophers (St. Augustine and Thomas Aquinas) onwards. Descartes, Locke, and Hume examined the problem of time from an empirical point of view, whileLeibnitz and Kant did so from an idealistic point of view. These thinkers ceased to concern themselves solely with the nature of time and its mode of existence, as the ancient Greek philosophers did, but started to think about the way we build up the concept of time and the role which the mind plays in our knowledge of time. They questioned whether time is a relation between the events themselves, or a sense impression, or an idea. As Fraisse (1979) pointed out, all agreed that our conception of time originates in our experience of succession and duration. More specifically, for Leibnitz time is the perception of the succession of changeable objects, for

Hume the succession of our perceptions of every kind including ideas and impressions, for Locke the awareness of the succession of our ideas in our mind, and for Descartes a mode of thinking duration.

Kant carried the investigation of time to another stage. Although he felt that time cannot be an abstraction from experience, he believed that it is not so closely related to the actual relations of things, in contrast to Leibniz's view, and attempted to overcome the momentary and separate view of successions described by Hume. He explicitly stated that while we cannot think of things independently of time, we can think of time apart from things. Kant's problem was to show that time is an a priori form of our perception. The conception of time in the philosophy of Kant has been excellently summed up by Fraser (1966) as follows:

> It is merely a form of intuition built into the mind in such a way that we must see phenomena as temporal very much as we must see things as red when we are wearing red glasses. Time is not a property of things but a property of the instrument by which we view things. And since we have no instrument other than the mind for observing them we are compelled to see the world as temporal. This was the answer to Hume's skepticism. It provides time with an objective status with reference to all objects that can ever be presented to our senses, yet it saves its subjectivity because apart from the mind there is nothing (p. 23).

Kant enunciated the whole struggle of the physical and mental, conceptual and perceptual, objective and subjective, absolute and relational views with respect to time which twentieth century thinkers continue to attempt to resolve.

New Concepts of Time in the Twentieth Century

Never has the intellectual atmosphere been as favorable to the awareness of the multiple manifestations of time as that of the twentieth century. The problem of time has gained great importance in multifarious formulations—in connection with different scientific areas, such as physics, psychology, biology, historiological sciences, anthropology, and linguistics. Moreover, when one looks into the arts, literature, and

criticism of the recent past, one also finds a growing interest in time. The most prominent views of time in our century have been developed along two lines: one within Einstein's general theory of relativity, the other within phenomenology's interpretation of the temporality of Being.

First, it is necessary to realize that relativity theory is exclusively concerned with the relation between the times assigned to events at different, distant places and the variance of those times with the state of motion which the observers assign to themselves and their measuring instruments. As astronomer, physicist, and philosopher of science Herbert Dingle (1966) explains: "Relativity theory is wholly concerned with 'time at a distance.' Time in itself—i.e., whatever time may be in one's own experience—is quite outside the scope of the theory" (p. 471). Consequently, all the philosophical and psychological problems associated with the notion of time in musical experience are irrelevant to and independent of the theory of relativity and the concomitant principle of reversibility of time. According to Richard Morris (1984), "if we look at time in subjective terms, we can say 'now' does not extend beyond 'here'" (p. 166). In this respect, it is interesting what Einstein wrote to the widow of a close friend, physicist Michele Besso: "Michele has left this strange world just before me. This is of no importance. For us convinced physicists the distinction between past, present and future is an illusion, although a persistent one" (Briggs and Peat, 1990, p. 135).

Phenomenology, on the other hand, has been primarily concerned with the notion of time as consciously experienced. Accordingly, the best way to stabilize and pin down the meager understanding of reality that we have is to see the world (Being) in terms of time—that is, in terms of the inner change and becoming of Being. As Cantore (1990) remarked, temporality characterizes phenomenology, just as timelessness characterized pre-phenomenological philosophy until the twentieth century. Most phenomenologists (e.g.,

Gaston Berger, Mikel Dufrenne, Martin Heidegger, Roman Ingraden, Gabriel Marcel, Maurice Merleau-Ponty, Eugene Minkowski, Max Scheler, Paul Ricoeur, and Alfred Schütz, among others) have been strongly influenced by Edmund Husserl, each in his own way, and each with many modifications and applications. The result is that there is "not one phenomenology, but many," as Lawrence & O'Connor (1967, p. 5) pointed out.

Husserl, the founder of phenomenology, addressed the problem of the experience of time in the *Phenomenology of Internal Time Consciousness* (1964). Husserl (1964) wrote:

> Since objective temporality is always phenomenologically constituted and is present for us as Objectivity and moment of Objectivity, according to the mode of appearance, only through this constitution, a phenomenological analysis of time cannot explain the constitution of time without reference to the constitution of the temporal object (p. 178-179).

According to Husserl, we direct our attention to the internal flux of lived experiences, which through memory, in the form of retention, constitute time in a linear continuum of "nows." In addition, we focus on what is homogenous in that flux—that is, on the objects of consciousness that "endure." Yet these two aspects of time consciousness are two inseparable sides to "the same activity of the mind"— one of which (the second), however, is closer to the objective world than the other (Minkowsky, 1970, p. xxxiv). In other words, we could say that the act of perceiving an occasion takes a mix of one's time and the time of the occasion in different proportions, depending on the nature of the occasion.

The notion of time has also been examined in a number of important and interesting psychologically oriented philosophers since the beginning of the 20th century, including Ernst Cassirer, Samuel Alexander, Jean Marie Guyau, Henri Bergson, Pierre Janet, Gaston Bachelard, William James, and John Fraser, among others. In spite of serious differences, there is a common understanding among such philosophers. They all laid

stress on the *subjective* or *psychological* time which is the medium by which change is revealed to our awareness, where we find not merely successive representations interconnected through memory, but continuity and temporal perspective as well (Block, 1990). Psychological time can be described as irregular, unstable, non-homogenous, uniform, ever-fluent, multi-dimensional, conditioned, relative, experiential, or internal as it is integrated with the particular experience by which it is formed, in contrast to *objective* time which the clock ticks off.

Along these lines, an important contribution to the philosophical study of time has been shown in the works of Henri Bergson who emphasized the primacy of human experience. Coming from the area of psychology, Bergson wrote the influential book *Time and Free Will* (1910), in which he postulated a psychological time which he called *durée* (duration), contrasting it to man's spatialized representation of time which he described as "homogenous," artificial, and not purely temporal. Bergson (1910) analyzed how experience always gives us a composite of duration and space as follows:

> When we hear a series of blows of a hammer the sounds form an indivisible melody in so far as they are pure sensations, and here again give rise to a dynamic progress; but knowing that the same objective cause is at work, we cut up this progress into phases which we then regard as identical; and this multiciplicity of elements no longer being conceivable except by being set out in space—since they have now become identical—we are necessarily led to the idea of a homogenous time (p. 125).

As far as the double progression of the Bergsonian philosophy of time is concerned, Deleuze (1988) remarks: "It is rather a case of dividing the composite in two directions, only one of which (duration) is pure, the other (space) is the impurity that denatures it" (p. 38).

Bergson's ideas have been extensively commented on and have found their contemporary continuation in a phenomenological approach to the temporality of consciousness. This book *Time and Free Will* has exerted important influences on recent

philosophical speculations about the experience of time in music. These will be discussed in the next subsection of this chapter.

The Dialectic of Time in Music

> *If we realize, at the end of a piece of music—quite irrespective of how long it lasted, whether it was played fast or slowly and whether there were many or very few notes—that we have "lost all sense of time,"—then we have in fact been experiencing time most strongly.*
>
> Karlheinz Stockhausen, Structure and Experiential Time, p. 65 [*Die Reihe* 1-4, 1958-1960, pp. 64-74]

> *In a manifold sense, music uses time. It uses my time, it uses your time, it uses its own time.*
>
> Arnold Schoenberg, *Style and Idea*, 1975, pp. 40-41.

Time in music is a matter that has interested many who write about music and musical experience. While it is an obscure problem that is difficult to penetrate, it is of great importance to those who consider the intricacies of aesthetic experience (for further discussion, see Lapidaki, 1992). Indeed, philosophers, musicologists, music theorists, music psychologists, composers, and performers have discussed—and sometimes confounded—the meaning of time in music and its implications in their fields.

One writer to whom this issue is important is Susanne Langer. The seventh chapter of her book *Feeling and Form* (1953) is exclusively devoted to "The Image of Time." Langer's ideas of time in music derive from those of the French school of musical aesthetics (e.g., Giséle Brilet, Basil de Selincour, and Pierre Souvtchinsky) which, rooted on Bergson's conception of pure *durée*, postulates that music is the art of time—*l'art du temps par excellence* (Brilet, 1949). Langer (1953) maintains that "music makes time audible, and its form and continuity sensible" (p. 109-110).

Thinking along the lines of the classical philosophical conflict between time as Becoming (experienced or lived time) and time as Being (clock time), with respect to music Langer distinguishes between "virtual" time—that is, the experienced or lived time of music—and "actual" time—that is, the one dimensional, infinite, pure succession of various temporal data, actual happenings, or moments in relation to clock time. For Langer music functions solely in virtual time.

More specifically, Langer claims that virtual time is subjective, dynamic, dramatic, and, therefore, the primary illusion of music. It embodies the images of the passage of life with which we are acquainted by intuition. However, virtual time is also regarded as logical. It has the same logical patterns as our tensions which are brought to life by rhythms (the most characteristic principle of vital activity) that can be manipulated by the composer. By stating that virtual time is filled with tensions and resolutions, Langer is stressing the psychological aspect of time in music. Virtual time is perceptible; it is experienced solely through listening, "... by letting our hearing monopolize it, organize, fill, and shape it, all alone" (Langer, 1953, p. 110). Unlike clock time which is one-dimensional, virtual time cannot be reduced to a single dimension.

Stravinsky's concept of time was also influenced by the French school of musical aesthetics, and, in particular, by the Russian philosopher Pierre Souvchinsky who lived in Paris and was a friend of the composer's. Concurring with Langer, Stravinsky (1947) claims in *Poetics of Music* that music is an art of time, a "chronological art," presupposing "... before all else a certain organization in time, a chronometry" (p. 28). In his view, a musical composition involves the functional realization of time through the temporal ordering of sounds.

On the one hand, "psychological" time is the flow of time which depends on our state of consciousness and the events that influence it. On the other, "real" time or

"ontological" time is the normal flow of time (clock time). Stravinsky maintains that it is the interaction of these two types of time that makes up musical time. Unlike Langer, he does not claim that music is perceived exclusively as psychological time. Rather, music "... establishes a sort of counterpoint between the passing of time, the music's own duration, and the material and technical means through which the music is made manifest" (p. 31).

Further, Stravinsky states that some music may be mainly grounded in real time and some music may remain faithful to psychological time. The prevailing characteristic of the first kind of music is similarity, which he believes leads to unity and true solidity in a composition. The second kind of music is ruled by contrast, which leads to variety. Stravinsky (1947) states: "For myself, I have always considered that in general it is more satisfactory to proceed by similarity rather than by contrast" (p. 31-32).

Another interesting point Stravinsky makes is that our time experience of music is teleological or goal-oriented. This is how he marks off his concept of musical time from the contemporary trend of spatialized or directionless or "moment" time which will be discussed later:

> Time, too, is a physical measure to me, and in music I must feel a physical measure here and there and not only a now, which is to say, movement from and toward. A time series may very well postulate a new parable about time, but that is not the same thing as a time experience, which for me is dynamic passage through time (Stravinsky & Craft, 1968, p. 127-128).

In agreement with Stravinsky, Leonard Meyer (1967) regards musical time from the aspect of its linear and causal logic as "a sequentially ordered series, articulated and made manifest by the chain of causally related events" (p. 65).

In the book, *A Composer's World: Horizons and Limitations*, Paul Hindemith (1952) maintains that musical time is a formal feature of music with functional significance. According to him, musical time evokes two different kinds of affect. On the one hand, musical time expressed by meter runs parallel to actual time because of its regularity. On the

other hand, musical time as expressed by rhythm, because of its incommensurable nature, produces an effect which in normal life is nonexistent.

Concurring with Hindemith, Epstein (1979) regards the distinction between meter and rhythm as a model for the relationship between "chronometric" and "integral" time, respectively. For him chronometric time, on the one hand, is the "... essentially mechanistic, evenly spaced, and in large part evenly articulated time set up within a musical measure (and larger units). Its measurements and demarcations are in the main pragmatic and convenient periodizations" (p. 58). Integral time, on the other hand, like rhythm, embraces "... the unique organizations of time intrinsic to an individual piece—time enriched and qualified by the particular experience within which it is framed" (p. 58).

In the book, *Music as Heard: A Study in Applied Phenomenology*, which is based on the notion of music as a heard phenomenon, Thomas Clifton (1983) attempts to explore "necessary constituents" of music that are not apparent by musical notation, by means of an avowed phenomenological method. Thereby, he views time as a necessary constituent of musical experience.

Clifton regards time as "... the experience of human consciousness in contact with change" (p. 55). Time is not an absolute medium, but an experience which is in constant flux. "Time has no grips on events. It is events, as lived through by people, which define time" (p. 55). Clifton also refers to time as "horizon," that is, the temporal edge of a single field, which may include multiple events that can be regarded as part of this field.

The distinction between "objective" (real, absolute) time and "musical" time, which is similar to Langer's virtual time, is important to Clifton. He clarifies this distinction by referring to the time that a musical composition "takes" (objective time) and the time that it "presents" or "evokes" (musical time) (p. 81). "A recording studio may wish to know the

time a certain composition takes," Clifton writes, "but its timing, in terms of minutes and seconds, will tell us nothing about time as meant by the composition" (p. 51).

It should be noted that the phenomenological approach, which illuminates the experience of a temporal event as demanding an infinite extendedness, is particularly suggestive for the study of new temporalities used by contemporary composers who intentionally reorder temporal progressions, deny continuity, suppress beat and pulsation, or work with static sound-shapes, in order to free time from its linear and causal logic. This is how Ihde (1976) explained the infinite extendedness that lends music its aura of possibilities, according to phenomenology:

> As I listen to music on the radio, the notes "well up" out of the "nothingness" of the future and "trail off" into the horizontally equal "nothingness" of the past, and the sense of horizontal "absence" is the experienced temporality of sound. These sounds "give themselves" into presence and then "fade out" in the temporal dance of the auditory dimension (p. 109).

This infinite extendedness, however, can be presented as space, "where the sound substance is formed as the primary object of projection and perception, its motion entirely secondary and contigent on the emerging structure of the sounding forms themselves" (Rochberg, 1975, p. 146). John Cage (as cited in Chatterjee, 1971) expressed his intention to project musical time into musical space as follows: "... And the path we are is not a path, not a linear but a space extending in all directions. Because it is no longer a case of moving along stepping stones (scales of any degree) but one can move, or just appear to, at any point in this total space" (p. 50-51). Stockhausen (Cott, 1973) wrote about the spatialization of time:

> The speed of the sound, by which one sound jumps from one speaker to another, now became as important as pitch once was. And I begin to think in intervals in space, just as I think in intervals of pitches or durations. I think in chords of space (p. 92).

In the same vein, Xenakis (1988) maintained:

> Due to the principle of anteriority the flux of time is locally equipped with a structure of total order in a mathematical sense.... Thus it can be counted. This is what the sciences in general do, and music as well, by using its own clock, the metronome. By virtue of this same structure of total order, time can be placed in one-to-one correspondence with the points of a line. It can thus be drawn (p. 89).

Boulez (1971, p. 88) distinguishes between "amorphous" time (unpulsed, undivided) and "striated" time (regular or irregular, but systematic) as corresponding to "smooth" and "striated" space, respectively.

Many composers criticized the notion of a strict spatialization of time in a composition. For instance, Ligeti (1983) wrote about Stockhausen's innovative ideas about spatialized time: "... a basic order that postulates a ratio of a:b as a regulating factor common to both pitch and duration (speeds) is irrelevant, indeed meaningless to a musical structure, which in structural terms reflects mental rather than physical processes" (p. 130).

George Rochberg (1963) regards the new kind of time dimension as a reinterpretation of an ancient one, which we previously considered (p. 16) in the discussion about ancient Greek philosophers:

> In the new music, time as duration becomes a dimension of musical space. The new spatial image of music seeks to project the permanence of the world as cosmos, the cosmos as the eternal present. It is an image of music which aspires to Being, not Becoming (p. 10).

It is interesting to note that Rochberg's remarkable interpretation of the spatialization of time in music corresponds in meaning to the following powerful description by Hermann Hesse (1965): "And eternity was nothing else than the redemption of time, its return to innocence, so to say, and its transformation again into space" (p. 181).

The Significance of Tempo in Music

Tempo perception is an extremely puzzling parameter of time experience, especially when we listen to, perform, compose, or analyze music. Although we can begin to comprehend its significance from our general experience, it has been only recently that we

have been able to study it precisely in an empirical way, thanks to important technological advances. Yet, the unavailability of highly controllable test apparatus may not have hindered the empirical study of tempo as much as did a general lack of understanding of the relationship of tempo to other aspects of musical organization that would provide us with an agreed upon music theoretical framework.

While there is near unanimity in the definition of musical tempo as the pacing of time of a musical composition, hence, the speed at which its performance proceeds (Donington, 1980), questions arise with respect to the way the "right" tempo of a composition can be determined. Does a piece of music have one and only one inherent tempo (absolute tempo), and if so, does this concept possess an absolute time framework? Or can a piece of music survive a wide range of tempi? The literature is far from consistent on these questions. For instance, Richard Wagner (as cited in Pöppel, 1990) wrote in his essay "On Conducting" with regard to tempo :

> If one wants to summarize what is involved in the right interpretation of a piece, on the conductor's part, then this consists in that he or she always indicates the right tempo, because the choice and determination of tempo makes us realize whether the conductor has understood the piece or not (p. 105, translated from German by E. Lapidaki).

Stravinsky (Stravinsky & Craft, 1980) stated that

> A piece of mine can survive almost anything but wrong or uncertain tempo ... What does it matter if the trills, the ornamentation and the instruments themselves are correct in the performance of a Bach concerto if the tempo is absurd? I have often said that my music is to be "read," to be "executed," but not to be "interpreted." I will say it still because I see in it nothing that requires interpretation (p. 135).

In a recorded interview with Tim Page, pianist and composer Glenn Gould (1982) said: "I have come to feel over the years that a musical work, however long it may be, ought to have basically one tempo, one pulse rate—whatever it may be—one constant rhythmic reference point."

Conductor and music theorist Epstein (1985) also embraces Gould's approach to tempo with the concept of proportional tempo, also called "theory of continuous pulse":

> So powerful is the element of pulse that if one violates it by distortion of tempo, one runs the risk of an unsuccessful performance. Such a distortion seems to be violating not only a "musical factor," but a biological one as well, one which sets ground limits to our aesthetic perception (p. 37).

Harpsichordist Ralph Kirkpatrick (1984) criticized the notion of fixed relationships of pulse and the concomitant belief in an absolute tempo as follows:

> We all have different pulse rates; we all have different chemistry. If one wishes to give to a piece of music a characterization that is different from that of another, to endow it with personality of its own, one may need to avoid, rather than cultivate, common relationships of tempo (p. 47).

Pianist Alfred Brendel (1977) opposes himself to the metronome-conscious interpretation of music which, as he points out, has managed to influence musical thinking "through the experiences of Stravinsky and jazz music" (p. 42, translated from German by E. Lapidaki). However, Brendel disagrees with Kirkpatrick's belief in the dominance of the interpreter's chemistry (nature) that influences the execution of tempo. Brendel superimposes a psychological tempo on the notion of metronomic tempo:

> The interpreter who follows the flow of music as naturally as possible—and hereby I mean the nature of music and not the nature of the player—will always give the "psychological listener" the feeling that he or she plays 'in the right tempo' (p. 43, translated from German by E. Lapidaki).

Similar ideas are expressed by Donington (1963/1973):

> Some movements allow a much narrower margin of tempo than others. Perhaps there is always just one interpretation, and therefore just one tempo, which most musicians will find more convincing than any other; or perhaps interpretation is always relative. In either case, the only way of finding the tempo is by responding to the music itself, with a sensitiveness not given to every musician alike nor to any metronome at all (p. 383).

Music theorists diverge in their opinions of whether structural relationships in music—formal characteristics, local-level and more global harmonic relationships, rhythmic and metric relationships—are in some way dependent on tempo (Berry, 1986;

Lester, 1982; Piston, 1978) or whether they remain independent of tempo (Aldwell & Schachter, 1978; Cooper & Meyer, 1966; Forte, 1979). To quote Piston (1978), for instance: "The speed of music justifies a broader view of the harmony than would be indicated merely by root changes" (p. 208). Clarke (1985) attempted to provide evidence for the psychological validity of modifications of performance tempo by demonstrating that these modifications are closely related to the structural characteristics of the music performed. In contrast to Piston's view, Cooper and Meyer (1966) maintain: "Tempo, though it qualifies and modifies [pulse, meter, and rhythm], is not itself a mode of organization. Thus a rhythm or theme will be recognizably the same whether played faster or slower" (p. 3).

Another stark contrast of opinion about absolute tempo may be seen in the positions of Reckziegel and Reinecke. Reckziegel (1961) asserted:

> The perceived tempo of music obviously depends not only on the duration of one or more abstract units but also on the rhythmic structure within this duration. Therefore, we would like to introduce the term of "inner tempo" (Inneres Tempo) which has been already used by ethnomusicology for some time (p. 215, translated from German by E. Lapidaki).

Reckziegel further expressed inner tempo as the equation $b_\rho = {}^1/_t \cdot 1d_t$ where b stands for inner tempo, t stands for the duration of the metric unit, and ρ stands for the average pulse number within the metric unit. He concluded that "the attempt to determine an inner tempo results in making measurable the musical time dimension, which is seemingly only comprehensible in a sensory way" (p. 223, translated from German by E. Lapidaki).

In an article entitled "On the Development of Research in Music Perception During Recent Decades," Reinecke (1974) stated that "no evidence has been found to prove that one specific musical piece has only one 'right' tempo" (p. 414, translated from German by E. Lapidaki).

Here one may conclude that in a single-movement composition or between the movements of large-scale compositions the relation of tempi to each other may have a definite and unambiguous relationship to an "inner" or "base" tempo (Margulis, 1984) which cannot be determined by the musical structure in a precise and absolute way. This perhaps may be the reason why composers set metronome markings to their music.

Although tempo is considered to be a prominent factor in harmonic rhythm, it is surprising that music theorists have paid relatively little attention to it. Indeed most music theories deal primarily with rhythm and meter and take a somewhat dim view of musical tempo (Lerdahl & Jackendoff, 1983). Rhythm and meter can be indeed structured, grouped, arranged hierarchically, notated, and imagined without exact measurement in units of real time. Nevertheless, as soon as they are listened to, they gain concrete dimension in a fixed period of time, at a certain tempo (Dürr, 1966). In other words, the rhythmic and metric order of a musical composition cannot be realized and, thus, measured without the parameter of tempo.

Yet there are apparently no theories of music that assert that because all note values are obviously relative to each other, a specific time value can only be determined by referring to the speed of the temporal structure of the music in relation to real (externally metered) time. While Glenn Gould (1982) considered the tempo of a composition to be "one constant reference point", Cooper & Meyer (1966), on the other hand, criticized the notion of constant relationships of pulse and absolute tempo of music:

> And while changes of tempo will alter the character of the music and perhaps influence our impression of what the basic beat is (since the beat tends to be perceived as being moderate in speed), tempo is not a relationship. It is not an organizing force .... It is important to recognize that tempo is a psychological fact as well as a physical one (p. 3).

Concurring with Cooper & Meyer with regard to the dual nature of tempo Kramer (1988) stated: "If we consider tempo as both the rate of beats and the rate of information,

then we can incorporate into this broad concept both the objectively measured and the subjectively felt" (p. 349). Furthermore, from a phenomenological standpoint, Clifton (1973) maintained that although musical time is an a priori, because it can be perceived immediately, tempo is not an a priori, though it concerns time, "... because we must learn to measure it" (p. 79).

Summary

Thus far we have been considering how most theoretical speculations about time are reflected as major driving forces, from time to time, in the language of musical temporality. However, the single most pervasive one is the conflict between the conceptions of time as Being and time as Becoming. If the main qualities which appeared in the discussion about musical time and tempo are aligned under the conception of time they most closely resemble, then the list of qualitative dichotomies, as shown in Table 1-1, should give some flavor for the manifold—and seemingly conflicting—manifestations of time experience in music.

The intent of this study, however, is to examine not these qualitative categories of musical time—as helpful and suggestive for listening to music they may be—but to attempt to empirically treat the temporal experience of music as a whole in which all these categories coexist and at the same time disappear while listening to music. Indeed, it has been in the spirit of disclosing a meaningful—yet paradoxical—link between the subjective time of music and its objective measurement that this study on tempo perception has been conceived. Tempo is to be thought of as incorporating both objective time, that is, the rate of beats per unit of clock time measured by the metronome and the subjective pacing of time.

Table 1-1

List of Qualitative Dichotomies of Time in Music

subjective	objective
musical	real
virtual	actual
lived time	clock time
dynamic	static
a sequentially ordered series of events	a perpetual series of "nows"
rhythmic	metric
multi-dimensional	one-dimensional
integral	chronometric
relative	absolute
mental	mathematical
principle of contrast	principle of similarity
incommensurable	commensurable
musical time as motion	musical time as space
time music evokes	time music takes
irregular	regular
non-homogenous	homogenous
amorphous	striated
linear	non-linear
continuous	discontinuous
motion	stasis
teleological (goal-oriented)	directionless (multiply-directed)

Our concept of subjective time of music can imply something quite close to what Mircea Eliade (1959) calls "sacred" time in order to describe the time of religious festivals and rituals. Although Eliade does not discuss music, it appears that some of his ideas can be interpreted as bearing to musical experience. I would like to suggest substituting the word 'festival' with 'music' in the following quote:

> A festival is precisely the reintegration of this original and sacred time that differentiates man's behavior *during* the festival from his behavior *before* or *after* it. For in many cases the same acts are performed during the festival as during

> nonfestival periods. But religious man believes that he then lives in *another* time ... (p. 85).

Yet we do not as a rule loose all sense of ordinary clock time as we listen to music; we realize how much clock time has elapsed as, for instance, we realize the passing of clock time as we work. Only when we give ourselves to music, the span of ordinary clock time that music occupies indeed begins to be suspended. Then time is not any more part of the ordinary clock time that precedes and follows and in which behaviors without musical meaning have their setting. In other words, when we listen to music in intense absorption, we transcend the time "music takes" to the time "music evokes," as Clifton (1983, p. 81) wrote. According to Fraser (1966), "the most striking effect of the temporal arts on man is a feeling of transcending time" (p. 201).

In order to investigate tempo perception the present study attempts to create the circumstances for people to intensely listen to music so that they can express the feeling of their subjective temporal experience, using the tempo of music as a reference point. By means of digital technology it attempts to objectively measure this sacred or transcended time music evokes, and eventually uncover whether there is a consistency in listeners' repeated subjective temporal judgments over a period of time.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Knowing artists, you think that you know all about Prima Donnas:
boy!, just wait till you hear scientists get up and sing.

W. H. Auden, *Shorts II*
[E. Mendelson (Ed.), *W. H. Auden, Collected Poems*, 1976, p. 644]

The review of research studies investigating perception of tempo in music will be divided into those dealing with:

(a) general considerations about various determinants of temporal judgments,

(b) the physiological basis of tempo sense,

(c) psychological tempo in music listening and performance, including discrimination of tempo changes,

(d) defining personal/individual factors of tempo perception: age, musical training, preference, and familiarity, and

(e) consistency in tempo perception

General Considerations

One of the more interesting and puzzling aspects of time in general is that clock time and psychological time can be quite independent of one another (Friedman, 1990; Ornstein, 1969). Most of us have at some time or other had the experience of a boring situation that we are certain took hours to unfold; yet, when we looked at our watch, we found that only a few minutes had actually gone by. We often relate similar experiences as we perform or listen to music. For example, our feeling that a musical composition goes fast or slow does not necessarily correspond with the objective measurement of time by the metronome.

Over a century ago psychologists interested in the phenomenon of time perception began to conduct experiments in order to clarify whether there is a sort of mental clock that speeds up or slows down, causing impressions of temporal pace to be uneven. Most of the experiments, however, were concerned with duration judgments or estimates of brief, empty, external stimuli or artificially filled time intervals of several seconds or less. A number of possible mental models and interpretations were developed, since no single theoretical framework could profess to explain the different facets of temporal experiences.

In the last twenty years, however, many systematic experimental attempts have been made in fields in addition to time psychology to address the temporal structure of phenomena of human behavior. These include work in psycholinguistics, visual perception, music perception, information processing in learning, performance of motor skills, memory, and attention, among others. According to Michon & Jackson (1985), "these newer findings are actually embedded in theoretical frameworks of wider importance" (p. 7). As we will see, this research may be useful in answering questions about the mental mechanisms and processes underlying our experience of the rate of musical time's flow (e.g., tempo), the subject of the present study. Music is one of the most time-involving human endeavors, so it should come as no surprise that the psychology of time and the psychology of music are closely interwoven.

As early as 1883, some of the prominent psychologists and psychologically oriented philosophers and physicists who speculated about the time sense acknowledged that psychological time involves changes. First, Ernst Mach (1883/1942) observed that "time is an abstraction, at which we arrive by means of changes of things" (p. 273). James also proposed that our perception of time's passage depends on our awareness of change. He wrote that "in general, a time filled with varied and interesting experiences seems short

in passing, but long as we look back" (1890/1950, p. 623). During the same time Guyau found that cognitive factors, such as "the number of events, the number of differences among them, the amount of attention paid to them, and various associations to the events", influence time judgments (as cited in Block, 1990, p. 24).

Around the middle of the century when time psychology started gaining refreshed attention, especially due to more sophisticated technological and methodological developments, the above mentioned cognitive views of time as change gradually matured and expanded. Moreover, the advances made in chronobiological research on the role of endogenous biological rhythms or central pacemakers that underlie and control brain processes, as we saw in the previous section, enriched the theoretical contexts of time psychology. Fraisse (1963), one of the most prominent time psychologists of that time, agreed with his forerunners that "psychological duration is composed of psychological changes" (p. 216). Gibson (1975) seemed to agree: "external stimuli ... provide a flow of change, and it is this we perceive rather than a flow of time as such" (p. 299).

Most explanations of the rate of time's passage seem to take into account the relations between psychological time as duration and (a) the content and context of the time interval, (b) memory, and (c) attention.

As far as the psychological content of a time period is concerned, after a series of experiments Frankenhaeuser (1959) reported evidence suggesting that: "we may assume that the experience of a certain duration is related to the total amount of experience (sensations, perceptions, cognitive and emotional processes, etc.) which takes place within the time period, in short, the *amount of mental content*" (p. 14, original italics). Along these lines, Block (1990) reported that a crucial determinant of duration experiences are the changes in the mental context in which the processing of temporal information takes place.

The mental context can be defined as "the different kinds of cognitive processes a person employs when he or she engages in various tasks or strategies of encoding during a time period" (p. 24).

The experience of time and its relationship with external events is not separable from the context within which they take place and the conditions of their measurement. Along these lines, Block (1985, p. 176) proposed an adaptation of Bransford's (1979) comprehensive "contextualistic" model of four kinds of interacting factors, all or any of which may affect psychological time: characteristics of subject (e.g., sex, personality, interests, previous experiences), contents of the time period (e.g., musical, linguistic, pictorial), the subject's activities during the time period(e.g., passive nonattending, passive attending, active responding), and the subject's time-related behaviors and judgments (e.g., judgments of rhythm, duration, pacing).

It should be noted that this general model of time experience has been helpful in speculating about and tying together most of the different variables relevant to the consistency of tempo as investigated in this study (e.g., characteristics of subjects: age, musical background, familiarity, preference; contents of time period: musical examples of different styles/genres, activities during time period: active attending through manipulation of tempo in real time; temporal behavior: judgments of right tempo).

With regard to the role of memory in the experience of duration, a very important development was Ornstein's (1969) "storage size metaphor" which holds great promise as a model for the perception of musical time. According to this metaphor, anything which might change the size of storage of the information filling a given period of time affects the experience of duration of that time period. As storage size increases, duration experience becomes longer. In a series of experiments Ornstein showed that crucial determinants of the

size storage of an interval are: the number of stimuli or the complexity of a stimulus and the way in which information is "chunked" and stored.

With regard to music, Kramer (1988) elaborates on the value of tempo in duration experience. According to him, although the metric hierarchy and the information content of two different performances of Stravinsky's *Symphonies of Wind Instruments* may be identical, yet we experience the one as longer than the other. Kramer (1988) concluded:

> The difference must come from tempo. I remain convinced that information processing and metric timing are more important and complicated mechanisms, but, as the examples described in this paragraph show, tempo is a factor in duration perception (p. 349).

Barry's (1990) "Tempo/Density Theory" also takes into account the effects of memory and "chunking" (organizing and structuring information) on duration and tempo experience in music. Barry (1990) comments that

> Within the tempo of the work, the larger the amount of density (in numbers of notes, harmonic complexity, extended range or whatever dimension) and the further it is from the norms, the more "effort" (processing activity) is needed to draw it to them and shape it coherently. Greater density demands greater processing "effort" and since the speed at which time passes is the speed at which information is processed, higher density musical information fills a longer experiential time than more normative information played at the same tempo (p. 167).

The experience of duration depends not only on the intrinsic tempo of music, but on individual perceptual factors, such as liking and familiarity, expectation, prior musical knowledge, and experience which affect the psychological complexity level of a musical work (Barry, 1990; Davies, 1978; Payne, 1979; Walker, 1963).

While the studies cited to this point identify a number of factors impinging on tempo perception, this study will examine not the foregoing abstract account of information processes involved in tempo experience— as helpful they may be—but will attempt to understand how different listeners perceive the tempo of the same musical pieces, and how

the same listener perceives the tempo of these pieces at different times. Therefore, we empirically treat personal variable factors, such as age, familiarity/liking, musical training/background, and individual musical preference which, interacting with the intrinsic musical structure (style), may influence the consistency of tempo judgments/selections when listening to the same musical work at different times.

In addition to the above mentioned factors which contribute to the perception of the temporal unfolding of a work's structure, it is worth considering what role attention plays in enhancing awareness of tempo. Various researchers have developed models of psychological time in which terms like "attention to time," "attentional allocation," or "attentional selectivity" play an important part (Thomas & Brown, 1975; Thomas & Weaver, 1975; Underwood, 1975; Underwood & Swain, 1973). Most evidence relevant to attentional models suggests that duration experience is positively related to the degree of attention that an information-processing task demands. In other words, the greater the demand on more intense attention due to the processing of more complex information in a given time interval, the longer or more irregular the estimates of duration of the time interval.

Several researchers have made an effort to clarify the elusive issue of attention one pays to the passage of time itself (Block, 1990; Block, George, & Reed, 1980, Underwood, 1975; Zakay, 1990), but no clear-cut theoretical explanation appears to be possible. Block (1990) wrote: "What, then, does it mean to attend to time itself? The answer may be that it involves an awareness of changes (or the lack of such changes) in events or cognitions occurring during a time period" (p. 22). Jones (1986) and Zakay (1990) emphasized that the indication and manipulation of time-related attributes to which a

subject pays attention are of major importance for a compatible experimental design in time perception.

The present study attempts to create experimental conditions under which the subject's attention can be concentrated on the pace of the passage of musical time by manipulating it in real time while listening to music. There is relatively little research that isolates the parameter of tempo in order to investigate listeners' judgments of tempo. Most of the studies on time perception in music involve rhythmic manipulations (Fraisse, 1978; Jones, 1986).

In fact, these psychological approaches to time considered briefly in this section tell us little about the psychological significance of tempo in music listening and performance. They offer, however, useful methodological bases for an empirical investigation of musical tempo that embodies aspects of psychological time.

Physiological Basis of the Sense of Tempo

Researchers have explored the possibility that certain human biological functions, such as heartbeats, breath, body temperature, and neuron oscillations in the brain, might be considered as 'time constants' or 'internal clocks' which play a significant role in the individual's experience of musical time. According to Winckel (1967), "... it is conceivable that some animals with an entirely different biological 'factor' are not capable of following the rhythm of our music" (p. 85).

There is an ample and conflicting literature documenting attempts to support the belief that human pulse serves as a physiological basis of time sense and tempo in music. As early as 1698, Loulie constructed a pendulum (chronometer) with 72 different swing durations in an attempt to measure the musical effect according to an average number of

pulse strokes. Moreover, music theorists during the Middle Ages and Renaissance through the Baroque period, such as Gafurio, Lanfranco, and Ramos (as cited in Bank, 1972), Mersenne (as cited in Donington, 1963/1974), and Quantz (1752/1966), believed that the average human pulse was linked to a 'general' tempo area of M.M.=60-80, in order to standardize the musical beat. Nevertheless, Brown (1979) comments that:

> There is often no means of knowing whether the original authors were thinking in terms of an "ideal" tempo only coincidentally similar to the average pulse, pulse-initiated tempi in actual musical practice, a numerical convenience related to the one commonly accessible measure of tempo, or romantically predisposed to associate the pulse of life with that of music. As any of these would account for the ubiquity of the MM=80 area in musicological literature, it may be less of a real "preference" and more of an artifact associated with the average human pulse (p. 27).

In the beginning of our century when the empirical study of psychological time was initiated, researchers have been concerned primarily with the concept of preferred tempo, as we will see later in this chapter. Along these lines, Smith (as cited in Isaacs, 1920, p. 281) maintained that subjects' choice of a preferred tempo is bound up with their individual pulse or respiratory rate. Dalcroze (1921/1980) also supported the view that the human heart provides a basis of rhythm.

In an attempt to find the origin of time measure in music in a unified physiological function, J. L. Okunewski (Winckel, 1967, p. 82) has presented in a list the pulse count for a number of piano compositions, in which he measured the pulses of the pianists in relation to the number of breaths per minute. Further, when Sachs (1953) "metronomized" Bach's Mass in B Minor—each movement separately and on various days—he found that "his beat was consistently near M.M.=80, covering now a quarter note, now an eighth, now even a half note (p. 34). Sachs concluded that "the pulse can certainly measure music. But just as certainly, it does not rule it" (p. 34). Concurring with Sachs, in his study on

music from the 13th to the 17th century, Bank (1972) recognized the physiological significance of M.M.=80 to pulse rate. However, he noted: "The theory of one tactus of invariable speed cannot be sustained" (as cited in Brown, 1979, p. 26). Beat speeds in contemporary musical practice have been also acknowledged by some musicologists as extending "from M.M.=50 to M.M.=140, with 80 being a middle speed," according to Apel (as cited in Duke,1989, p. 67).

Empirical research has been concerned with the study of "internal" clocks or biological rhythms that may be associated with both endogenous and acquired periodic processes in human physiology other than the previously discussed human heart rate or respiration. In a series of experiments it has been reported that judgments of subjective time depend on the speed of oxidative metabolism in the brain, a chemical process that is influenced by our internal body temperature. The results clearly demonstrate that raising or lowering our internal body temperature elicits faster or slower—respectively—chemical motions in the cells of the brain that act as a "chemical clock" or "pacemaker" (Hoagland, 1933).

More specifically, Hoagland depicted the effect of body temperature on the frequency of subjectively counting seconds and tapping rhythms, in the so called Hoagland's "Arrhenius plot". Clock time seemed to pass slower to subjects with higher temperatures and hence accelerated biochemical changes; therefore, they counted or tapped faster. On the other hand, subnormal temperatures and hence a decrease of metabolic rate had the opposite consequence on subjects' rate of tapping and counting (Hoagland, 1933). Hoagland (1966) reports that he first experimented on his wife, a trained musician, "with a good sense of short intervals," when she fell ill with influenza (p. 321). He asked her to count to sixty at a speed she believed to be one per second 25 times in the course of her

illness. Her speed of counting was measured with a stop watch, and her temperature was recorded each time. She unknowingly counted faster at higher than at lower temperatures. Confirmatory evidence of this view came from Aschoff (1985) who also hypothesized a link between metabolic rate and the degree to which elapsed time was underestimated.

In an examination of the various factors affecting tempo behavior in repeated music performances, Brown (1981) observed that morning performances (between 8 and 9 a.m.) were significantly faster than evening performances (between 9 and 10 p.m.). Moreover, the evening performances were more consistent with respect to tempo. Brown (1981) concluded:

> If tempi are more consistent at a particular time of day, the circadian body temperature variation may be the relevant factor. However, as body temperature has been reported to be at a maximum in the evening (Colquhoun, 1971), the expectation was for faster and not slower tempi at this time (p. 38).

It seems indeed that the effect of normal internal temperature changes on subjects' perception of musical tempo is insignificant, since they fluctuate less than $^{1}/_{2}{}^{0}$F around a mean of 98.6^{0} F (37.0^{0} C.). Hoagland's experiments (1966) guided him to the conclusion that biological oxidations due to normal internal temperature, proceeding at a relatively constant speed, give us a "linear", "uniformly flowing" short-time subjective time scale which we can coordinate with our objective clocks. This being the case, it appears that this is an area which would not warrant further exploration with respect to tempo perception in music, unless we have to deal with extreme temperature fluctuations in individuals.

A considerable manifestation of the relation between metabolic rate and time sense that may be pertinent to the present study appears in the aging process. Researchers reported a rapid fall in both circulation and oxygen consumption of the brain from childhood through adolescence followed by a more gradual but progressive descent

through the remaining years of life (Fischer, 1966). Indeed it is a familiar experience that time for the child appears to run much more slowly than time for an adult (Hoagland, 1966). Unfortunately there has as yet been no study that sheds light on the question whether the slowing of cerebral oxygen consumption with advancing years influences the perception of tempo in music.

Many researchers assume that a possible basis for tempo perception in music may rely on neural oscillations in the brain proceeding with a remarkably stable rate. Mental structures might, therefore, display considerable morphological stability. Studies have been concerned with time processes on intervals of a fraction of a second to several seconds. For instance, Pöppel (1976) opted for a period of 20 to 30 milliseconds as the perceptual moment or time quantum, which is defined by Stroud (1955) as "the least timewise element of psychological experience" (p. 180). Furthermore, Pöppel (1990) reported evidence postulating an "integration mechanism" in our brain with a period of about 3 seconds which is roughly equivalent to the time span of the conscious or psychological present. This value has been established by studies in various fields, such as time psychophysics and visual perception. Pöppel (1990) proposed that this time limit of 3 seconds could be the basis for a central neural pacemaker or biological clock that causes tempi and tempo relationships in music to be "unbiological" and hence with unpleasant aesthetic consequences for listener with "traditional listening habits", if they are not tuned to this clock in our brain (p. 119, translated from German by E. Lapidaki).

Concerned with the precision of selecting and maintaining the 'right tempo,' the American musician and music theorist David Epstein (1985) investigated tempo relationships within pieces of music from different cultures. He concluded:

> This (selection of a particular tempo) is not a matter only of music 'per se.' Our biological system is involved as well. Clearly this system entrains within itself the

> beat or pulse that pervades the music. This beat remains constant, entrained-embedded, if you will—in the time clocks of our system. We organize these beats or subbeats, into collections which form the various tempos of a work. There is thus a profound biological connection with pacing and tempo in the performance of music, which in turn has psychological ramifications of the deepest sort (p. 37).

Epstein (1985) also wrote:

> So powerful is the element of pulse that if one violates it by distortion of tempo, one runs the risk of an unsuccessful performance. Such a distortion seems to be violating not only a "musical factor," but a biological one as well, one which sets ground limits to our aesthetic perception (p. 37).

Concurring with Epstein, an investigation of repeated musical performances over aperiod of several years also indicates that "music engages and programs a 'psychobiological' clock, or clocks, which function subconsciously" and guides the execution of proportions of musical temporal parameters, such as duration, rhythm, and tempo (Clynes & Walker, 1986, p. 87). It has been observed that changes in durations of subsections from one performance to the other often have a tendency to be balanced by changes in other subsections in order to preserve the same overall duration of the piece, although the performer is not aware of this. This observation will be discussed in detail in the section following about consistency and temporal precision in musical thought and performance.

Much remains to be known about the temporal organization of nervous system interactions with regard to musicperception, and about internal clocks and their anatomical characteristics as well as properties within the structure of the brain. To my knowledge, no research unambiguously reveals and defines the existence of a specific central neural pacemaker that may regulate the concept of tempo in musical performance and listening.

In spite of the psychobiological explanations of time experience based on 'clocks,' there are researchers who support the variable nature of time experience within and among

individuals. It appears that different individuals on the same musical occasion, and even the same individual on different musical occasions, exhibit a temporal behavior for which no predetermined 'clocks' are available or apprehensible. Radocy (1980) pointed out that people perceive music as having varying rhythmic regularity and tempo regardless of the speed of their physiological processes. Concurring with Radocy, Clifton (1984) made the following comment: "The 'time sense' cannot be fruitfully attributed to a specific organ or physiological function. If the term makes sense at all, it can only refer to the activity of human consciousness" (p. 56).

Indeed the theory of physiological internal-clock mechanisms and the role they play in human tuning to temporal contingencies has not been supported consistently in empirical studies. Campbell (1990) attributed to these mechanisms two qualities "not commonly associated with clocks – sloppiness and sluggishness" (p. 115). Michon (1985a) claimed that "evidently we have reached the limits of a psychobiological explanation of human time experience in terms of >clocks<: there are no discernible rules that could explain why one >clock< or >clock system< would be preferred over another" (p. 31). It is interesting to mention, however, Macar's conclusions (1985) with regard to studies concerned with physiological time bases:

> Although large individual variations are the rule, it is surprising to observe that systematic trends may affect temporal judgments quite noticeably, though this is general true for only one or two subjects per experimental group .... Clear hypothesizing and clever experimental designs may uncover more of these idiosyncratic strategies" (p. 124).

Rather than trying to explain human time experience in terms of 'clocks' rooted in our physiology and anatomy, it has been suggested that a different frame of reference is essential, one which deals with time, the so called psychological time, as a conscious product of cognitive mechanisms and processes. In the next section we shall see how

problems surrounding the psychology of time take on a new dimension when the time involved is "filled" with music. More specifically, the following section offers an overview of the state of thought concerning the psychological basis of tempo perception while listening to or performing music.

Psychological Tempo in Music Listening and Performance

Most music theorists and psychologists agree that tempo is a perceptual quality of music specifically linked to "the number of perceived musical elements per unit of time, or to the absolute duration of the different values of the durations" (Fraisse, 1982, p. 151), or to the total impression of speed (Gabrielsson, 1986). Cooper & Meyer (1966) postulated that "... it is important to recognize that tempo is a psychological fact as well as a physical one" (p. 3). Kramer (1988) defined tempo as the rate both of metric beats—"the objectively measured"—and of information transmission and reception—"the subjectively felt" (p. 349). Jones (1990) generally stressed "... the real value of tempo as interpreted and produced by a musical artist ... and of how listeners hear tempi" (p. 214).

Most music research has been primarily dominated by considerations of rhythm, meter, and how they are perceived. Recently music psychologists have tended to more systematically study this relatively neglected temporal property of music. In this section we will review more recent contributions (and some of their predecessors) that concentrate on the following topics related to tempo perception: (1) the impact of tempo on affective responses to music, (2) the ability to discriminate tempo changes in music listening, and (3) the execution of tempo changes in music performance.

The Impact of Tempo on Affective Responses to Music

With regard to the affective aspect of tempo, Dürr (1966) noted that "... it is essentially the tempo which determines the emotional effect of rhythms" (p. 183). Commonly scored musical tempo designations such as *allegro, appassionato, dolce, tranquillo, agitato, grazioso,* etc., indicate characteristic mood effects in their original meaning. In a series of experiments, Hevner (1935, 1937) studied the influence of tempo, among other elements of music, on mood responses of listeners by manipulating one element at a time while holding the others unchanged. Her findings disclosed that faster tempi were associated with adjectives of a checklist of emotional responses, such as "exciting," "joyous," "happy," "playful," and slower tempi with the opposite adjectives. She also found that tempo was the single most crucial element of music in determining mood responses. Not surprisingly, Rigg (1940), Farnsworth (1954), de la Motte-Haber (1968), Behne (1972), Gabrielsson (1973, 1982), and LeBlanc & McCray (1983) unraveled similar findings that show a strong relation between affective responses to music and tempo.

It is possible, however, that a number of other musical parameters (e.g., loudness, timbre, meter, notational arrangement, style, etc.) and personal factors (e.g., age, familiarity, musical training, etc.) influenced the affective judgments of music made in these studies. Although these studies do not have a particular relevance to the issue of consistency of tempo judgments over time, they are relevant because they establish the strong impact of the perceptual dimension of tempo in responses to music.

Tempo Changes in Music Performance

An important consideration in the study of musical expression is the execution of tempo changes in performance which are not precisely captured in the composer's notation. It should be noted that tempo changes have been considered as an important factor of musical expression. A number of authors agree that ritardando or accelerando occur due to the performer's desire to give spirit and expression to music. Recently researchers attempted to explain these tempo fluctuations by objectively measuring them, especially by means of computer programs and other technical advances that allow for accurate registration and timing of the so called "microstructure" of the musical performance. Thereby, different models were developed and conclusions drawn depending on the methodology of the experiments and the composer, the musical style, or the size of the musical examples.

In most cases there is critical evidence of flexible constraints or restrictions on expressive timing patterns, such as ritardandi, accelerandi, and rubati, that recur in actual expert performances (Friberg, 1991; Todd, 1985; Sundberg, Friberg, & Frydén, 1991; Sundberg & Verillo, 1980; Shaffer, 1981; Kronman & Sundberg, 1987; Gabrielsson, 1988; Feldman, et al., 1992; Repp, 1994, 1992). These constraints can be demonstrated as classes of optimal geometric or mathematical temporal structures or shapes for melodic events. Researchers interpret these shapes as frameworks within which performers manifest their individual expression and artistic freedom for a favorable musical communication with the listener. This evidence carries with it no assumptions of conscious awareness or intention on the part of the performer (Feldman, Epstein, & Richards, 1992; Clynes & Walker, 1982). Some of the studies of performance expression also combine measurements with perceptual judgments of listeners that verify the aesthetic validity of the

measured constraints. These judgments are ceded completely to the listener's intuition (Repp, 1992; Sundberg & Verillo, 1980; W. F. Thompson, 1989).

Clynes (1983, 1986, 1987) suggested that there are specific recurring patterns of timing that convey the composer's character. These expressive patterns associated with individual composers are called the composer's "pulse " and illustrates the musical "signature" of the composer ." A number of other studies have also shown a clear indication of the stability of expression, in general, and of tempo changes, in particular, in repeated performances that may span several years (Wagner, 1974; Clynes & Walker, 1982). For a more thorough discussion of the issue of tempo stability in performances over time, the reader is referred to the section of this chapter dealing with consistency of tempo perception.

Tempo perception can be regarded as involving both conscious and unconscious mental processes in musical expression. On the one hand, the conscious aspect manifests itself in the dynamic search by the performer for tempo variations that would be faithful to the composer's designations in music notation, and capable of communicating to the listener the composition's expressive potential. On the other hand, the unconscious aspect of tempo perception is apparent, as musicians are often only dimly aware of these tempo modifications, which they control in the physical actions of musical production intuitively rather than intentionally. As Feldman, Epstein, & Richards (1992) wrote, this intuitive judgment of the performer concerning tempo variations demonstrates

> ... *an underlying, unconscious conception of music* as a quasi-physical thing that "moves forward" as it unfolds through time, now speeding up and now speeding down, in accord with the moment-to-moment flux in its rhythmic, harmonic, and affective character—a conception reflected in musicians' common use of terms as "movement," "motion," and "flow" to characterize the progression of music (p. 202, italics added).

In addition, there is evidence that musical listeners tend to prefer tempo variations that conform to constraints reflecting the composer's pulse "... without being aware of the microstructure as such" (Repp, 1992, p. 222).

The present study attempted to further the investigation into perceptive abilities of tempo during the listening process by examining whether listeners are consistent in their judgment or preference of correct tempo of a musical composition with repeated listenings over a period of time. Furthermore, it examines whether factors intrinsic to the music itself (e.g., musical style) or personal attributed to the listeners (e.g., age, musical education, familiarity, and preference) may also play a part in aiding consistency of tempo judgments. The next section discusses the research into tempo perception that primarily considers the above mentioned personal factors.

The Ability for Discrimination of Tempo Changes in Music Listening

Another issue that tempo research has raised, especially in the area of music education, is the sensitivity for discrimination of tempo changes in metronomic and musical excerpts. Among many studies on this issue may be mentioned those by Kuhn (1974), Madsen (1979), Wang (1984), Madsen, Duke, & Geringer (1986), Ellis (1989, 1991), Dorhout (1979/1980), Wapnick (1980), Yarbrough (1987), and Brown (1979). Reviews and discussions also appear in Fraisse (1982) and Jones (1990).

A number of studies have indicated that experimental subjects perceive a decrease in tempo more accurately than an increase (Ellis, 1989; Kuhn, 1974; Madsen, 1979; Wang, 1984). Other studies on perception of tempo changes have generated antithetical findings. In these, subjects perceived an increase in tempo more accurately than a decrease (Madsen, Duke & Geringer, 1984; Geringer & Madsen, 1984; and Wang, 1983).

Furthermore, it has been reported that the initial tempo of the gradual changes in interaction with the direction of change may have an affect on tempo perception. Concurring with Yarbrough (1987) , Ellis (1991) concluded that thresholds for the detection of tempo change in a simple melody were greater for increases than for decreases at M.M.=48 and M.M.=84 (slower tempi), but greater for decreases than for increases at M.M.=192 and M.M.=228 (faster tempi).

Kuhn (1974) and Kuhn & Gates (1975) concluded that subjects had more difficulty recognizing a constant tempo than a modulation in tempo. The absolute identification of rate in number of metronomic clicks per minute was not especially accurate as well (Kuhn, 1974). Along these lines, Wapnick (1980) and Madsen (1979) found that subjects are not especially good in detecting tempo changes. According to Lunney (1974) and Wapnick (1980), subjects are better at detecting tempo differences at faster than at slower tempi. However, other experimental studies have indicated the opposite results: changes or differences in tempo are detected more accurately in slower than in faster tempi (Dorhout, 1979/1980; Madsen, 1979, Wang & Salzberg, 1984).

Generally, however, relationships between the ability for discrimination of tempo changes and age or previous musical experience generally have been overlooked (Geringer & Madsen, 1984; Wang, 1983; 1984) or vague (Madsen, 1979; Wang & Salzberg, 1984). It should be noted, however, that other factors may be also responsible for these conflicting modes of tempo perception, such as the content and context of experimental stimuli, as a number of tempo researchers pointed out (Wang, 1983; Ellis, 1991; Lapidaki & Webster, 1991).

Defining Personal Factors of Tempo Perception

Age

Is the origin of time concepts already present in infancy or early childhood? Is there a gap between the temporal experience of a young child and the adult and in what respects? Are time judgments the product of a gradual evolution with age? These are some of the fundamental questions—pertinent to the present study—that the developmental psychology of time attempts to answer in order to explore the growth of temporal awareness. Visual perception was the first area to receive attention by developmental experimenters, especially from about 1960 onward. Thereafter the hypotheses and methodologies of the first studies with visual stimuli were to be expanded to other kinds of stimulation, and of importance here, of course, is auditory and musical stimulation.

Insights into the development of time and tempo perception are of self-evident consequences for music education. For instance, if music teachers take into consideration disclosures of scientific developmental observations of temporal awareness, they might be capable of accumulating an inventory of varied educational objectives and musical materials appropriate to the child's changing tempo perceptual capacities at each age or grade level. In fact one's ability to perceive, recognize, identify or select the tempo of a musical piece is an important—though neglected—aspect of music education practice, since tempo notably affects one's perceptual organization of the music's temporal relations (Duke, 1994). After all, musical time (e.g., rhythm and meter) and tempo (e.g., speed of music) are central and interdependent concepts in music perception. As Dürr (1966) pointed out: "If we take rhythm as the mode of appearance of time in music, then musical speed, the *tempo*, is the expressive mode of rhythm" (p. 183, original italics).

Among developmental psychologists, Piaget (1954, 1969) was one of the first who considered the problem of time with particular regard to its relationship with speed in his pioneering studies on the origins of the knowledge of time. This is how Piaget (1966) summarized the theoretical implications of his observations of time perception in children that can be further extended to music, one of the so called temporal arts:

> Namely we define velocity through the passage of time; but we can arrive at time, and measure time, only by accepting velocity ..... The hypothesis that I should like to defend is that psychologically time depends on velocity, that time is a coordination of velocities, or, better yet, of movements with their speeds, even as space is a coordination of changes of place, that is to say of abstract motion made up of velocities (p. 202).

One of the main concerns of the present research is the investigation of the following question: Is tempo perceptual ability and, more specifically, the capacity for consistent right tempo judgments/selections for particular pieces of music over a period of time affected by age? In other words, are adult listeners more stable in their judgments of the right tempo of a musical composition than adolescent or pre-adolescent listeners? As we shall see, investigations on the effects of maturation upon the development of tempo perception, thus far, seem to be piecemeal, indicating, therefore, that this is an area which would warrant further exploration.

In a number of studies it has been shown that sensitivity to temporal properties of sound (e.g., brief durations and rhythmic sequences) appears very early in life (Fraisse, 1982; Morrongiello, 1984; Morrongiello & Tehub, 1987). According to Demany, McKenzie, & Vurpillot (1977), new-born children could discriminate two pairs of rhythmic sequences which could be interpreted as alternating intervals of notes and rests of different durations in music. Another study (Morrongiello,1984) demonstrated that the difference

between two sound series, the second of which changed the location of the silent interval by 0.04 sec, was distinguished by six-month-old children.

Yet, with regard to discrimination of tempo change findings seem to be inconsistent. On the one hand, Clifton & Meyers (1968) reported that fourth-month-old infants do not perceive a difference in tempo between a sequence consisting of sounds of 500 milliseconds (msec) and another sequence consisting of sounds of 1000 msec followed by intervals of 1000 msec. More recently, on the other hand, Berg (1974) and then Leavitt, Brown, Morse, & Graham (1976) found that 6-week-old infants could discriminate a basic change of tempo between two simple sound sequences (a sequence of sounds of 400 msec followed by intervals of 600 msec and another sequence of sounds of 800 msec followed by intervals of 1200 msec). Moreover, Trehub & Thorpe (1989) and Trehub (1993) observed that infants recognize and respond to a melodic sequence independent of changes in its tempo or rate of presentation. Nevertheless, these collections of normative data do not seem sufficient for yielding a cognitive explanation of tempo sensitivity at such an early developmental stage.

Observations of preschool children have illustrated that perception of temporal parameters in music improves with age. For example, studies on the development of song in the preschool period suggest that children gradually blend a regular rhythmic organization into their singing of a standard tune between the ages of 18 and 30 months (McKernon, 1979). Another issue that emerged from the study of early songs was whether children's singing maintains a steady beat. The evidence is contradictory and, therefore, as Hargreaves (1988) pointed out, needs further empirical testing. On the one hand, Dowling (1984) maintains that at the age of 32 months a child is capable of keeping a steady beat when singing a spontaneous song. According to Zenatti (1993) "... between the ages of 4

and 5 children gain sufficient organizational capacity to impose a regular structure on the rhythmically grouped patterns" (p. 189). Concurring with Zenatti, Davidson & McKernon (as cited in Zenatti, 1993, p. 188) also found that children's reproductions of a new folk song were dramatically different between the ages of 4 and 5. The five-year-olds were able impose a regular beat on their reproductions, which was not the case a year earlier.

Results from a large-scale exploration of the musical experience of preschool children suggest that, for most children, a consistent synchronization of bodily movements with the pulse of music considerably improved late in preschool age (Moog, 1976). It is of interest, however, that many young children in Moog's sample synchronized their movements with respect to the tempo of music much earlier in life, which, according to Gabrielsson (1986), indicates early "attentiveness to motional-emotional aspects of the music" (p. 160). Furthermore, Morrongiello, et al. (1985) found that the optimal tempo for the presentation of melodies to preschoolers appears to be significantly faster than the tempo for infants.

Results of numerous studies (Piaget, 1969; Friedman, 1990; Fraisse, 1982; Pouthas, 1985) seem to be consistent with the postulation that between 6 and 8 years of age there is a transition period with respect to many aspects of temporal awareness. Time becomes a more basic dimension that encompasses all situations, and temporal judgments reach an increasingly stable level between about eight and twelve years. According to Friedman (1990), this dramatic change in temporal awareness strongly suggests an increase in children's sense of the uniformity of time (e.g., acquisition of conventional time) and an increase in the scale and number of temporal structures and patterns that can be conceptualized (e.g., acquisition of logical time).

Dowling & Harwood (1986) noted that "during the second year of life, children impose the regular beat on longer and longer time spans, a trend that continues throughout childhood" (p. 194). Furthermore a significant general feature of children's time judgments which bears a particular relationship to this study is their considerable inter-individual or intra-individual inconsistency if we examine children in the same condition or if we examine each child in different conditions (Montanegro, 1985; Levin, 1977). Montanegro (1985) suggested that a satisfactory model of children's time judgments should embrace "... several potentially available rules in order to explain the variability of judgments" instead of only one rule at each level of development (p. 279).

As far as music in particular is concerned, there seems to be consensus that after the age of 6 or so children begin to listen to and represent musical concepts, such as pitch, melody, harmony, and rhythm, in ways notably similar to adults (Petzold, 1963; Davidson, McKernon, & Gardner, 1981; Shuter-Dyson & Gabriel, 1981; Imberty, 1981; Dowling, 1982). The studies of the development of children's perception and production of music that Hargreaves (1988) reviewed led her also to "... the clear conclusion that by the age of six or seven, children possess many of the fundamental skills required for full-scale musical perception and performance" (p. 83). Nonetheless, research in the area of the development of tempo perception is rather patchy and insufficient to provide any coherent explanation of how the cognitive mechanisms underlying children's perception of tempo change with age.

Taebel (1974) studied the growth of tempo perception from kindergarten through second grade. One of his results was that age is an important variable for the child's conceptualization of tempo. In a longitudinal study Petzold (1969) found that first-, second-, and third-graders' auditory perceptual ability got better, while fourth-, fifth, and

sixth-graders demonstrated no marked improvement. Piper & Shoemaker (1973) concluded that kindergarten children demonstrated greater difficulty in reproducing slower than faster tempi. This is in accord with Petzold's observation (1969) that faster tempi were easier to reproduce. With regard to the ability to maintain a steady beat, however, Petzold (1969) observed that after the second grade there was little improvement with age.

According to the findings disclosed from Dorhout's study (1979/1980), tempo perceptive ability seems not to cease to develop after the third and fourth grade. Further studies investigating the development of children's competence in maintaining a steady beat, have been carried out by Thackray (1972) and Kuhn & Gates (1975). They all seem to agree that the ability to maintain a steady pulse does not change significantly in children ages seven through fifteen (Thackray, 1972; Kuhn & Gates, 1975).

There is apparently general agreement amongst most researchers that the growth of tempo perceptual ability does not improve dramatically beyond a certain age. A number of personal factors—besides age—responsible for this plateau have been suggested, and it seems likely that the development of tempo experience is the outgrowth of a combination of several of them. These personal (e.g., associated with the listener) factors may be separated into three general categories: musical training or education, musical preference, and familiarity.

The present study attempted an examination of questions relating to the effects of musical background, preference, and familiarityon the consistency of tempo judgments. A review of studies relating to these factors is now given.

Musical Background

Musical background (or experience) has long been hypothesized to influence musical development by enhancing children's attention to musical materials. According to Hargreaves (1988), musical training "... refers to the self-conscious, directed efforts that are made to improve specific musical skills" (p. 84). With regard to the development of perceptual structuring of musical time, a similar observation was also made by Imberty (1981), who observed that in most cases musical development stops at age 12, unless a special effort is made by education:

> When the subject through psychological maturation becomes capable of constructing richer temporal structures, these habits will inhibit the new possibilities. That explains the blockage of processes of evolution which can be noticed at about the age of 12 and which results in the situation that an uncultivated adult conserves a judgment and a perception close to those of a child. The role of education is therefore to prevent this blockage and these inhibitions by familiarizing the subject very early with multiple experiences which enrich the stereotypes memorized by acculturation (p. 129).

Although a great deal of work has focused on the relationship between rhythm perception and musical training, there are relatively few studies that have examined musical training as a variable in tempo perception. In fact, most research on tempo perception deals with the ability to detect tempo changes, as described earlier in this chapter. Along these lines, Dorhout (1979/1980) concluded that musical experience (e.g., participation in specialized musical activities) contributes significantly to an improvement of tempo perception. Similarly, Yarbrough (1987) found that musicians generally seem to be more accurate in discriminating tempo changes than non-musicians. Further Ellis (1991) pointed out that "high-experience subjects appeared to demonstrate superiority in detecting tempo changes in all conditions" (p. 168).

However, complications seem to exist concerning the relationship between musical training and the ability to recognize identical rates of pulses. Dorhout (1979/1980) reported that the experienced musicians in the samples of the studies by Kuhn (1974), and Kuhn & Gates (1975) were found to possess the same difficulty in the identification of identical tempi as the children with limited musical experience of his sample. Sheldon's data (1994) also suggested that there was no significant difference between music and non-music majors with regard to steady-tempo examples. Furthermore, Madsen (1979), Wang (1983), and Wapnick (1980) concluded that the amount of musical experience does not relate to perception of tempo changes. In summary one might say that the combined results of all above mentioned experiments into tempo listening, in spite of their variability in methodology, scope, and types of training investigated, generally imply that perception of tempo change is not precise in both musicians and non-musicians.

Since the parameter of tempo is often addressed in the context of rhythm apprehension, it is interesting to note that "novices" perceptions of rhythm are closely bound to the tempo at which rhythms are performed and heard", which is not the case with expert musicians, according to Duke (1994, p. 33). In fact, musicians identify identical rhythms presented at different tempi as the same, because they have learned to organize rhythmic structure with reference to the metrical relation between durations and an ongoing regular pulse (Duke, 1994; Fraisse, 1982; Handel & Lawson, 1983; Handel & Oshinsky, 1981). On the one hand, Povel & Essens (1985) maintained that musical training affects the ability to feel the beat of music or to maintain an internal clock. Data by Drake (1968), on the other hand, seem to demonstrate the opposite: a five minute practice session on methods for comprehending the subdivisions of the beat did not significantly improve the ability to keep a steady tempo.

Yet, although research has offered some insight—though contradictory, in many cases—into the relationship between tempo perception and musical training, several questions still remain unanswered, such as the degree to which musical training influences listeners' judgments of a composition's correct tempo, or the over time stability/variability of these judgments. The Lapidaki & Webster study (1991) revealed no overall, statistically significant results, indicating that music background influences consistency of right tempo judgments for selected musical compositions. Nevertheless, it is worth noting that adult listeners with no or limited formal music education differed from highly experienced musicians by the tendency to adopt generally faster tempi.

Since tempo is regarded as the most important parameter that gives music or rhythm its "proper motion character" (Gabrielsson, 1986, p. 150), the development of tempo perceptual abilities should be considered crucial for a thorough understanding of the aesthetically expressive qualities of music. Instead of focusing solely on reading of notated structural temporal parameters of music (e.g., correct rhythm, meter, subdivisions of time periods, accents, and the like), music instruction should promote the development of listening skills, especially in the context of the imprecisely represented motional and emotional aspects of music, as is the case of tempo. As Gabrielsson (1986) emphasized: "The tempo is very important for the listener's impression of the music, and frequently the difference in tempo is what you notice first, when you compare different performances of the 'same' piece of music" (p. 148).

In this context it is interesting to mention Farnsworth's similar observation:

> ... of the variables which give meaning to music, tempo plays the largest role .... The listener is most likely to change the affective terms with which he describes a piece of music whenever its tempo is appreciably slowed or hastened. Other alterations of the musical matrix change less strikingly how he will describe the music he is hearing (as cited in Kuhn, 1974, pp. 270-271).

Preference and Familiarity

It seems worth considering musical preference as an important personal factor that contributes to perceptual experience of music. The term "preference" is seen here to reflect an individual's relatively transitory liking for one musical piece as compared with another (Abeles, 1980; Hargreaves, 1988; Konecni, 1982; Zenatti, 1993). It is likely that listeners of the same age group with similar musical training and cultural background may not elicit judgments of a composition's correct tempo in a uniform way or with the same degree of over time consistency. Because of their individual preference of likes and dislikes in music, some listeners will tend to have a more positive attitude to some musical excerpts than others during the listening process with correspondingly higher degree of attention to and concentration on the organization of musical events. For that reason, they may want to explore the preferred excerpts further or be more eager to arrive at a judgment (LeBlanc, 1980, 1987). As Barry (1990) noted:

> Individual preference as a selector highlights the importance of attention for perception. ... Further, since organization is a function of musical time, the way that time is felt to pass in music is also dependent on attention (p. 21).

The issue of preference seems to be particularly crucial for the present study, since it uses large-scale authentic musical pieces as stimuli. According to Barry (1990), "individual preference plays a much larger and more important part in substantial sections or complete musical works than in the very short, stylistically neutral material used in many experiments in musical perception" (p. 21).

There is ample scientific evidence that musical preference is further refined by stimulus familiarity which is regarded as a key source to account for musical likes and dislikes for different musical works (Berlyne, 1971; Sluckin, Hargreaves, and Colman, 1983). Familiarity with a musical piece or idiom gained from prior formal or informal

exposure to music contributes to the listener's ability to extract meaningful criteria that help him/her to make sense of incoming musical stimuli (Barry, 1990). According to Lerdahl & Jackendoff (1983), once a listener "becomes familiar with the idiom, the kind of organization that he attributes to a given piece will not be arbitrary, but will be highly constrained in specific ways" (p. 3). Furthermore, there is ample evidence that children seem to show culturally favored responses to music with age, because they spontaneously or subconsciously become familiar with musical sounds heard in the social environment to which they belong (Farnsworth, 1958; Francès, 1988; Hargreaves, 1988; Imberty, 1981; Zenatti, 1993). Geringer & Madsen (1987) also found a marked influence of excerpt familiarity on listeners.

The present study seeks to clarify whether familiarity with a particular musical work or style may affect the listener's formation and consistency of correct tempo judgments/choices. Therefore, the listening examples selected represented a wide variety of musical styles, such as Baroque, Classical, Impressionistic, contemporary, popular, and dance music.

While there has been a large number of studies on the effect of tempo on affective responses to music, inquiries on the nature of tempo perception have failed to take adequate account of the effect of experimental stimulus preference and familiarity. One reason for this neglect seems to be that most auditory stimuli used in tempo research either do not represent real music, as is the case with brief rhythmic sequences and other stylistically neutral information (Duke, 1994; Ellis, 1991; Holbrook & Anand, 1990; Kuhn, 1974; LeBlanc & Cote, 1983; LeBlanc & McCrary, 1983; Madsen, 1979), or they consist of musical material which are not selected so as to vary widely in their likely familiarity to the

subjects (Farnsworth, Block, & Waterman, 1924; Halpern, 1988; Levitin & Cook, 1995; Sheldon, 1994).

Thus far, the answers given to questions about the relationship of tempo perception to personal factors of aesthetic response to music, including stimulus preference and familiarity, are in many respects still incomplete. This is due both to the complexity of temporal phenomena in music and to the lack of suitable methods for investigation of these crucial questions. The remainder of the chapter is devoted to a review of the literature that deals with the problem of stability or variability in tempo perception between performances of the same piece.

Consistency in Tempo Perception

There is near unanimity in the definition of musical tempo as the speed at which the performance of a composition proceeds (Donington, 1980). According to Gabrielsson (1986), "tempo designates the perceived rate of the beat or pulse, while the latter terms [rate, rapidity, speed] refer to the 'total' impression of speed" (p. 148). Similarly, Fraisse (1982) pointed out that tempo "corresponds to the number of perceived elements per unit time, or to the absolute duration of the different values of durations" (p. 151).

Nevertheless, does a piece of music have one and only one inherent tempo, and if so, does this seemingly well-established concept possess an absolute or correct time framework? Can a composition survive a wide range of tempi? The literature is far from consistent on these questions.

Empirical research on the broad subject of tempo has taken many directions. As mentioned earlier, there has been extensive inquiry into the effect of tempo on listener preference (e.g., Brown, 1981; Geringer & Madsen, 1987; LeBlanc, 1981; LeBlanc &

Cote, 1983; LeBlanc & McCrary, 1983; Wapnick, 1980, 1987) and on discrimination of tempo changes in music listening (e.g., Kuhn, 1974 and Wang, 1983). Much of this work is important in establishing a theoretical base for preference and discrimination, but does not speak directly to the question of consistency which has been little studied, especially with musical stimuli because it presents many problems. As Gabrielsson (1986) claims: "When real music is used as stimulus, an important problem is how to vary its rate" (p. 148).

In the process of exploring the literature concerning tempo consistency in musical and nonmusical environments, it is of interest that most investigations were performed around the first half of the century and were often referred to as "personal" or "preferred" or "mental" tempo studies (e.g., Braun, 1927; Frischeisen-Köhler, 1933; Harisson, 1941; Miles, 1937; Mishima, 1956; Rimoldi, 1951; Wallin, 1911). Most commonly, subjects were asked either to tap a telegraph key as their response task or to use a metronome to indicate what tempo appeared to be the most natural. In other words, subjects had to judge whether the speed of metronome clicks was either too slow or too fast. In Wallin's (1911) study, subjects listened to pairs of different rates of a metronome and were asked to state which tempo was felt to be more appropriate. There were considerable individual differences in the preferred rates. In fact, these ranged between the extreme rates offered by the metronome. Braun (1927) asked subjects to produce a steady series of taps at any rate they chose; he recorded the tapping rates of six subjects in 11 sessions, at intervals of several weeks between each session. Braun found that subjects were relatively consistent in their preference rate, and that the variance within subjects was very small in comparison to the variance between subjects. Furthermore Miles (1937) experimented with subjects who

were instructed to tap regularly a rate that seemed more satisfactory to them. He concluded that each subject had his or her own preferred range of rates.

With regard to subjective consistency in rate of self-paced movements of specific parts of the body, Harisson (1941) found no similar tempi between any of the tasks performed. Three decades later, Smoll (1975) maintained that individuals were relatively consistent concerning their personal tempo manifested in situations involving repetitive motor responses. However, Mishima (1951-52) pointed out that "mental tempo is constant within a field, but it varies with different fields" (p. 27). Furthermore Rimoldi (1951) reported that "fast individuals are consistently fast and slow individuals are consistently slow within relatively long periods of time (from two to four weeks)" (p. 301), while Frischeisen-Köhler (1933) concluded that the effect of time between sessions on the variability of tempo appears to be inconsiderable.

More recently, two studies by Clynes & Walker (1982, 1986) on stability in performed tempo are worth noting. Repeated performance by the same musicians and of the same compositions were timed over a number of years. The research findings suggested a high degree of consistency and precision in the execution of tempo. The researchers reasoned that music appeared to engage and program a psychobiological clock or clocks which functioned subconsciously but gave conscious read-outs and thereby seemed to guide the performers' realization of tempo in an exact and stable manner. These findings are consistent with the timing of a symphony orchestra in several performances of the same compositions over several years at different music halls of the world measured by Winckel (1962). Similarly, Wagner's (1974) timing of different performances on the piano of the same piece by Herbert von Karajan showed highly consistent tempi. Epstein (1985),

while studying tempo perception in a cross-cultural context, reached the following conclusion:

> So powerful is this element of pulse that if one violates it by distortion of tempo, one runs the risk of an unsuccessful performance. Such a distortion seems to be violating not only a musical factor, but a biological one as well, one which sets ground limits to our aesthetic perception (p. 37).

The virtual unanimity of this testimony (e.g., Brendel, 1977; Collier & Collier, 1994; Donington, 1963/1974l; Gould & Page, 1982-3; Pöppel, 1990; Stravinsky & Craft, 1980) suggests that when music researchers finally explain the cognitive and neurological underpinnings of how temporal information in music is coded and represented they will unravel perhaps the most mysterious aspect of music cognition. Yet much remains to be investigated in this aspect.

In addition to studies that employ listening to stimuli like metronome clicks or performance tasks, of particular interest are those investigations that ask the listener to make judgments about tempo with hardware that allows for variable-speed control over the musical stimulus. Farnsworth, Block, & Waterman (1934) designed a study that examined whether there is one tempo consistently associated with familiar waltz and fox-trot tunes. In that study, subjects (non-music major college students) were blindfolded and placed in front of a Duo-Art reproducing piano with the tempo lever in hand. The task was to place the lever at the position considered to give the "proper tempo" for the tunes played by the piano. Subjects were also placed at a telegraph key, so that they could tap the "proper tempo" for the same tunes; the taps were recorded on a polygraph. According to the findings, the variations of the means for the proper waltz tempo were slight but for the fox-trot were equivocal in some degree. Findings seemed to suggest a mean of controlling "absolute tempo" of about 120 beats per minute. In addition, the findings reported a

positive correlation between the tapping behavior and the setting of the Duo-Art tempo lever, that is, "between the more motor and the more sensory aspects of tempo" (p. 233). Five years later, Lund (1939) repeated this study and arrived at similar findings, although in his experiment tempi for waltz and fox-trot were slightly faster. Moreover, measuring the principal tempo of an extensive number of selected recordings known as the "Carnegie set," Hodgson (1951) proposed that all music is based or geared to one underlined human or psychological beat or tempo between 60 and 70 beats per minute, which indicates a strong preference tempo.

The Farnsworth, et al. and the Lund research were important studies because of their use of real music with hardware that allowed subjects to have control over tempi. They were also limited in that they only investigated popular ballroom dance music which subjects might associate with familiar body movement. As Donington (1963/1974) observed: "Dance steps can only be performed correctly within narrow margins of speed" (p. 392).

Behne (1972) used both a mechanical device, the so called "Springer-machine," for manipulating the tempo of recorded music, and real renditions of the same piece in different tempi as well (p. 70). All pieces were composed particularly for the study. The findings showed that listeners judged the tempo of certain pieces as correct within a relatively wide range of tempi. In addition, the listeners' judgments appeared to approach halfway the composer's metronomic designations (p. 123). Behne's findings seem to suggest "the existence of a certain 'tolerance width', that is, of different possible tempi" (translated from German by E. Lapidaki, p. 129). Therefore Behne concluded that the existence of a single right tempo for a piece of music is an "exceptional case."

Halpern (1988) conducted a two-part study on tempo perception with non-music major college students. It is remarkably similar in purpose and design to the 1934 work by Farnsworth and his associates. However Halpern does not note the connection. In her two-part investigation, nineteen well-known popular songs served as stimuli and were presented to subjects by an Apple II computer controlling a synthesizer (Study 1). Most of the songs had the characteristic that no single reference version and, thus, no single uniformly correct tempo existed—e.g., "Happy Birthday," "Twinkle, Twinkle, Little Star," "London Bridge is Falling Down." Instead of manipulating the tempo lever of a player piano, as was the case in Farnsworth's study, subjects could change the tempo of the tunes by manipulating the software interface on the computer until they sounded "correct." Instead of tapping on a telegraph key, subjects were instructed to set a metronome to coincide with what they imagined to be the correct tempo of the songs.

Results reported a generally positive relationship between the metronomic evaluations and the setting of the tempi on the computer, that is, between "imagined" and "perceived" correct or preferred tempi for each tune. The results are indeed similar to those found by Farnsworth and his associates concerning the positive correlation between the tapping task and the setting of the tempo lever. It was also found that imagined tempi seemed to regress to a middle range of approximately 100 beats per minute, between the faster and slower perceived tempi. In Study 2, though, which utilized 10 of the tunes of Study 1 and only the "imagery" task (e.g., the metronome setting), it was reported that the mean preferred tempo was 109 beats per minute, significantly faster than the mean imagined tempo from Study 1 and much closer to the mean tempo of 120 beats per minute reported in the Farnsworth, et al. study. Both parts of Halpern's research suggest that familiar, popular tunes are represented in our mind with a particular tempo.

Levitin & Cook (1995) conducted a similar two-part study in order to investigate if we remember a song in its original tempo. In Experiment 1 of the study 46 college students unselected for their musical background were asked to choose a song they knew very well among fifty-eight CDs containing the best known popular songs and to hold it in their hands. They were instructed to close their eyes and imagine that the song was actually playing. Then they were told to try to reproduce the song from memory by singing, humming, or whistling. Their reproductions were recorded on DAT. After the first reproduction subjects were instructed to repeat the procedure with another song of their choice. The durations of each subjects' reproduction was then compared with the corresponding original excerpt on the CDs using a softwere program. Results showed that long term memory for tempo is very accurate.

Interesting as these results may be, they do not demonstrate whether judgments of tempo are consistent across separate trials over an extended period of time, especially when subjects are presented with musical compositions from Western art music of different style periods. Also of importance would be how these judgments might differ among subjects with different musical backgrounds.

To investigate these issues, Lapidaki & Webster (1991) conducted a study in which subjects were 15 highly experienced musicians (5 composers, 5 performers, and 5 music education specialists) recruited from a pool of professors and graduate students of a University School of Music and 5 non-musicians who were professors and graduate students from other departments of the University and had little formal music education and involvement in musical activities. Three music examples (e.g., J. S. Bach's "Air in D Major" from the Suite Number 3 in D major; F. Chopin's Prelude Number 7, Op. 28, and A. Schoenberg's second piece from "6 kleine Stücke," op. 19) were chosen because they

represented a wide range of musical styles and familiarity. The examples were recorded on a Macintosh SE computer linked via MIDI to a Casio CZ-1 synthesizer. The software program employed had the ability to allow for musical stimuli and for no overall alterations of any musical attributes of the sequences other than tempo, so that subject could listen to the "real" pattern of timing and loudness which illustrate the compositions' expressive character.

All subjects were tested individually at three sessions at three-day intervals. For each of the three testing sessions, subjects were asked to make judgments of each of the three compositions. They were asked to listen to each composition and indicate to the experimenter to change the tempo until it sounded "right." The experimenter changed the tempo as directed until the subject was satisfied. Each subject was encouraged to take as much time as was needed and to listen to the composition as often as necessary. Once the three compositions were judged, the subject was asked to return in three days time for the next trial. Each trial for each subject systematically varied the order of the compositions and the initial tempo of the presentation of the compositions in order to eliminate the possibility of contextual cues.

The findings of the Lapidaki & Webster study showed that when tempo is judged by highly skilled musicians in repeated listening tasks to the same compositions, initial tempo has a dominant effect on correct tempo judgments. Simply stated, no single correct tempo emerged as a consistent entity of individual or group performance across the four trials. The sample of adult non-musicians indicated a basis for a similar conclusion. These results did not support the observations reported by Farnsworth, et. al. (1934), Lund (1939), and Halpern (1988) that there is one tempo consistently associated with particular listening examples. On the contrary, listeners' perceptions of correct tempo for a particular

composition varied dramatically from one individual to another. Musical background of the subjects seemed to have some effect on consistency of correct judgments, with music educators and composers having the most consistent judgments as groups. Nevertheless, this tended to vary according to the composition in question. Many of these tendencies approached statistical significance and suggested important questions for further study.

It is obvious, however, that additional work is necessary with larger and more varied musical samples and with better measures of individual familiarity with, and preference for judged compositions. Also of interest would be how these judgments may differ among subjects from different age groups.

To investigate these issues the present study employed subjects from different age groups (e.g., adult, adolescent, and preadolescent listeners). Subjects were presented with musical examples which represent a wide range of musical style or genre (e.g., Baroque, Impressionistic, contemporary, rock ballad, and dance music). Also of importance was how these judgments might differ among adult, adolescent, and preadolescent listeners with different musical background (musicians and non-musicians). Another aspect of this study relates to the connection between listeners' tempo judgments and their familiarity with the musical examples. The present study also investigated the interplay of tempo judgments to musical preference.

Conclusion

This review of related literature concerning scientific thought and insight about tempo shows that we have come a long way in our understanding of how musical tempo is perceived. Nevertheless, there is still a long way to go, since many questions remain unanswered.

We can expect further development of many projects and ideas that have been discussed in this chapter. Fortunately, the link among the various sources that may be tapped to find out what processes are underlying the experience of tempo in music is strong. As we have seen, there are several such sources, physiological, biological, and psychological. In addition, in this review questions pertaining to the unique characteristics relating to the perception of tempo have been also considered from points of view that draw upon music education and developmental psychology of music.

This chapter was in fact a search for a framework on which the experiment on the consistency of tempo perception that follows is based. Although omissions and simplifications are unavoidable in a short review of literature like this, it has hopefully provided some flavor of the exciting phenomenon of tempo and its areas of research.

The next chapter provides a description of the design and the methodology of the present study that examines the consistency of correct tempo judgments across four trials among subjects with differing age, musical background, familiarity with, and preference for selected music of various musical styles.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

Chapter 3 presents the reader with a description of the research design and methodology of the present study. First, the chapter begins with the basic assumptions of the study . Then the research questions are posed to guide the methodology. This is followed by detailed accounts of the selection and characteristics of musical examples, subjects, equipment, and procedures used to collect data.

Basic Assumptions

The purpose of the present study is to examine the consistency of right tempo judgments of various musical styles among subjects with differing musical background, age, familiarity with, and preference for selected music. To investigate these issues, I reasoned that if a correct tempo did exist, subjects ought to be able to arrive at *consistent judgments* about the tempo of examples despite the examples being from different style periods and being presented with differing initial tempi.

I also wondered whether people from *different age groups* (e.g., adults [28-52 years], adolescents [junior and senior high school students], and preadolescents [fifth and sixth grade children]) and from *different musical background* would demonstrate different levels of consistency. Each of these groups interacts with music in different ways and each might have developed different cognitive abilities.

Furthermore, it was of interest to examine what effect *the style* of the musical stimuli would have on consistency of judged tempo. If we consider musical style as the composer's "primary form of self-identification" (Corbett, 1994, p. 80) or the way of

cultivating a personal musical vocabulary, then one should think that tempo is a significant 'signature' element unique to a composition's style.

Finally, it was also assumed that *familiarity* with the musical examples and their respective musical styles or genres, and individual *preference/liking* for a particular musical example might affect consistency of judgments concerning the correct tempo of the stimuli. Therefore, the musical stimuli were selected so as to vary widely as to their familiarity and preference to the listeners.

Research Questions

Six specific questions were posed:

(1) Is there a consistent judgment of correct tempo across four separate sessions of the same musical examples using varying initial tempi for each trial?

(2) Is the consistency of tempo judgment affected by the age of the listener?

(3) Is the consistency of tempo judgment affected by the musical background of the listener?

(4) Is the consistency of tempo judgment affected by the style (or genre) of music?

(5) Is the perception of tempo affected by

a) the familiarity or unfamiliarity (novelty) with the individual pieces and

b) the overall style of the music?

(6) Is the consistency of tempo judgment affected by the listener's preference/liking for a particular musical example?

In comparison to the present study, the Lapidaki & Webster study (1991) posed only a portion of the above mentioned research questions.

Methodology

Characteristics and Selection of Musical Examples

In approaching the question of the influence of musical style on the consistency of the judged correct tempo, I was concerned to select musical examples from various styles. This decision was based on the premise that the musical elements, among which tempo plays an important part, ". . . cannot be divorced from its affective and sentimental, as well its intellectual, significance within the work and, consequently, more generally within the stylistic language" (Rosen, 1972, p. 21).

In addition, in the various periods and genres of the history of Western music the concept of tempo had different functions in music (Behne, 1972). From the 16th century on, especially during the Late Baroque period, the compositional practice is characterized by a steadily growing number and differentiation of tempo designations. This underlines the developing significance of tempo as a perceptual quality in a work of music. In 1816 the invention of the metronome provided an apparatus for determining the exact tempo desired by the composers. According to Behne (1972), theoretically the metronome could have been developed after Galileo's pendulum experiments (16th century). However, the reason why its invention took such a long time is that the musicians' interest for a tool to precisely measure tempo did not reach its apogee until the end of the 18th century.

Therefore, the musical examples used in the present study traverse almost three centuries, from 1720 to the present. It was felt that the listening material should reflect the various levels of flexibility set by composers with regard to the interpretation and perception of correct tempi. Nevertheless, due to the time constraints for each session, it appeared essential to limit the number of the stylistically diverse listening musical examples (Table 1-3). Based on my experience with using listening examples in the classroom, all

pieces were approximately from one to two minutes in duration. The length of the musical examples appeared to be long enough to provide a genuine interaction with the music, yet short enough to keep the subjects' attention.

The C-major and A-minor *Two-Part Inventions* by J. S. Bach were chosen because a notable feature is their uniformity of metrical pulse. The stability of the motion through the keys — from tonic to tonic — seems to mirror the regular progression of beat to beat and measure to measure. Based on the idea of free conversation of the two lines upon the same musical matter, these inventions represent an absolute strictness of compositional design which embraces in exemplary unity every element of musical organization: tempo, meter, rhythm, melody, harmony, and form. In addition, almost everyone who has studied the piano knows them. As Bach wrote in a later autograph manuscript of these pieces in 1723, three years after he composed them for the "Little Clavier Book" for his eldest son, Wilhelm Friedemann, "lovers of the clavier, but especially those desirous of learning are shown a clear way ... above all to arrive at a singing manner in playing, and at the same time to acquire a strong foretaste for composition."

Clair de Lune by Claude Debussy was published as part of the "Suite Bergamasque" for piano in 1905. It is ruled less by metric than by motivic considerations. The most immediately noticeable features of this piece are its unbroken continuity of melodic passage-work, its rich harmony based on parallel chords and the whole-tone scale, and a colorful but clear textural palette. It is above all music which is as vague and intangible as the changing colors of 'clair de lune,' that is, the pale, grayish-blue glaze applied to various kinds of Chinese porcelain.

The *Piano Piece* is one of Michalis Lapidakis' solo piano works, written in 1993 and only performed once. The composition draws on a distinctive Greek traditional melody but without undue emphasis on folkloric aspects; it is rather concerned with structural

Table 1-3

Experimental Stimuli Arranged by Composer, Title, and Musical Style

Johann Sebastian Bach (1685-1750)	*C-major Two-Part Invention* BWV 772	Baroque
Johann Sebastian Bach (1685-1750)	*A-minor Two-Part Invention* BWV 784	Baroque
Claude Debussy (1862-1918)	*Clair de Lune* from the "Suite Bergamasque" (1905)	Impressionistic
Michalis Lapidakis (1960-)	*Piano Piece* (1993)	Contemporary
The Beatles (1962-1970)	*Yesterday* (1965)	Rock ballad
Manos Hadjidakis (1925-1994)	*Never on Sunday (The Children of Piraeus)* Title song for the film "Never on Sunday" (1960)	Dance music

devices and the expansion of form. The composer transforms scattered fragments of the melody or the whole melody into less simple musical structures throughout the piece which are then rotated in a variable sequence. The work has an emotive immediacy, an uncluttered utterance, and a rhythmic clarity possessed by a transparent pulse.

Yesterday, written by John Lennon and Paul McCartney, is considered to be one of the biggest commercial success stories in the history of rock music. However, the success

is more than commercial. In this song the Beatles have created a breakthrough in the language of rock music with its own inherent drama, humor, harmony, and form, concentrating on a broad range of emotions which meticulously define the music's structure.

The Children of Piraeus was composed by Manos Hadjidakis for the internationally celebrated 1960 film "Never on Sunday" by Jules Dassin, featuring Melina Mercouri. The score of the film rewarded the composer with an Oscar and in a short time made him one of the world's foremost composers of popular music. *The Children of Piraeus* is probably the most sung, most whistled, most hummed, most played, most recorded, and most danced to Greek melody. It is based on a 2/4 meter which is unquestionably the most frequent Greek form of dance expression, the so called *Khasapiko*. The dance itself is unmistakable, even to an ear untrained in Greek rhythms. *The Children of Piraeus* and*Yesterday* as well were selected because they are known from various contexts and in various versions.

All musical examples were chosen because they represented a wide range of subjects' familiarity and preference. For the sake of uniformity, all musical examples were chosen from the piano repertoire, excluding *The Children of Piraeus* and *Yesterday* which were originally composed for voice and instrumental ensemble. Nevertheless, both pieces have been scored, performed or recorded in piano versions. Only complete (e.g., satisfactory in presenting a comprehensive musical statement) compositions were used as listening examples, so that listeners could have a sense of actual musical context, in contrast with stylistically neutral, trivial or fragmented auditory material used in many studies in music perception.

The author, who is thoroughly familiar with the pieces and had played them many times, performed them on a digital piano connected to a microcomputer that registered

performance data in Musical Instrument Digital Interface (MIDI) format. (See the subsection on "Apparatus," for a more detailed description of digital equipment and direct computer input and output of performance data.) The performances were free of hesitations and technical accidents, and were judged by a highly experienced composer and pianist to be appropriately expressive renditions of the scores within a range of aesthetic acceptability for each composition.

Subjects

In view of the four individual meetings I was planning for each subject and the volume of data that would be generated, I set the maximum number of participants in the study at 90. Thirty were adults (28-52 years), 30 were adolescents (16-18 years old), and 30 were preadolescents (10-12 years old). Thus, there were three developmental stages or corresponding age groups, with 30 subjects per group.

Individuals in each age group were selected on the basis of musical background and willingness to participate. Musical background represents the subject's level of formal or private music education and/or participation in the following areas:(a) vocal or instrumental instruction, (b) regular lessons in music theory, history, or composition, or (c) participation in specialized musical activities, such as music performance, composition or teaching (as a professional or nonprofessional musician). For uniformity's sake, subjects with adequate music education and/or involvement in at least one of these areas were referred to as "musicians," and subjects with little or no musical education as "nonmusicians." Within each age group, half the subjects were musicians, half were non-musicians. Table 2-3 illustrates the sample used in the study, including their developmental stages and musical background. The categorization into these two groups has been based

on the subjects' answers to a survey concerning their age, school grade, and musical background (see Appendix A).

Table 2-3

Subject Sample Arranged by Age and Musical Background

Adult Subjects

The adults (n=30) used in the study were not sampled, bur rather recruited on the basis of a set of criteria: age (28-52 years) and musical background. With regard to musical background, the group of adult musicians represented a wide array of significant experience in music. It consisted of 15 highly creative individuals from a pool of musicians who have remarkable career profiles. In addition, all subjects, except four of them, held a graduate degree in music from a European or an American university.

The 15 adult nonmusicians were professionals in fields other than music; all held a graduate degree in different disciplines. These individuals had no training in music, but did have wide ranging backgrounds in music listening consistent with what might be expected for well-educated adults.

Adolescent subjects

The adolescents (n=30) who participated in the study were junior and senior students (16-18 years) enrolled in a midwestern public high school. In selecting the public high school for the study, I sought a school that met the following characteristics: (a) the music program must offer sufficient opportunities to experience music through performance; (b) the music program must incorporate a variety of musical media, such as choral groups, orchestra, bands, electronic and acoustic instruments, and ensembles with mixed instrumentation; and (c) the music program must motivate and prepare students for successful future professional involvement with music. In considering the public school systems available to me as a researcher in the Chicago area, one high school met the characteristics cited above more than adequately. This high school is located in a northern suburb of Chicago and serves a generally affluent community. The makeup of the student body is approximately 82 percent Caucasian and 18 percent minority groups.

After consultation with the director of the high school's music program and orchestra conductor, fifteen junior and senior students were randomly chosen to participate in the study from a pool of 25 orchestra players who had instrumental training and/or participation in a musical ensemble as members or soloists for more than six years.

With regard to the adolescent nonmusicians, a chemistry teacher and an English teacher at the high school were asked to select junior and senior students from their classes who had never participated in the school's music program or did not benefit from previous private music lessons and/or involvement in any kind of musical activity. A total of forty-six students met the above criteria to comprise a pool from which 15 students were randomly selected.

Preadolescent Subjects

The preadolescents (n=30) who participated in the study were fifth and sixth grade students (10-12 years) recruited from a pool of students at an independent Greek school in the Chicago metropolitan area.

Similar to other ethnic groups in the United States, Greek-Americans demonstrate a strong connection with their language, heritage, and culture which is being transmitted to the younger generations through the Greek schools. These are private educational establishments that children attend twice a week for approximately 3-4 hours each session, in addition to their attendance at public or private American elementary schools. In selecting this particular school for the study, I sought an educational environment on the elementary level that met the following conditions: (1) all students were comparable in ethnic background, socioeconomic milieu, and community traditions; (2) the school director, the teachers, the parents, and the students were willing to support the study on the basis of scheduling and accessibility of private testing space.

In accordance with the district's request and Northwestern University's guidelines for research with human subjects, a consent form was sent home to parents of all students in the two fifth-grade classes and the sixth-grade class (see Appendix B). The letter informed parents about the study and asked them to indicate on the accompanying permission slip whether they would be interested in having their child participate. Positive responses for each class ranged from 20 to 27, for a total of 71 responses. The three school teachers reviewed these responses for students who were systematically taking music lessons and/or were regularly involved in a musical activity for at least three years. Fifteen such students from both the fifth- and sixth-grades were identified by the school teachers, building a total pool of 15 preadolescent musicians. To arrive at a total of 15 preadolescent

nonmusicians (e.g., students with no musical training), 5 such students were randomly selected from each of the 3 classes.

Apparatus

Musical examples were performed on a YAMAHA P-150 digital piano with 88 weighted keys connected to a Macintosh SE computer that registered performance data in MIDI files format by means of a sequencing program.

For the playback of the performance data—stored in MIDI files in the microcomputer—the MIDI sound generator Roland Sound Canvas SC-55 was used which was connected via an Opcode MIDI Translator to a Macintosh SE computer and a Peavey KB15 amplification/speaker system. "Piano 1" was the timbre of sound output and "Room 1" the sharply-defined reverberation effect that simulates the natural echo of a room with a broad spread. Besides its realistic quality of piano sound, the Sound Canvas was used because of its compact size which allowed for its easy transportation to the various testing sites.

The software program employed for both recording and playback of performance data was the professional MIDI sequencing program *Performer* (version 2.0) from Mark of the Unicorn. This program was chosen in large part because of its ability to alter the graphic window display on the Macintosh so that the metronome controls could be easily manipulated. In addition, the program had the capacity to vary the tempo precisely, without altering any other musical attributes (e.g., pitch, timbre, articulation, etc.).

The tempo of each musical example—that is, the initial tempo—could be easily set by the experimenter prior to each session of each musical example. The mouse was used by the experimenter to manipulate the tempo, following the explicit directions of each subject. Figure 1-3 displays the Macintosh screen in the test series. Set in manual tempo mode, the

tempo slider was used to display and change the tempo in real time in the metronome window. To change tempo, the experimenter dragged the triangular indicator along the slider: to the left decreased the tempo, to the right increased it. The experimenter could also use the arrows at either end of the slider: the + (plus) arrow increases the tempo and the – (minus) arrow decreases it. Subjects were not asked to use the mouse themselves, since to do so would have required training for a number of subjects.

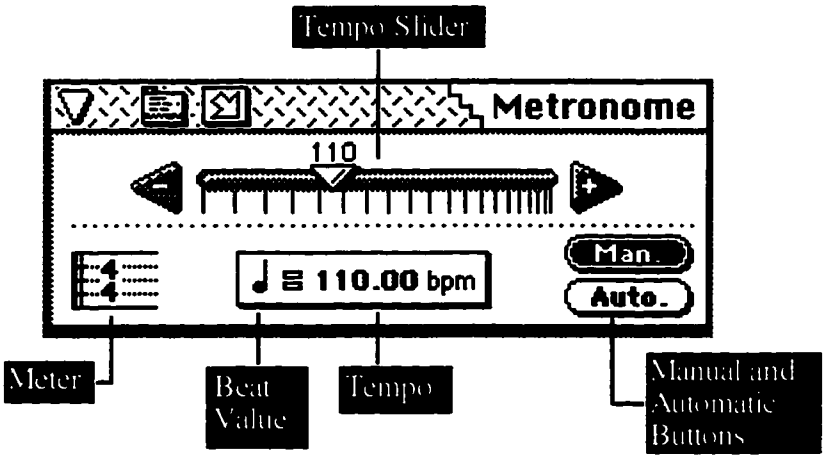


Figure 1-3. Computer screen display used to view and change the tempo.

Procedures

Each subject was tested individually by the experimenter (the author) in a private room, isolated from outside noise. All adults were tested at the experimenter's home music studio. The high school and elementary school students were tested in rooms made available to the experimenter in their respective schools.

In all sites the testing setup was identically arranged to ensure continuity. The computer was placed on a table facing the experimenter and shielded from the subject's view, with the sound generator and the amplification/speaker system mounted a

comfortable distance away. It was felt that the subject ought not to view the tempo displayed on the computer screen while listening to the musical examples in order to minimize distractions in the decision making process.

Before the actual testing examples were presented to subjects for judgment in the first session, the experimenter showed them the equipment to be used and answered any questions they had. The experimenter also explained to them the options they had for controlling tempo utilizing an excerpt of W. A. Mozart's *C-major Piano Sonata* (first movement) as stimulus so that that they could grasp the wide range of tempi available to them as well as the preciseness and ease with which the tempi could be changed by the technology. All subjects found the computer's capability to control the digital audio's tempo engaging. All remained on task independently. In addition, to confirm their age and musical background subjects were asked to fill out a survey form (Appendix A).

For the four testing sessions, subjects were given the active task to explore and, finally, determine by themselves the right tempo for each of the six examples. Subjects were asked to listen to each composition and indicate whether the experimenter should set the tempo "faster" or "slower" until it sounded right to them. One might put it this way: the listeners had to reconstruct the musical examples examining the influence of tempo on the music until they came to the decision of right tempo. Each subject was encouraged to take as much time as was needed and to listen to the composition as often as necessary.

The following instructions were given to each of the subjects by the experimenter at the beginning of each piece in all four testing sessions: "I want you to help me find the tempo which you feel most comfortable with for this particular piece. There is no trick involved or right or wrong answer. If you want the tempo to increase, say 'faster' and, if you want it to decrease, say 'slower.' Then, when you have found the "right" tempo, that

is the most appropriate tempo for the piece in your opinion, tell me. There is no time restriction. Are you ready to begin?"

The experimenter changed the tempo as directed until the subject was satisfied. When the subject indicated that the tempo sounded right, the experimenter recorded the metronome value, and then reset the computer for the next composition in the session. Once the six compositions were judged, the subject was asked to return within at least four days time for the next session. This slow pacing of trials was observed in order to prohibit memory carryover from one trial to another.

Each session for each subject systematically varied the order of the compositions and the initial tempo of the listening examples in order to eliminate the possibility on contextual cues. Two initial tempi were used: M.M. = 20 and M.M. = 200; all tempo judgments in the Lapidaki & Webster study (1991) had lain within this range. Each initial tempo was repeated twice: either in the first and third or in the second and fourth trials. Table 3-3 illustrates the order and the initial tempi in which the six examples were presented to subjects in the four testing sessions.

All judgments were recorded by noting the beats per minute (M.M.), usually referenced as the metronome marking (M.M.). These values were used as continuous scales for appropriate statistical measures, including means, standard deviations, ranges, and repeated measures analyses of variance. The .05 level of significance was adopted as the alpha level.

In order to examine subjects' familiarity with the listening examples a questionnaire form was handed to them at the beginning of the first testing session (see Appendix C). Subjects had to answer questions concerning their familiarity with the particular example and its relevant musical style, after they judged the correct tempo of the example.

Table 3-3

Order and Initial Tempi of Musical Examples in Each Trial

1st Trial		2nd Trial	
Musical Examples	**Initial Tempo M. M.**	**Musical Examples**	**Initial Tempo M. M.**
1. Bach I[a]	20	1. Greek Dance	200
2. Debussy	200	2. Bach II	20
3. Greek Dance[b]	20	3. Beatles	200
4. Lapidakis	200	4. Lapidakis	20
5. Beatles	20	5. Bach I	200
6. Bach II[c]	200	6. Debussy	20

3rd Trial		4th Trial	
Musical Examples	**Initial Tempo M.M.**	**Musical Examples**	**Initial Tempo M.M.**
1. Beatles	20	1. Bach I	200
2. Lapidakis	200	2. Lapidakis	20
3. Greek Dance	20	3. Beatles	200
4. Debussy	200	4. Bach II	20
5. Bach I	20	5. Greek Dance	200
6. Bach II	200	6. Debussy	20

Note. [a]Bach I refers to the *C-major Two-Part Invention.* [b]Greek Dance refers to Hadjidakis' *The Children of Piraeus.* [c]Bach II refers to the *A-minor Two-Part Invention.*

Finally, with regard to the question of their individual preference/liking for a particular musical example, subjects were asked to rate it on a scale ranging from 1 (*least-*

liked or *poor*) to 4 (*most-liked* or *excellent*), after they judged the correct tempo of the example at the fourth testing session. This information was recorded and used in later analyses.

CHAPTER 4

REPORT AND DISCUSSION OF RESULTS

This chapter reports an analysis of the data collected from the 90 subjects who participated in the study. First, each research question will be dealt with separately in the presentation of data. This will be followed by a discussion of the results.

Presentation of Data

Research Question 1:

Consistency of Tempo Judgments

The hypothesis for this question was that subjects would demonstrate consistency, over a period of time, in their judgment of correct or most appropriate tempo of musical examples that they heard at four trials. It was of interest whether subjects would exhibit consistency in their perception of correct tempo, in the face of a systematic change of the tempo at which the pieces were first presented in every trial (e.g., the initial tempo). Two initial tempi were used—one fast (M.M.=200) and one slow (M.M.=20)— which were alternated in each trial.

To test the hypothesis that listeners would render consistent judgments of tempo, independently from the initial tempi, a one-way repeated measures analysis of variance (ANOVA) for each musical example was performed using tempo judgments at each of the four trials as the independent variable. The .05 level of significance was adopted as the alpha level for these tests.

Results for these analyses are shown in Tables 1a-4 for Bach I and Bach II, in Table 1b-4 for Debussy and Lapidakis, and in Table 1c-4 for Beatles and the Greek dance. These tables display all means of tempo judgments across the subject groups of pre-adolescent, adolescent, and adult musicians and non-musicians. Cell means are then broken

down by trial. Finally, the trial average column contains average means across all subjects for individual trials. The F ratio is displayed in the last column. It is evident that listeners did not exhibit significant consistency in their judgments of the most appropriate tempo of the musical examples across the four trials. The hypothesis was rejected ($p < .0001$).

Further examination of Tables 1a-4, 1b-4, and 1c-4 revealed that both means of tempo judgments for the trials with the fast initial tempi were higher than the means for the trials with the slow initial tempi with respect to all musical examples. In other words, there was a clear relationship between the initial tempi and listeners' final choices of most-appropriate tempo: the slower initial tempo generally evoked slower preferences, and so on.

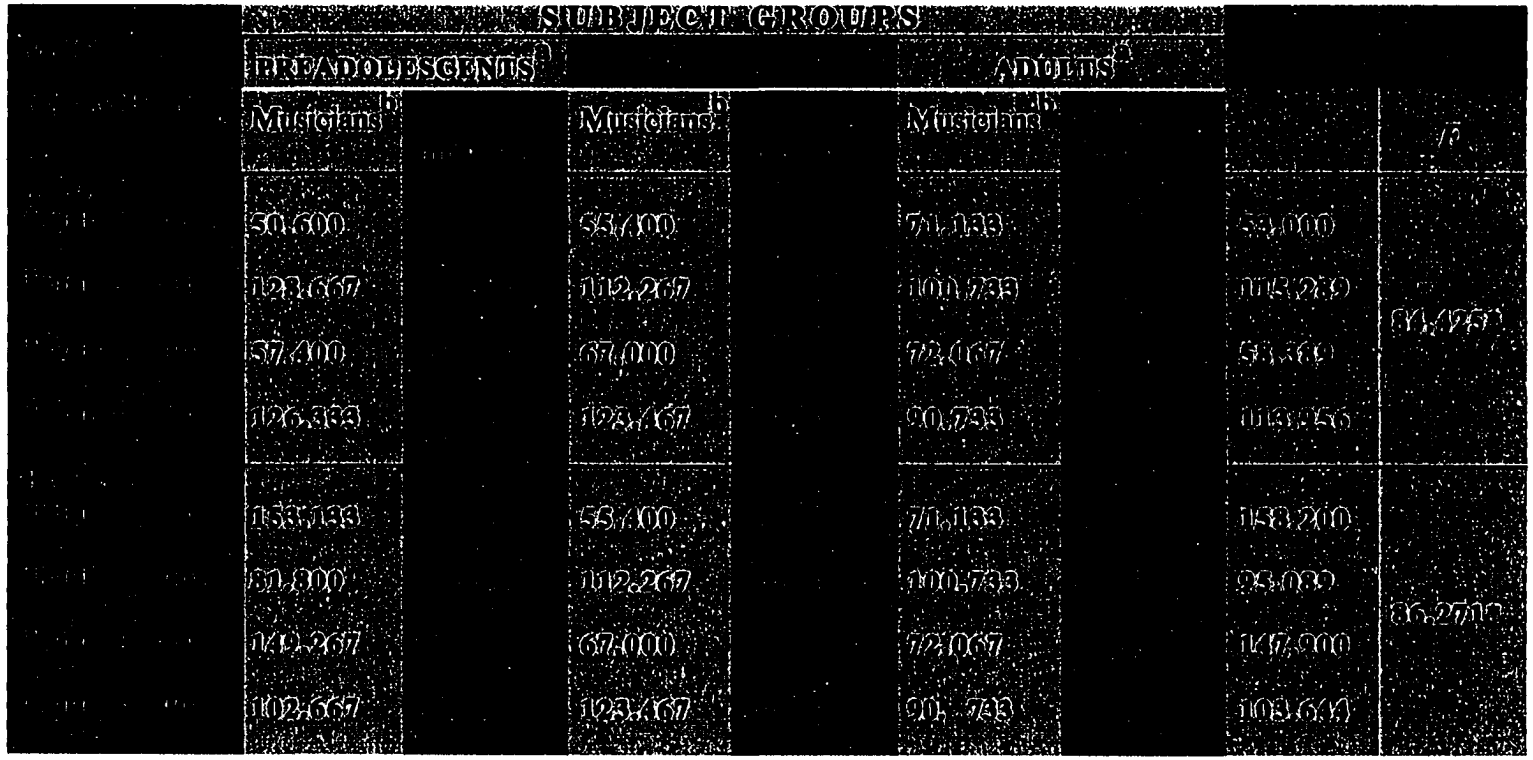
Given this finding, it seemed appropriate to investigate differences between listeners' tempo judgments observed at trials with the same initial tempo (e.g., differences between trials 1 & 3 and trials 2 & 4). An independent samples paired t-test was performed for each musical example. Results did not show evidence that repetition of the fast initial tempo evoked more consistent judgments than the repetition of the slow initial tempo or the contrary.

Research Question 2:
The Variable of Age

Subjects were recruited from different age groups—30 adults (28-52 years), 30 adolescents (junior and senior high school students), and 30 preadolescents (fifth and sixth grade children). Therefore, it was of interest to examine whether subjects from different age groups would demonstrate different levels of consistency of tempo judgments. To test the effect of age on the consistency, the most appropriate way would be to perform a one-

Table 1a-4

Cell Means for Tempo Judgments from Each Trial at Fast and Slow Initial Tempi Arranged by Musical Example (Bach I and Bach II) and Subject Group



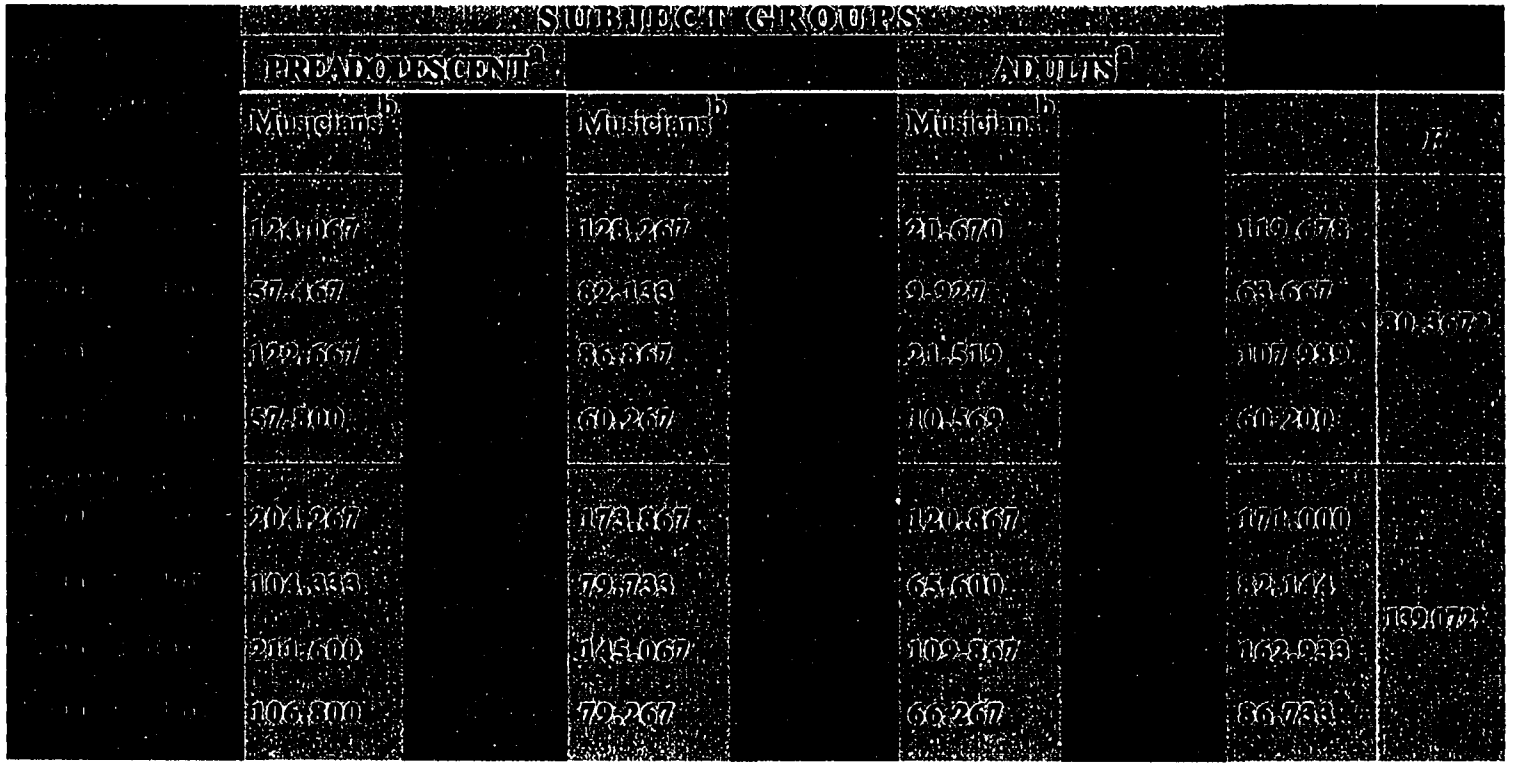
	SUBJECT GROUPS				
	PREADOLESCENTS[a]		ADULTS[a]		
	Musicians[b]	Musicians[b]	Musicians[b]		F
	50.600	55.400	71.133	59.000	
	123.667	112.267	100.733	115.233	
	57.400	67.000	72.067	58.367	91.475*
	126.333	123.467	90.733	113.156	
	153.133	55.400	71.133	153.200	
	61.800	112.267	100.733	93.033	
	149.267	67.000	72.067	147.900	86.271*
	102.667	123.467	90.733	103.611	

Note. N=90. [a]n=30. [b]n=15.

*p < .0001.

Table 1b-4

Cell Means for Tempo Judgments from Each Trial at Fast and Slow Initial Tempi Arranged by Musical Example (Debussy and Lapidakis) and Subject Group



	SUBJECT GROUPS			
	PREADOLESCENT[a]		ADULTS[a]	
	Musicians[b]	Musicians[b]	Musician[b]	
	123.1067	126.2667	20.6670	109.6733
	37.4667	62.1533	9.9267	63.6667
	122.6667	86.8867	20.1519	107.9333
	57.5300	60.2667	10.5569	60.2000
	201.2667	173.8667	120.8667	177.0000
	101.3333	79.5733	65.6600	92.5067
	210.1600	145.0667	109.3667	162.9333
	106.8300	79.2667	66.2667	86.7733

	F
	30.3672
	139.0724

Note. N=90. [a]n=30. [b]n=15.

*$p < .0001$.

Table 1c-4

Cell Means for Tempo Judgments from Each Trial at Fast and Slow Initial Tampi Arranged by Musical Example (Beatles and Greek Dance) and Subject Group

	SUBJECT GROUPS			
	PREADOLESCENTS[b]		ADULTS[b]	
	Musicians[a]	Musicians[b]	Musicians[b]	
	85.533	76.133	76.200	93.933
	126.267	103.067	103.267	120.533
	82.000	91.000	85.667	96.000
	133.267	105.933	96.400	121.133
	110.600	86.133	76.200	93.933
	129.533	103.067	103.267	114.556
	106.800	91.000	85.667	96.600
	124.067	105.933	96.400	133.533

Note. N=90. [a]n=30. [b]n=15.

*$p < .0001$.

way repeated measures analysis of variance (ANOVA) for each listening example using tempo judgments of trials and age as variables. However, the sphericity assumptions for the univariate test for an age effect were clearly violated (p value=0.0000).[2] Therefore, either a repeated measures multivariate analysis of variance (MANOVA) procedure or the adjusted univariate test had to be utilized for each musical example. It should be noted that the multivariate technique determines the linear combination of dependent variables that illustrates the largest statistical difference between the groups under study (Gabriel & Glavin, 1978). Both analyses led to the same conclusion, namely that consistency of tempo judgments across the four trials for all examples were significantly influenced by the age group of the listener ($p < .02$). It is also evident that subjects did not exhibit significant consistency in their judgments across all four trials. Table 2a-4 shows the mean number of tempo judgments of the six listening examples across the trials for each age group.

Furthermore, in order to ascertain which age group exhibited the highest degree of consistency, the individual deviation scores (IDS) averaged over the four trials of each piece were used as an additional measurement of tempo judgment consistency for each

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[2] Test for Sphericity: Mauchly's Criterion = 0.0438711
Chi-square Approximation = 1681.188 with 5 df
Prob > Chi-square = 0.0000

Applied to Orthogonal Components:
Test for Sphericity: Mauchly's Criterion = 0.0803042
Chi-square Approximation = 1356.0996 with 5 df
Prob > Chi-square = 0.0000

musical example. IDS reflects the standard deviation of the four different tempo judgments (Y1, Y2, Y3, and Y4) at the four trials for an individual.[3]

IDS gives a more global sense for the deviations of each group. IDS was used as the primary response variable to answer questions about consistency associated with other factors of interest such as age, musical background, familiarity, and preference. As shown in Table 2b-4, results clearly indicated that adults were the most consistent and preadolescents the most inconsistent with regard to all musical examples ($p < .001$). The following consistency scale for all musical examples was observed with respect to the three age groups: preadolescents < adolescents < adults.

Research Question 3:

The Variable of Musical Background

Another question of interest was whether the consistency of tempo judgments was affected by the musical background of the listeners. Therefore, subjects were selected on the basis of musical training: within each age group, half the subjects were musicians, half were non-musicians. To examine the effect of musical background, a repeated measures multivariate analysis of variance (MANOVA) for each musical example was employed using tempo judgments of each trial and musical background as variables. The reason that

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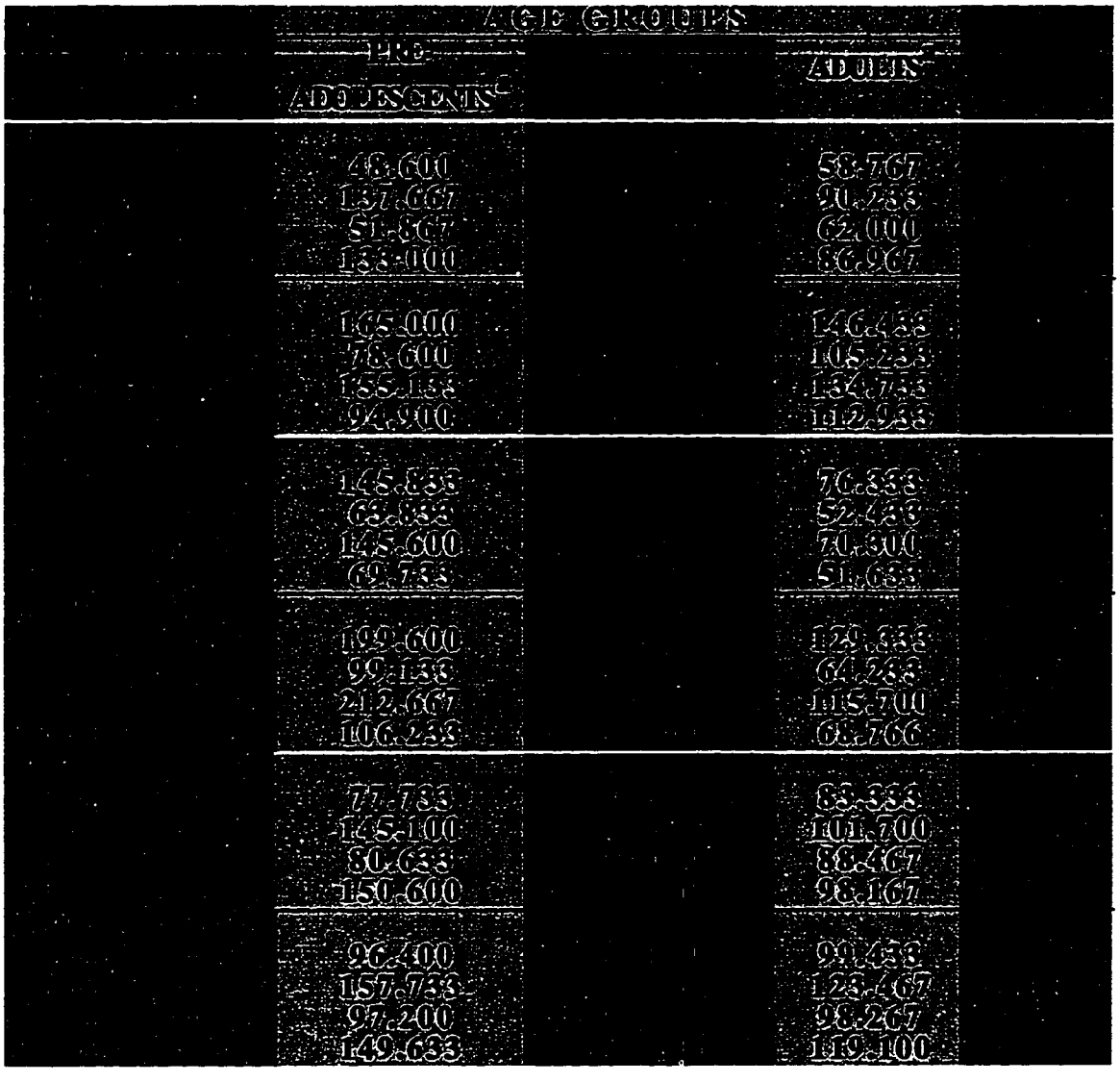
[3] $$\text{IDS} = \frac{\sqrt{(Y1 - Yavg)^2 + (Y2 - Yavg)^2 + (Y3 - Yavg)^2 + (Y4 - Yavg)^2}}{4 - 1}$$

Where

$$Yavg = \frac{Y1 + Y2 + Y3 + Y4}{4}$$

Table 2a-4

Cell Means for Tempo Judgments from each Trial and F ratio from MANOVA Procedure Arranged by Musical Example and Subjects' Age Group



	AGE GROUPS	
	PRE-ADOLESCENTS	ADULTS
	48.600	58.767
	137.667	90.233
	51.867	62.000
	138.000	86.967
	165.000	146.433
	78.600	105.233
	155.133	134.733
	94.900	112.933
	145.833	76.333
	68.833	52.433
	145.600	70.300
	69.733	51.633
	199.600	129.333
	99.133	64.233
	212.667	115.700
	106.233	68.766
	77.733	88.333
	145.100	101.700
	80.633	88.467
	150.600	98.167
	96.400	99.433
	157.733	128.467
	97.200	98.267
	149.633	119.100

Note. N=90. [a]*n=30*

*$p < .02$.

Table 2b-4

Cell Means for Individual Deviation Scores (IDS) Averaged over the Four Trials Arranged by Musical Example and Subjects' Age Groups from ANOVA Procedure

	AGE GROUPS			
	PRE-ADOLESCENTS[a]		ADULTS	
	M	*SD*	*M*	*SD*
	51.168	35.200	18.592	23.733
	49.654	26.975	22.769	23.676
	48.962	23.330	15.511	20.484
	64.351	28.047	37.551	30.765
	48.466	21.085	11.094	17.947
	41.404	26.969	14.613	18.628

Note. N=90. [a] n =30.
P < .001.

the regular repeated measures univariate analysis of variance (ANOVA) was not performed was that data did not exhibit sphericity. Results showed that the musical background of the listener did not significantly affect consistency of tempo judgments for all six pieces, with the exception of the Debussy composition (p <.01). Table 3a-4 presents the tempo judgment means from the four trials both for musicians and non-musicians.

To investigate whether musicians were more consistent than non-musicians, an independent samples t-test was performed which used IDSs among the trials of each piece as an additional measurement of tempo judgment consistency (see Table 3b-4). Results clearly indicated that the only piece for which musicians and non-musicians differed in consistency of tempo judgments was the Debussy (p < .01).

Research Question 4:

The Variable of Musical Style

The musical examples selected in the study represented the following five musical styles: Baroque (Bach I and Bach II), Impressionistic (Debussy), contemporary (Lapidakis), Rock ballad (Beatles), and dance music (Greek dance). Thus, it was of interest to answer the research question which deals with the effect of the musical style of the listening examples on the consistency of judgments that listeners would render with regard to their most appropriate tempo across the four trials. In order to answer this research question, a repeated measures ANOVA procedure using style as the experimental factor (five levels corresponding to the five different musical styles of the pieces) and the mean number of IDS averaged over the four trials of each style as the response variable was performed. As shown in Table 4-4, results revealed that the rock ballad style exhibited the highest degree of consistency followed by the styles of Greek dance music, Impressionism, and Baroque, respectively. The tempo judgments for the contemporary piece were the least consistent among all styles. In other words, the following consistency scale with respect to the musical styles was observed in subjects' tempo judgments: Rock ballad > Greek dance music > Impressionism > Baroque > Contemporary.

Research Question 5a:

The Variable of Familiarity with Musical Examples

To provide an answer to the fifth research question which dealt with the effect of subjects' familiarity with the musical examples on the consistency of their tempo judgments, all subjects were asked to rank their familiarity with each piece on a scale of five levels, based on the times they had heard the musical examples prior to the first trial

Table 3a-4

Cell Means for Tempo Judgments from each Trial Arranged by Musical Example and Subjects' Musical Background (e.g., musicians and non-musicians) from MANOVA Procedure

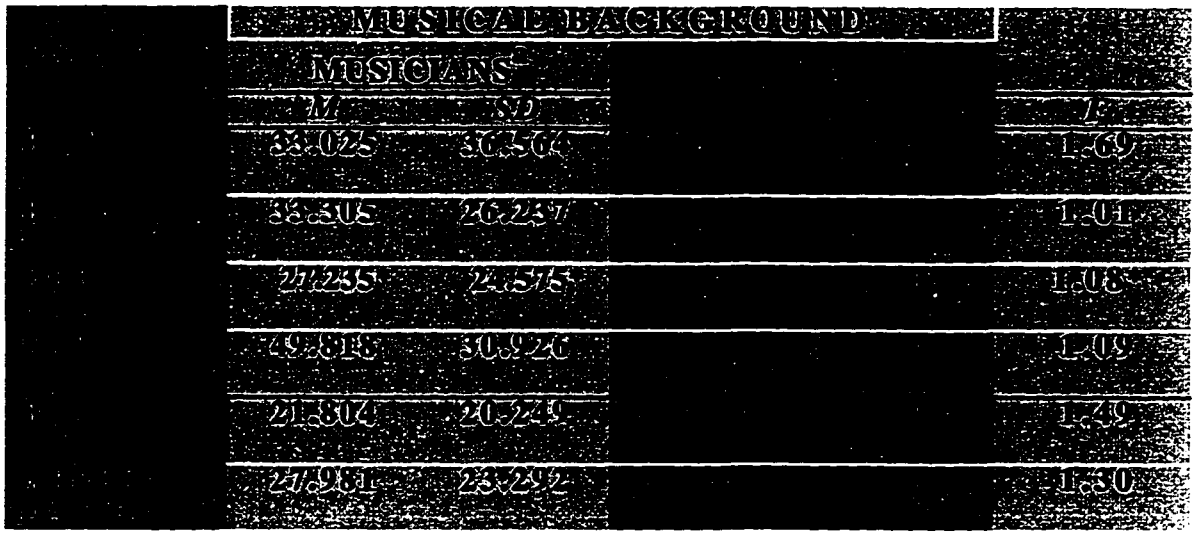
	MUSICAL BACKGROUND					
	MUSICIANS					
	59.064					0.794
	116.889					
	65.489					
	113.511					
	155.067					0.728
	98.311					
	145.844					
	107.333					
	102.156					4.000*
	62.000					
	88.200					
	54.689					
	166.333					0.732
	83.222					
	155.511					
	84.111					
	82.622					0.475
	114.400					
	86.222					
	115.200					
	99.067					0.973
	140.867					
	99.600					
	134.711					

Note. N=90. [a] n=45.

*$p < .01$.

Table 3b-4

Cell Means for Individual Deviation Scores (IDS) Averaged over the Four Trials Arranged by Musical Example and Subjects' Musical Background (e.g., musicians and non-musicians) and F ratio from an Independent Samples T-test Procedure



	MUSICAL BACKGROUND		
	MUSICIANS		
	M	*SD*	*F*
	38.025	36.504	1.69
	38.305	26.257	1.01
	27.235	22.575	1.08
	49.818	30.926	1.09
	21.804	20.249	1.49
	27.981	23.292	1.30

Note. N=90. [a]n=45.

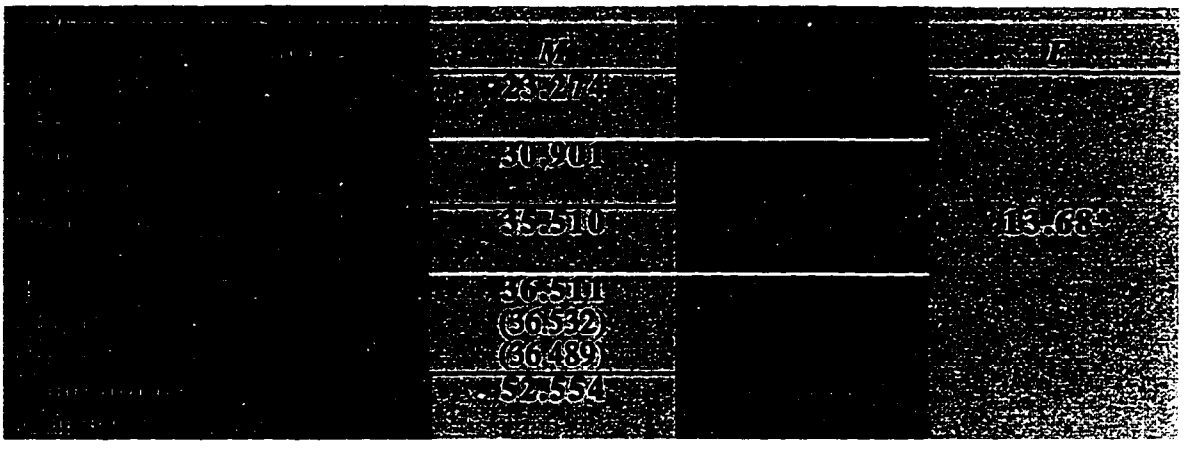
*p < .01.

(e.g., familiarity level 1 = *Never*, 2 = *Once*, 3 = *2 to 5 times*, 4 = *6 to 10 times*, and 5 = *more than 10 times*). A repeated measures MANOVA was performed using tempo judgments for each example averaged over the four trials and the 5 familiarity levels as variables. Results indicated that familiarity with musical examples significantly influenced tempo judgments (p < .001).

In order to investigate the effect of familiarity level on tempo judgments for each musical example, a subsequent repeated measures ANOVA was performed using familiarity levels as the experimental factor and the mean number of IDSs averaged over the four trials of the musical example as the response variable. As Table 5a-4 shows, an

Table 4-4

Cell Means for Individual Deviation Scores (IDS) Averaged over the Four Trials Arranged by Musical Style



Note. Each style is represented by one musical example, except of Baroque style which is represented by two musical examples (e.g., Bach I and Bach II).

N= 90.

*p < .0001.

increase of familiarity had a significant effect on consistency of tempo judgments for all musical examples ($p < .05$). Concerning the Lapidakis composition, the familiarity effect could not be estimated, since there was only one level of familiarity among all subjects (e.g., familiarity level = 1).

Research Question 5b:

The Variable of Familiarity with Musical Styles

In order to answer the question whether familiarity with the musical styles that the listening examples represented had an effect on subjects' consistency of tempo judgments, all subjects had to rank their familiarity with each style on a scale of three levels (e.g.,

familiarity level 1 = *I just do not know this style at all*; 2 = *I have heard music of this style, but not very often*; and 3 = *I really know this style of music.* A repeated measures ANOVA was employed using IDSs after averaging over trials and familiarity levels as variables. Results showed that an increase of familiarity with the style of the musical examples resulted in an increase of tempo judgment consistency ($p < .0001$).

With respect to each individual style, the ANOVA tests of significance demonstrated that increased familiarity with the styles of Baroque, Impressionism, Rock ballad, and Greek dance music significantly influenced the degree of consistency of tempo judgments for the particular examples that represented these styles ($p < .0001$). However, greater familiarity with the contemporary idiom did not lead into more consistent choices of most appropriate tempo for the Lapidakis composition (Table 5b-4).

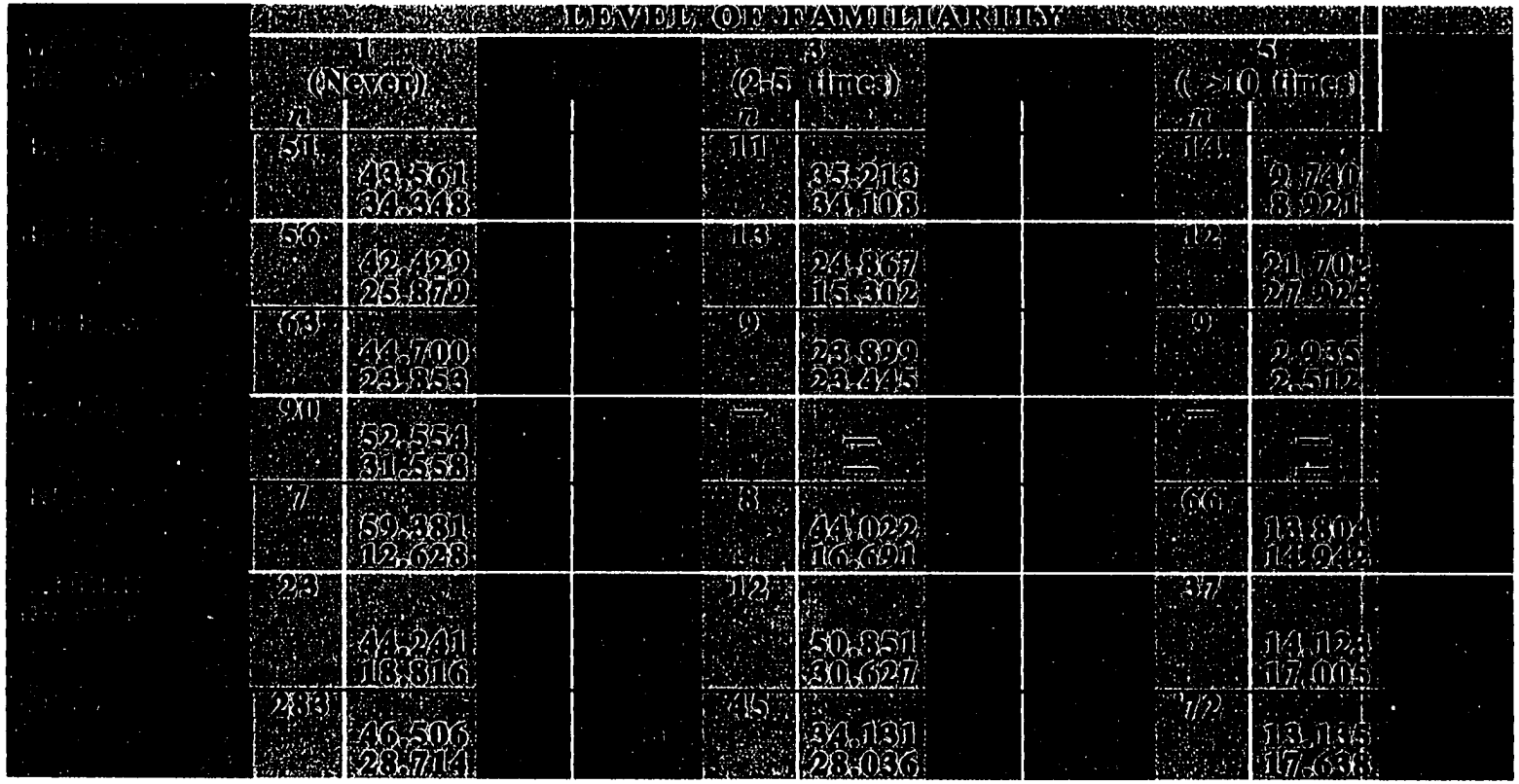
Research Question 6:
The Variable of Preference

To investigate the last research question concerning the effect of preference for the individual listening examples on consistency of tempo judgments, all subjects were asked to rank their preference for each example on a scale of four levels (e.g., preference level 1 = *Poor*, 2 = *Good*, 3 = *Very good*, and 4 = *Excellent*). A repeated measures MANOVA was employed using tempo judgments averaged over the four trials and preference levels as variables. Results revealed that tempo judgments were significantly affected by subjects preference for the musical examples ($p < .05$).

To further analyze these results, a repeated measures ANOVA procedure was performed using preference levels as the experimental factor and the mean number of IDSs averaged over the four trials of each example as the response variable. As shown in Table 6-4, there was a significant influence of the degree of preference on consistency ($p < .001$),

Table 5a-4

Cell Means for Individual Deviation Scores (IDS) Averaged over the Four Trials Arranged by Musical Example and Level of Familiarity Reflected in Number of Times of Previous Listenings from ANOVA Procedure



	LEVEL OF FAMILIARITY					
	1 (Never)		3 (2-5 times)		5 (>10 times)	
	n		*n*		*n*	
1	51	43.561 34.343	111	35.216 34.108	114	2.740 8.921
2	56	42.429 25.879	13	24.867 15.302	12	21.702 27.925
3	63	44.700 23.853	9	23.899 23.445	9	2.935 2.512
4	90	52.554 31.563	—	— —	—	— —
5	7	59.381 12.628	8	44.022 16.691	66	13.804 14.942
6	23	44.241 18.816	12	50.851 30.627	37	14.123 17.005
Total	288	46.506 28.714	45	34.131 28.036	172	13.165 17.638

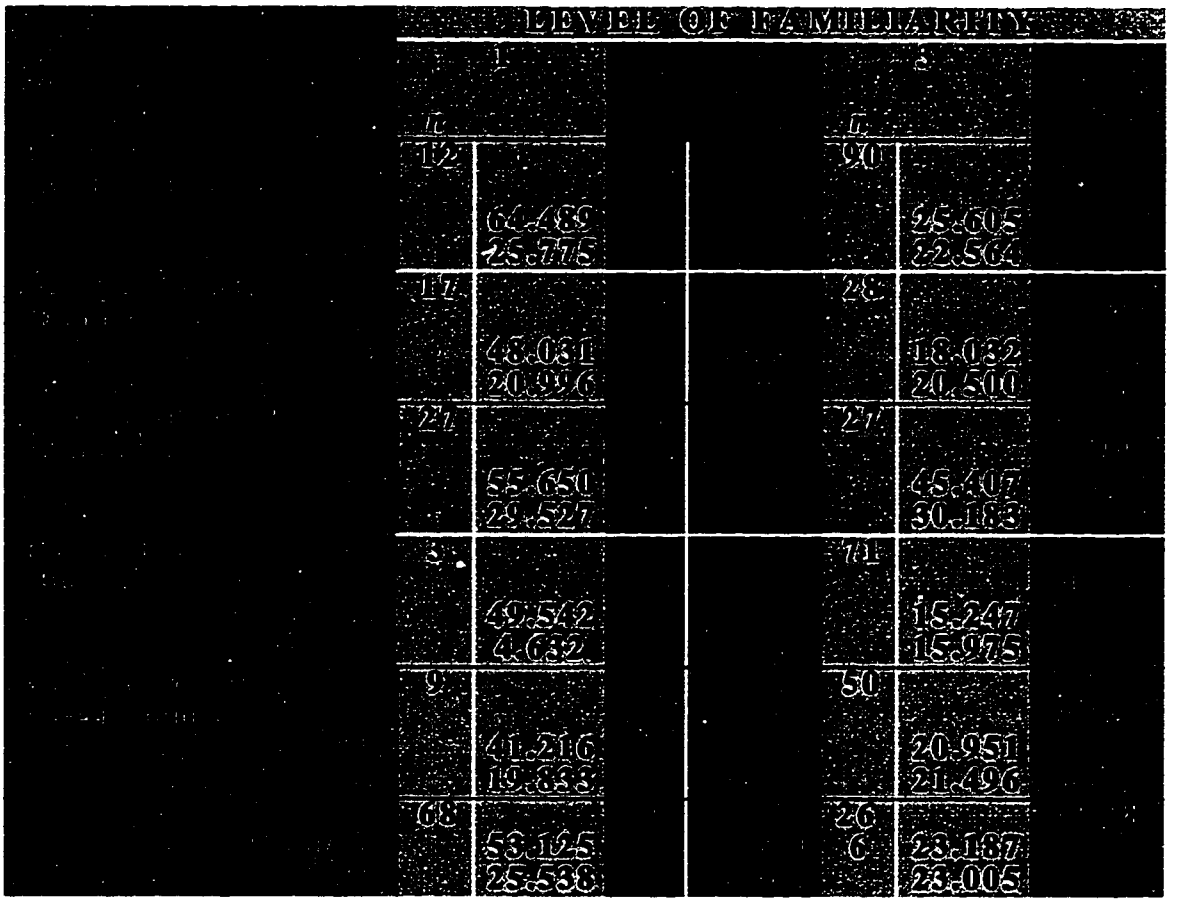
Note. *n*=number of subjects out of 90 in each familiarity level.

*$P < .05$.

for three of the pieces (Bach I, Bach II, and Debussy). But with regard to Greek dance, Lapidakis, and the Beatles consistency did not increase with preference.

Table 5b-4

Cell Means for Individual Deviation Scores (IDS) Averaged over the Four Trials Arranged by Musical Style and Level of Familiarity with each Particular Style



Note. Familiarity level 1 = *I just do not know this style at all.* 2 = *I have heard music of this style, but not very often.* 3 = *I really know this style of music.*

n=number of subjects out of 90 in each familiarity level.

*$P < .0001$.

Table 6-4

Cell Means for Individual Deviation Scores (IDS) Averaged over the Four Trials Arranged by Musical Example and Level of Preference for Each Example from ANOVA Procedure

	LEVEL OF PREFERENCE					
	1		3			
	n		*n*		*F*	
51	20.680		48	41.420 34.825	6.07*	
4	59.022 35.196		35	35.952 22.071	9.20*	
117	57.634 20.232		23	40.581 23.977	15.58*	
25	68.903 28.435		19	45.618 35.713	2.29	
—	—		30	21.485 25.161	0.28	
2	28.623 32.537		30	30.472 23.424	0.001	

Note. Preference level 4 = *Excellent*; 3 = *Very good*. 2 = *Good*. 1 = *Poor*.

n=number of subjects out of 90 in each familiarity level.

*$P < .001$.

Discussion of Results

In this last section, I discuss the various effects on consistency of tempo judgments, in the order they are posed in the research questions, both with specific reference to the results reported above, and with general reference to understanding the mental processes involved in tempo perception.

Consistency of Tempo Judgments

Past research has shown some evidence of consistent tempo judgments in listening tasks, especially in terms of quite familiar—often, popular—music. What is not clear from this work is just how consistent tempo judgments might be over a period of time with compositions taken from diverse musical styles representing a wide range of familiarity and preference, especially if the subjects were drawn from a population of different age groups and musical backgrounds.

Moreover, the listening task that subjects had to perform across four separate trials, over an extended period of time, consisted of the manipulation of tempo until they selected the most appropriate tempo for the musical examples. It appeared essential for this experimental research to employ an interesting and enlightening way for the listener to actively explore tempo while examining the influence of tempo on music in isolation. It was possible to study listeners' tempo perception thanks to a highly controllable digital test apparatus which enabled manipulation of tempo in real time without change of other expressive musical parameters, such as pitch, dynamics, and others. This was important for the design of the study, since it utilized real musical examples.

It is tempting to assume that judgments under such conditions would be relatively consistent in the face of simple changes in initial tempi, explained in large part by the way

coding systems might work in the "deep structure" of mental representation. This study provides little evidence to support a claim for such a belief. It is quite clear that when tempo is judged in repeated listening tasks of the same compositions, initial tempo has a strong effect on correct tempo judgments. On the one hand, these results support the observations reported by Lapidaki & Webster (1991) with regard to the importance of initial tempo on tempo judgment consistency in repeated listening tasks. On the other hand, the results do not support the research by Levitin & Cook (in press), Halpern (1988), Hodgson (1951), Lund (1939), and Farnsworth et. al. (1934) that there is one tempo consistently associated with particular listening examples. Yet, the above mentioned studies are far from clear about how this conclusion would apply in repeated listenings to the same examples over a long period of time.

Absolute Tempo

A closer look at the range separating the fastest from the slowest tempo judgments of individual subjects for each piece often revealed strikingly small discrepancies. The question becomes, then, how great these discrepancies are, and whether they are perceptible. It was reasoned that the range between the slowest (T1) and the fastest (T2) tempo judgments reflects the degree of consistency among individual tempo judgments across all four trials. Thus, if the difference between T1 and T2 is virtually imperceptible, then the four tempo judgments are considered consistent. Ideally, T1 and T2 should be in exact 1:1 ratio to be considered consistent. If this was not the case, the following formula (Epstein, 1995, p. 519) was used that expresses by what percentage of time T1 and T2 can deviate from the 1:1 ratio and still be regarded as consistent:

$$\Delta = \frac{(r \times T1) - T2}{T2'} = 1 - \frac{T1}{T2}$$

Where

T1 = beat duration of T1 (e.g., longest beat duration)

T2 = beat duration of T2 (e.g., shortest beat duration)

T2'= beat duration of ideal T2 (which should be in exact 1:1 ratio to T1—that is, equal to T1)

Δ = the percentage by which the actual T2 varies from T1 (or the ideal T2) [4]

r = ideal ratio 1:1 (or its decimal equivalent 1.0)

It should be noted that all calculations utilized the real-time version (e.g., duration of beat in seconds) of metronome markings (M.M.= beats per minute) [5]. According to Epstein (1995, p. 519), the practical import for converting metronome markings to real time beat durations is that their relation is direct rather than inverse, as is the case with metronome indications

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[4] The difference between the actual T2 and the ideal T2 is called the "just noticeable difference" (JND) or the "differential threshold" in psychophysical research of time.

[5] Formula for convering metronome markings (M.M.) to real time in seconds:

$$\text{Beat duration (secs)} = \frac{60 \text{ [sec/min]}}{\text{M.M.}}$$

For example:

	Metronome marking [beats per min.]	**Real-time version [beat duration in secs.]**
Tempo judgment 1 (T1)	30	2.0
Tempo judgment 2 (T2)	120	0.5
Relationship T1/T2	30/120=1/4	2.0/0.5=4/1

In assessing whether Δ is perceptually negligible, a tolerance level has been set at five percent, commonly known as the "Weber fraction." Percentages or deviations which are equal or below 0.05 should imply "good" individual tempo consistency. To be sure, the use of T1 (the tempo with the shorter beat duration) instead of T2 (the tempo with the longer beat duration) as the base tempo is arbitrary. However, a number of studies in psychophysics of time also use the shorter duration as the base time period (Hirsh, Monahan, Grant, & Singh, 1990; Macar, 1985; Halpern & Darwin, 1982; J. G. Thompson, Schiffman, & Bobko, 1976).

One must keep in mind that the Weber fraction seems extremely strict when applied to real musical stimuli of considerable density and duration such as those in this study. Therefore, I used the Weber fraction merely as a measure of individual ranges of tempo judgments, since no other criterion appeared to apply in this case, for the time being. "In its absence, we must use the available criterion of the Weber fraction for whatever degree of measurement and precision it can provide" (p. 521), proposed Epstein (1995) referring to his research on "proportional tempi" of the same motives in one movement or among various movements of a composition.

It should be noted, however, that the Weber fraction has not been further employed in the analysis of data. Instead, individual deviation scores (IDS) was the primary response variable used to answer questions about consistency's association with other variables of interest, such as age, musical background, familiarity, and preference. The main reason for this decision was that the Weber fraction, on the one hand, utilizes only two pieces of information (the slowest and the fastest judgments) across four trials. This may result in what statisticians call "lack of efficiency". On the other hand, IDS gives a more global

sense of the deviations by taking into account all four tempo judgments rendered by subjects across trials.

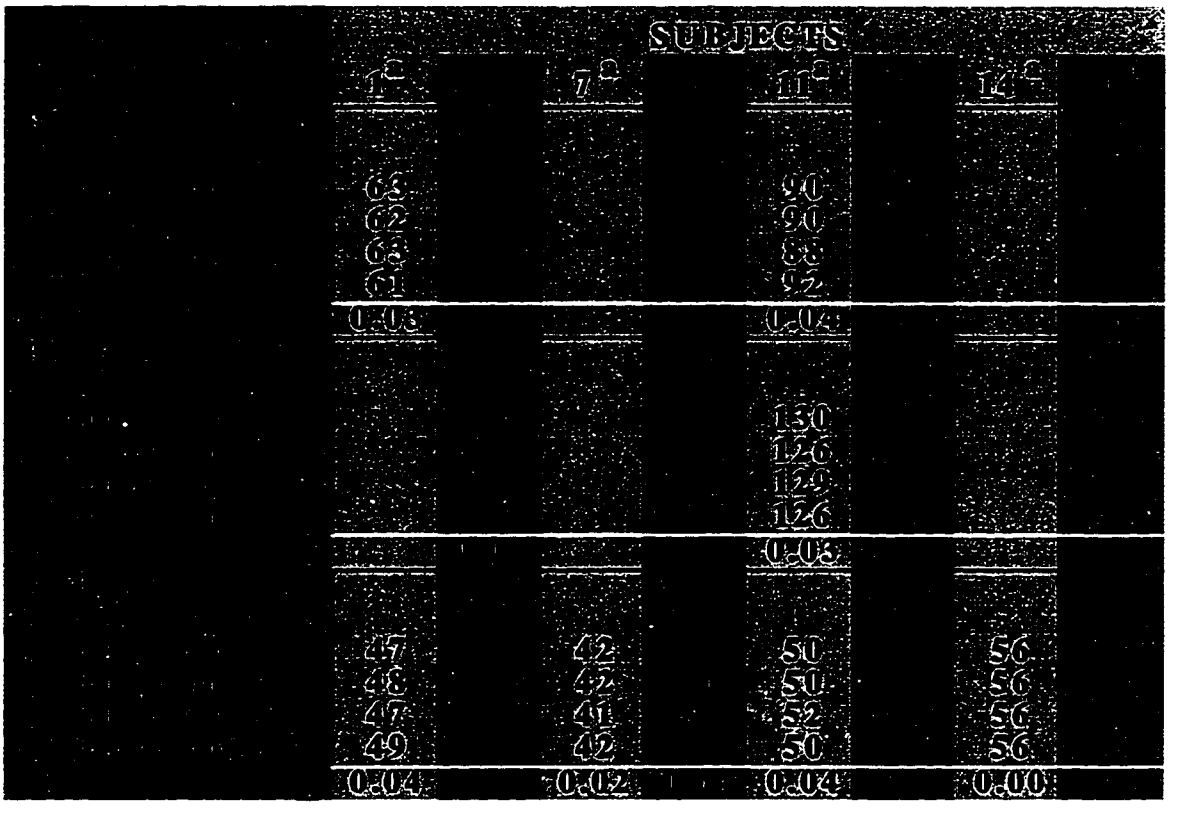
Tables 7a-4 and 7b-4 show the most appropriate tempo judgments of individual subjects who exhibited extraordinary small ranges between the fastest and the slowest tempo judgments. Table 7a-4 demonstrates their tempo judgments for Bach I, Bach II, and Debussy. Table 7b-4 presents their tempo judgments for Lapidakis, Beatles, and the Greek Dance. These have been selected according to the ratios of the fastest against the slowest judgments for each musical example that represent percentages below perceptible limits as determined by the criterion of the Weber fraction. These percentages are found in the row— designated as Δ—below the tempo judgments of each musical example.

It becomes clear that these consistent individual responses do not represent the larger spectrum of listeners selected for this study who were affected by the initial tempo in their tempo judgments. Therefore, these 'consistent' subjects should be regarded as isolated cases that allow only tentative conclusions. It appears that a relatively small number of listeners (e.g. adult musicians and non-musicians) possess an exceptional ability with respect to acute stability of large-scale timing in music. This ability to give over time consistent tempo judgments to a piece of music in conditions seemingly devoid of an external tempo reference (a score or the body interaction involved in performance) may be referred to as "absolute tempo," analogous to "absolute pitch."

It must be also noted that "absolute tempo" has been observed with musical examples that were thoroughly known by the subjects. Nevertheless, this finding should be treated with caution, since these subjects did not exhibit "absolute tempo" with respect to all pieces for which they had the same level of familiarity. Contrary to absolute pitch, one

Table 7a-4

Subjects with the Most Consistent Right Tempo Judgments for Bach I, Bach II, and Debussy, and their Δ, according to the Weber fraction

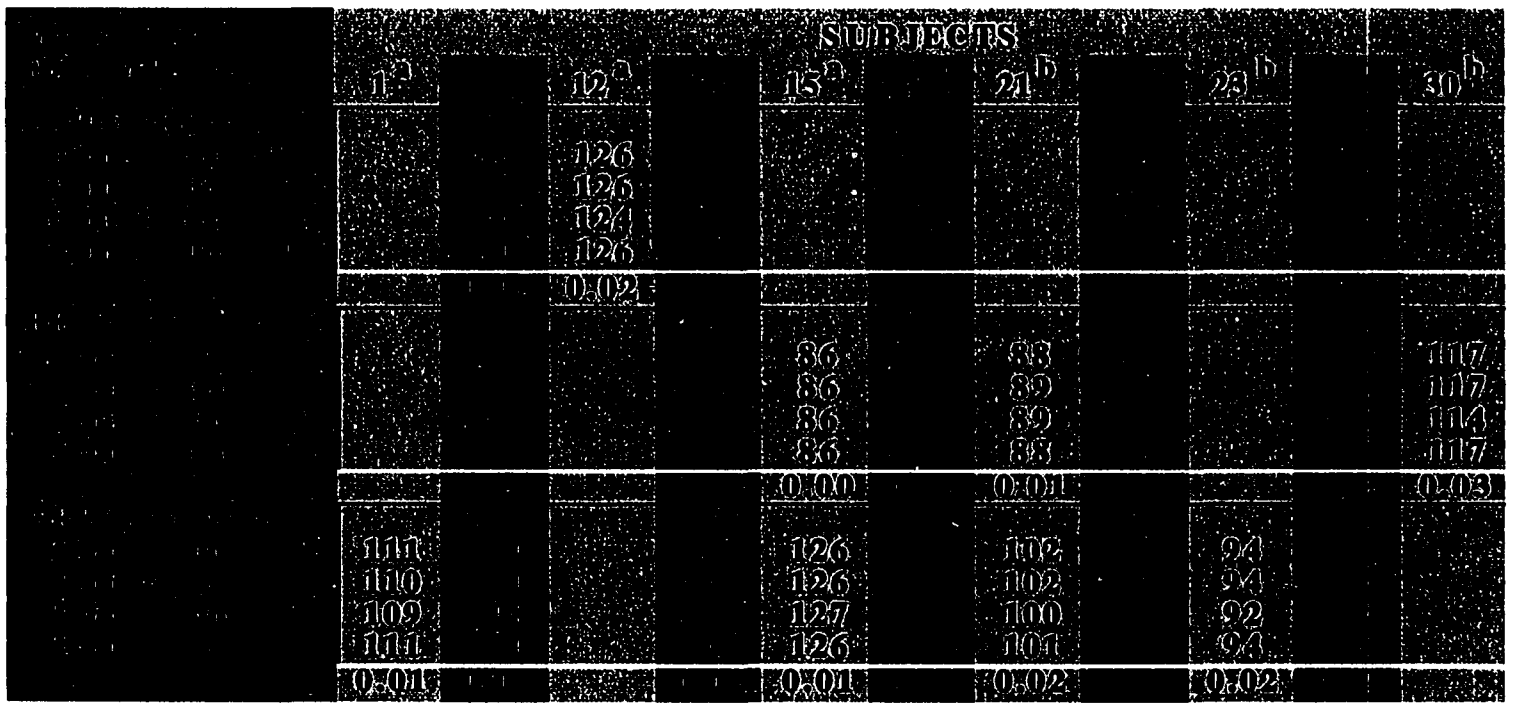


Note. Values represent beats per minute, usually referenced as the metronome marking (M.M.). Δ illustrates ratios between the fastest and slowest tempo judgments (converted in their real-time version) below perceptible limits as determined by the criterion of the Weber fraction.

[a] Adult musician. [b] Adult non-musician.

Table 7b-4

Subjects with the Most Consistent Right Tempo Judgments for Lapidakis, Beatles, and Greek Dance, and their Δ According to the Weber Fraction



Note. Values represent beats per minute (M.M.). Δ illustrates ratios between the fastest and slowest tempo judgments (converted in their real-time version) below perceptible limits as determined by the criterion of the Weber fraction.

[a] Adult musician. [b] Adult non-musician.

might suppose with respect to "absolute tempo" that the same person seems to follow different cognitive strategies of timing for each individual piece, which leaves one wondering whether the stability in viewpoint is to some extent discrete rather than continuous.

Interestingly enough, these subjects reported that they were surprised when they heard that their right tempo choices were virtually identical across trials. Thus, it would seem that physical, psychological, and environmental factors, such as, fatigue, mood or time of day, did not have an effect on their tempo judgments. One reason might be that music engages and programs psychobiological clocks or neural oscillations (Goody, 1977; Epstein, 1985; Clynes, 1986; Pöppel, 1990) which function subconsciously but give conscious read-outs and thereby guide the listeners' choice of right tempo in an exact and stable manner.

In addition, the assumption that consistent tempo judgments occur subconsciously or intuitively is supported by the notion of "implicit cognition" that has been the subject of increasing interest and debate in the most recent psychological research (Dorfman, Shames & Kihlstrom, 1996, p. 259; Underwood & Bright, 1996). The term implicit cognition has been used to characterize situations in which mental processes can influence perception outside of phenomenal awareness and voluntary control. For example, implicit cognition can refer to a subject's behavior that is shown to be influenced by stimulus events such as tempo changes that are too subtle to be consciously perceived (Lapidaki, 1990). With regards to consistency of right tempo judgments, I agree with Epstein (1995) who summarized this position as follows: "Ultimately decisions about rightful tempo rest upon intuition. Intuition is not absolute, however: it, too, can modify, our perception of music enriched by concepts structural, affective, historical, neural" (p. 107).

Findings of a high degree of tempo consistency observed in some subjects of this study seem to be closer to the high stability of timing reported by Clynes (1969) when he compared the total durations of three studio performances of Brahms' *Haydn Variations* conducted by Toscanini in 1935, 1938, and 1948. It is noteworthy that the total playing time of those performances were practically identical. Similarly, Clynes & Walker (1986) observed the same stability in repeated public performances of the Sidney String Quartet covering a period from 1975 to 1979. This finding is consistent with timings of numerous live performances measured by Winckel (1962) and Wagner (1974). Moreover, total durations of two recordings of Bach's *Goldberg Variations* played by Glenn Gould (1982) as much as 26 years apart also showed an extraordinary large-scale stability greater even than that of individual sections of the composition.

In summary, the above mentioned authors concluded that this precise stability of timing in performance provides evidence that thoroughly known pieces appear to exist in the mind of some performers as an entity with a precise temporal size or a rigorous pulse that may destroy the expressive quality of music if violated. Nonetheless, it must be noted that the ability of stable and precise large-scale timing is "atypical of the large community of performers," as Epstein (1995, p. 502) points out.

The Variable of Age

The majority of empirical studies of temporal perception in music has been carried out on adults (Levitin & Cook, in press; Halpern, 1988; Hodgson, 195; Lund, 1939; Farnsworth et. al., 1934). However, there is general agreement that the experience of musical time is not separable from characteristics of subjects such as their age or developmental level (Petzold, 1966; Thackray, 1972; Shuter-Dyson & Gabriel, 1981; Bamberger, 1994; Zenatti, 1993). Despite the presumed role of age, few researchers have

evaluated this presumption regarding tempo. To counter this deficiency, it has proved necessary to investigate the following question: Is the capacity for consistent tempo judgments for particular pieces of music over a period of time affected by the age of listeners (e.g., preadolescents (10-12 years), adolescents (16-18 years), and adults (28-52 years)?

First, the findings indicate that all subjects, independently of age, were significantly affected by the initial tempo with respect to the consistency of their tempo judgments. Taken together with previously reported studies (Petzold, 1963; Davidson, McKernon & Gardner, 1981; Shuter-Dyson & Gabriel, 1981; Imberty, 1982; Dowling, 1982), this finding is consistent with the notion that after the age of 6 or so children begin to perceive music in ways notably similar to adults.

However, of further interest is the evidence that the degree of consistency in tempo judgments tends to gradually increase from preadolescence through adulthood. A statistically significant difference exists between the tempo consistency of preadolescents and adolescents and between adolescents and adults. Thus, the following consistency scale for all musical examples becomes apparent: preadolescents < adolescents < adults.

Trying to reach an understanding of these developmental trends in listening tasks, we need to reflect that consistency of tempo judgments and the development of tempo awareness are intimately interwoven. In other words, as awareness of tempo is attained with age, it seems that the ability for consistent tempo judgments improves.

Listeners between age 10 and 12 seem to be limited to an awareness of tempo, which does not appear to reflect simultaneous perceptual organization and integration of other relevant features of musical stimuli, such as harmonic, rhythmic, and metric relationships. Therefore, they are experimenting with their choices of most appropriate

tempo for the musical examples with greater flexibility and ease. As a result, children at this age show wide fluctuations among their right tempo judgments of the same piece, and thus low consistency over time.

However, tempo awareness does not seem to cease developing after the age of 10. What appears clear from the responses of the adolescent subjects is that a more musically integrated tempo awareness has been established by this maturation level, which is not yet completely developed. Thereby, the fluctuations among tempo judgments become smaller and the stability greater.

Finally, by adulthood, tempo awareness is rather finely detailed in most cases, and the ability for consistent judgments is greater. Only adult subjects who rendered extraordinary small ranges between their fastest and slowest tempo judgments are only adults. Generally, this implies that adult listeners have a relatively more definite mental representation of the tempo of the musical examples than the adolescent listeners. This allows them to perceptually organize more and more relevant features of an example into a coherent and stable structure. Thus, one might conclude that only when the representation of music has stabilized in the mind through maturation, is the corresponding temporal stability noticeable (Clyne & Walker, 1986).

Finally, findings from this study with respect to developmental trends in tempo awareness do not concur with the notion that the growth of tempo perceptual ability does not improve dramatically beyond approximately the age of seven (e.g., Petzold, 1969; Thackray, 1972; Kuhn & Gates, 1975). An exception to this seemingly general consensus is Dorhout's study (1979/1980), who concluded that tempo perceptual ability significantly develops from the fourth through the twelveth grade level (ages 9-17). Nonetheless, these studies primarily dealt with the competence to maintain a steady beat or the identification of

identical tempi in sounds similar to those of a metronome. At present we know of no other studies that examine tempo perception employing such a wide range of age levels, as does the current study.

The Variable of Musical Background

In general, the capability to perceive different musical parameters, such as tonality, harmony, form, and rhythm, without necessarily being able to identify and analyze them, is considered to be the outgrowth of implicit musical knowledge or acculturation (Hargreaves, 1986; Francès, 1958/1988; Bigand, 1993). In this situation what listeners know is not something they are aware of knowing, but rather it is acquired from knowledge that is implicitly or subconsciously built into their auditory systems through common everyday exposure to music in their cultural environment. There is general agreement among researchers, on the other hand, that this knowledge becomes explicit or conscious only after musical training (Dowling, 1993). In essence, musicians presumably possess a fuller understanding and appreciation of a piece of music, due in part to their possession of a sophisticated scheme or set of rules for encoding its musical events in terms of musical meanings and, thus, to assign to it a stable structural description (Sloboda, 1994; Dowling, 1994; Wolpert, 1990; Lerdahl & Jackendoff, 1983).

This research led me to hypothesize that that music education may have some bearing on consistency of tempo judgments. However, this study revealed no overall, statistically significant results to support this contention. The implicit assumption of this conclusion is that the ability for consistent tempo judgments in listening tasks is probably a maturational one that is independent of music education. In other words, the musician's grasp of tempo seems initially very much like the non-musician's. Thinking along these lines, Davidson (1994) noted:

> Suprisingly, when deprived of the advantage of their instruments, these young talented musicians look like non-musicians. This, in turn, strongly suggests that instrumental training by itself does not guarantee a grasp of musical relationships, and that musical thinking in these cases is constrained to the use of the instrument (p. 128).

Similarly, referring to the neural bases of melodic and temporal functions, Peretz (1993) pointed out:

> Indeed, there is no reason to think that in terms of relatively basic musical activities, musicians behave differently from non-musicians.... Moreover, there is currently no evidence, at the level of functional analysis considered here, suggesting that musical education exerts an influence on cerebral organization (p. 213).

As far as previous research on tempo is concerned, findings are contradictory with respect to the relationship between tempo perception and musical experience. On the one hand, Dorhout (1979/1980), Yarbrough (1987), and Ellis (1991) concluded that musicians generally seem to be more accurate in discriminating tempo changes than non-musicians. On the other hand, studies by Kuhn (1974), Kuhn & Gates (1975), Wang (1983), Wapnick (1980), and Madsen (1979) found that the amount of musical experience does not relate to perception of tempo changes.

Yet it is of interest that the following tendency has been observed, although it is not statistically significant: musically experienced preadolescents (nearly everyone learning an instrument or taking music lessons) showed somewhat smaller fluctuations in their tempo judgments across trials than preadolescents with limited musical education. Moreover, the same trend occurred in every age group between musically experienced and inexperienced subjects.

While it may be quite reasonable to say that an increase of consistency is probably evidence of musical acculturation, it is not necessarily true at high levels. Indeed, adult musicians showed the smallest fluctuations in their tempo judgments and, thus, the highest

degree of consistency. In addition, the majority of subjects who exhibited the ability of "absolute tempo" also derived from the sample of adult musicians.

The only time musicians and non-musicians of all age groups significantly differed in consistency of most appropriate tempo judgments was with regard to *Clair de Lune* by Claude Debussy. A possible explanation for this finding is that this particular piece is the only case among the musical examples that is built upon different rhythmic, melodic, and harmonic densities, while its basically steady pulse serves as a unifying agent. We experience a slow overall tempo (Andante très expressif) and rapid movements within this slow tempo at the same time. Thus tempo becomes a function not only of the beat rate but also of the number of unfolding events per unit of time.

On the face of it, it is assumed that musically trained listeners seem to make a more conscious effort to select a tempo that encompasses these different densities, such as rhythms which quicken from three eighth notes in a beat in the slow passage that opens the work to six sixteenth notes in the rapid arpeggios, in order to give to the flow of music a meaningful motion that is also physically attainable in performance. Thereby, it becomes apparent that such an integrative cognitive strategy presupposes a fairly stable representation of the large-scale temporal structure that is based on some definite relation of relevant musical parameters. This probably accounts for the fact that the musically trained listeners did not show dramatically wide fluctuations in most appropriate tempo judgments of Debussy's composition across trials.

This assumption is confirmed by the widespread agreement in music cognition that musically trained listeners appear to use more extended time patterns in shaping schemes that control and integrate local-level temporal relationships into the large-scale, complex (yet hierarchic), and coherent structure of a piece of music (Shaffer & Todd, 1994;

Gabrielsson, 1993; Sloboda, 1994; Lerdahl & Jackendoff, 1983). Indeed, one might say that musical training may increase performance in listening tasks by alerting listeners' perceptual organization of stimuli, especially when the regularity of stable musical patterns breaks down.

Another reason listeners with music education showed smaller fluctuations in their tempo judgment of the Debussy piece than non-musicians is because the former may be said to take into consideration the physical constraints that are imposed on a performer in the execution of tempi. In fact, most musically experienced listeners in this study played an instrument, unlike non-musicians. Tempo preferences by non-musicians not only exhibited wider fluctuations but they were often also very high in speed, often at the limits of human performance. On the other hand, another reason for the particularly slow preferences by the musicians for the Debussy example might be that the example itself (Andante très expressif) was highly familiar to musicians.

The Variable of Musical Style

Another issue this study investigated was whether the stylistic framework in terms of which the specific musical examples were interpreted by listeners influenced tempo consistency. Whereas it is true that a general tendency in familiarity and preference may play an important role in perception, there are interesting aspects to be found in individual innate structural characteristics of the styles that facilitate listeners to extract criteria for determining the right tempo of the particular musical examples. Thus before we looked at personal perceptual factors associated with the listener (e.g., familiarity and preference), we had first to clarify the intrinsic sonic distinctiveness of the examples asdefined by their stylistic context, and see how it affected tempo judgments. As far as the significance of style is concerned, Barry (1990) pointed out:

> It allows us to *adopt relevant criteria* which limit and direct attention onto specific areas—for example, information relevant to a string quartet as distinct from a Mass setting; criteria for Baroque style, or comparing Pergolesi's original music with Stravinsky's reworking in *Pulcinella*. Such criteria are both the signposts bearing directions, and the lenses which focus attention on the work (p. 23, original italics).

Results revealed that consistency covaries with the style of the musical examples. More specifically, the style of the rock ballad exhibited the highest degree of consistency followed by the styles of Greek dance music, Impressionism, and Baroque, respectively. Tempo judgments for the contemporary idiom were the less consistent among all styles. In other words, the following consistency scale with respect to the musical styles was observed in subjects' tempo judgments: Rock ballad > Greek dance music > Impressionism > Baroque > Contemporary.

As we shall see in the discussion below that draws from both experimental data and music analytic interpretations, this scale of consistency in the selection of the right tempo may provide us with a plausible and useful initial description of the temporal, melodic, and harmonic implications of the different styles and genres within which the whole perceptual construction of the experimental stimuli can function. Until much more experimental studies on tempo perception with real musical excerpts have been carried out, it is infeasible to say how unequivocal these implications are, or how many subjects can unfailingly pick them up in a listening task.

First, results clearly indicate that subjects exhibit the highest degree of consistency when selecting the right tempo within the framework of a style which is characterized by consonance between pitch-level and natural temporal grouping/accenting, as is the case of the rock ballad. A possible explanation could be that regularity or consonance in both rhythmic and melodic structure may facilitate tempo perception. In a sense, this contention concurs with a large body of evidence implying that musical consonance in a composition

is easily chunked, encoded, and remembered by listeners in Western musical culture (Monahan, 1993; Zenatti, 1993; Dowling, 1994).

On the other hand, however, the contemporary musical idiom (as reflected in Michalis Lapidakis' *Piano Piece*) is primarily characterized by an ambiguous sense of tonal harmonic and rhythmic structure, due in part to frequent occurrence of non-diatonic pitches and conflicts between melodic and rhythmic patterning. With respect to this stylistic context there was statistically significant evidence of the lowest degree of consistency in judgments of right tempo. This result clearly indicates that in the absence of a continuous "consonant" tonal patterning or progression which should not necessarily suggest complete "randomness or atonality," according to Butler and Brown (1994, p. 206), stability in tempo judgments is strongly minimized. In addition, a number of studies on pitch perception seem to support the notion that a consonant tonal-harmonic framework improves the accuracy of perceptual judgments by listeners (e.g., Monahan, 1993; Bartlett, 1993; Cuddy, 1993; Zenatti, 1993; Francès, 1958/1988).

Moreover, it seems probable that the contemporary idiom in general lends itself more room for a multitude of tempo inflections on the part of the listener, due in part to the discontinuity and non-homogeneity of musical material that often lead to a loss of reference to a regular or fixed pulsation. This stylistic characteristic is described by Pierre Boulez (1976) as follows:

> I saw that it was posible to abolish completely all idea of speed in the real sense of the word, and even all numerical ideas, by piling up obstacles. If one introduces into a structure of fairly simple rhythms accumulations of grace notes that cause the tempo to be interrupted the whole time, one completely loses the idea of speed (p. 69).

As far as the genre of Greek dance music (khasapiko) is concerned, results showed that the mean of individual deviation scores across trials were small, but not as small as in

the case of the rock ballad which had the highest consistency among all styles and genres. These tempo flunctuations across trials, however, cannot be explained in terms of the general belief that the qualitative "feel" of the accent and tempi of dance music are fairly fixed. As Donington (1963) wrote, commenting on the seeming naturalness of tempi of dance movements: "Dance steps can only be performed correctly within narrow margins of speed" (p. 392). Moreover, this result does not support the notion that there is one tempo consistently associated with popular ballroom music (waltz and fox-trot) both in listening and tapping tasks (Farnsworth et al., 1934; Lund, 1939). Presumably, the fact that this genre of Greek dance (in 2/4 meter) is not as melodically typical in the Western musical tradition as are waltz, fox-trot, or other ballroom dances, may have some bearing on the lack of precise consistency in subjects' right tempo judgments.

In the above mentioned statistically significant consistency scale with respect to the effect of style on tempo judgments, the Impressionistic and Baroque styles lie in the middle of the scale. In fact, individual deviation scores across trials for Impressionism as represented by Debussy's *Clair de Lune* are somewhat smaller than those for the Baroque style.

Impressionism is distinguished by the undirectional quality of harmonic textures. Chord progressions seem not to go anywhere, merely functioning as affective impressions with no clear aim. Yet chords are not distant from conventional diatonicism. In addition, the overall sense of pulse underlying this distinct harmonic palette is "basically steady" throughout a section or among sections (Epstein, 1995, p. 329). From a cognitive point of view, one might say that the Impressionistic style seems to suggest that only a small range of tempi would give the flow of music a perceptually acceptable motion.

For example, if the selected tempo is too slow, this would cause local undirectional harmonic events to perceptually disintegrate, and, thus, the flow of music would sound dull and uninteresting. On the other hand, too fast tempi would transform the almost floating quality of these undirectional events (or suggestive impressions) and, thus, change the affective character of music. An effort on the part of listeners to find a perceptually meaningful balance in they way the music should sound—by using the composition's tempo as a point of reference—might be the reason subjects' choices of most appropriate tempo for the Impressionistic style showed smaller fluctuations across trials than for the Baroque style which provides an entirely different context.

Baroque style possesses a coherent and systematic musical grammar that is characterized by an absolute strictness of compositional design. As Cone (1968) wrote:

> In this music, events of the same kind tend to happen either at the same rate of speed, or at precisely geared changes of rate, whether these events are cycles of keys, short-range harmonic progressions, or sequences of melodic motifs. In the best of this music, the contrapuntal texture, either actual or implied, sets up a hierarchy of events, each proceeding at its own rate, yet all under a strict metric control that extends from the entire phrase down to the smallest subdivision of the beat (p. 62).

This hierarchical contrapuntal texture is so masterfully constructed that it does not run the risk of losing its affective quality when interpreted within a large range of tempi. That is, perhaps, one of the reasons that the choice of tempo was left to the performer in the Baroque era (Sachs, 1953, Donington, 1963/1974). Tempi for all 24 preludes and fugues of J. S. Bach's *Well-Tempered Clavier* (Vol.1) from recorded performances by various pianists and hapsichordists also span a wide spectrum (Palmer, 1981; Epstein, 1995). It seems that as long as the contrapuntal relationships are maintained, the values of tempoare not crucial.

This might be the reason that subjects' choices of most appropriate tempo for the Baroque style showed large individual deviation scores across trials. It is interesting, however, that the same degree of deviation was exhibited for both pieces that represented the Baroque style (C-major and A-minor *Two-Part Inventions* by J. S. Bach). This result appears to emphasize that the same stylistic constraints perceptually guide the listener in a similar way in the cognitive process of selecting the right tempo.

Nonetheless, we have to approach these results with caution because this study was not designed to examine the role of tempo in individual musical styles in depth. Moreover, it is an undeniable occurrence of compositional practice that composers often mix different musical styles in a piece. As Clarke (1989) rightly points out:

> Each piece can make use of a substantial number of principles that are specific only to that work, and which are consequently inexplicable or at best explicable only at a very general level in terms of a broad and general structural theory (p. 19).

In summary, the general point is that tempo is not perceived entirely independently of the other parameters of a piece, but rather is part of its integrated sonic structure. If the stylistic constraints of the piece are perceptually too demanding (complex) or unconventional in terms of typical rules in the tonal Western tradition, listeners may not be able to develop a stable mental representation of the musical structure. This results in a corresponding temporal instability. Nevertheless, we should keep in mind that there exists a number of different styles in music, and each of them appears to be perceived psychologically in a different way due to differences among individuals in terms of familiarity and liking.

The Variable of Familiarity

There is statistically significant evidence that an increase of familiarity with the particular musical examples resulted in an increase of consistency of right tempo judgments

for all examples indiscriminately. In other words, it was necessary for an example to be judged highly familiar in order for the judgments of its right tempo to exhibit small deviations across trials.

In light of these results, it seems reasonable to conclude that, on the one hand, familiarity gained from formal or informal exposure to music hightens the ability to form a stable mental representation of music that enables the listener to render fairly stable tempo judgments across trials. On the other hand, novelty yields the opposite results in terms of temporal stability of judgments. One may say that only when the representation of music has stabilized in the mind through familiarization is the corresponding temporal consistency noticeable.

Furthermore, in listening to music, familiarity with a musical style can be of great consequence "... in relating the intent of the music" (Meyer, 1994, p. 56). According to Lerdahl & Jackendoff (1983, p. 3), once a listener "becomes familiar with the idiom, the kind of organization that he attributes to a given piece will not be arbitrary, but will be highly constrained in specific ways." Results showed that an increase of familiarity with all styles in question, except for the contemporary, significantly influenced the degree of consistency of tempo judgments.

Along these lines, it is noteworthy that all individuals who exhibited the above discussed extraordinary ability of "absolute tempo" were thoroughly familiar with either the examples themselves for which they rendered consistent tempo judgments or their musical styles.

It is interesting that greater familiarization with the contemporary idiom did not lead into more consistent choices of most appropriate tempo for the *Piano Piece* by Michalis Lapidakis. The reader should be reminded here that this composition was selected because

it had never been publicly performed before the experiment; as a result, all subjects were unfamiliar with it.

This finding appears to suggest that exposure to or familiarity with the contemporary musical idiom which is not typical of the conventional tonal grammar does not appear to enhance our comprehension of right tempo and the consistency of tempo judgments for contemporary compositions. In this case, tempo consistency seems to depend on familiarity with the particular stimulus pattern that is heard rather than on familiarity with its style. Thus, one could argue that the contemporary idiom does not set up a strong context that facilitates the formation of the concept of right tempo for individual compositions. It is noteworthy, in this regard, that both listeners who rendered absolutely consistent judgments (e.g., "absolute tempo") across trials for the Lapidakis' composition were composers (see Table 7b-4).

As far as previous research on tempo perception is concerned, most studies have failed to take adequate account on familiarity. One reason for this neglect seems to be that most auditory stimuli used in tempo research consist of musical material which are not selected so as to vary widely in their likely familiarity to the subjects. For example, studies on correct tempo selections only investigated popular ballroom dance music (Farnsworth, et al., 1924) or highly familiar popular songs, such as "Do Re Mi," "Happy Birthday," and "Yesterday," among others (Halpern, 1988; Levitin & Cook, 1995). The results of such studies showed that there is one tempo consistently associated with familiar tunes.

Along these lines, it is worth noting that the finding of this study regarding the effect of familiarity on tempo consistency in a listening task may be compared with Clynes' & Walker's observation (1986) that the only time performances by the Sidney String Quartet showed low consistency was with a composition with which the string quartet was

less familiar than with the other works reported in the study. According to the researchers: "Concepts need time to settle, to be established.... This need of time for musical concepts to stabilize touches the essence of a musical concept" (p. 113).

Moreover, from the examination of the role of style on tempo consistency we have learned some interesting aspects of how listeners with limited or no music education, especially preadolescents, perceive the concept of musical style. Initially, it appears understandable that these subjects are unlikely to classify music as Baroque, Impressionism, etc., by name (Hargreaves, 1986). However, it has been informally observed in this study that none of the subjects showed any degree of confusion or lack of confidence when they were asked to describe how familiar they were with the styles of the pieces in question.

Thus, it seems reasonable to assume that style sensitivity of this sort is probably of an abstract or general nature in the minds of all listeners older than 10 years, independent of relevant declarative musical knowledge. Indeed, one might say that listeners' style sensitivity relies heavily on the formation of general family resemblances among different musics they have heard in their environment rather than on a concrete or explicit categorization of defining stylistic features. This assumption fits in with findings of studies that, after the age of 10, subjects develop a high level of sensitivity to artistic styles (for a more detailed discussion see Hargreaves, 1986, pp. 55-59; Gardner, 1972).

The Variable of Preference

Seeking to clarify the nature of the cognitive mechanisms involved in the formation of right tempo judgments and their consistency over a period of time, it was of interest to examine the role of preference for the experimental stimuli. The term 'preference' is understood here to reflect a listener's liking for one musical example as compared with

another. Subjects evaluated their preference for each listening example on a scale from *most-liked* or *excellent* to *least-liked* or *poor.*

Results revealed that tempo judgments across trials were significantly affected by subjects' preference with respect to the listening examples. This observation implies that listeners tend to render more stable tempo judgments for the pieces they like than for the ones they dislike. One reason might be that they have a positive attitude towards musical examples they like and a negative attitude towards the ones they do not like. As a result, they seemingly pay greater attention to the music of their preference noticing relationships within the large-scale musical organization more thoroughly during the task of selecting the right tempo. Thus, their tempo choices reflect a rather definite representation of how the music should sound in its right tempo, and this is more easily retained in long-term memory. Thus the observable judgments of most appropriate tempo for the preferred examples show relative stability. This assertion is compatible with the observation that attention is intimately linked to both memory and more accurate perception of extended temporal auditory events (Jones & Yee, 1993).

This assertion, however, does not imply that we cannot exhibit higher degrees of stability or that we cannot listen attentively to something we do not like. There is significantly statistical evidence indeed that it was not necessary for listeners to like *Yesterday* by the Beatles, and *The Children of Piraeus* (the Greek dance) by Manos Hadjidakis (e. g, examples which received the highest ranking in familiarity), in order to exhibit small individual tempo deviations and, thus, greater stability in their judgments for these pieces. Moreover, with repect to the *Piano Piece* by Michalis Lapidakis, which presented the greatest novelty among the listening examples, results also showed that preference did not significantly infuence consistency of tempo judgments. Therefore, one

might conclude that familiarity or novelty have clearly a stronger effect than preference on tempo judgments. This evidence does not seem generalizable beyond these individual musical examples, but it is worth noting when designing future research studies.

No other study in tempo perception appears to take into account the variable of preference. As Hargreaves (1986) rightly pointed out: "When preferred styles are employed in experiments alongside the 'high art' works that are the most common stimuli in psychological research on the arts, the results may be quite different" (p. 58).

The remainder of the dissertation is devoted to a summary and recommendations for music research, in general, and music education, in particular, considering information accrued through this investigation.

CHAPTER 5

SUMMARY AND RECOMMENDATIONS

> *A thing or idea seems meaningful only when we have several different ways to represent it—different perspectives and associations. Then we can turn it round in our minds, so to speak: however it seems at the moment, we can see it another way and we never come to a full stop. In other words, we can think about it.*
>
> *Marvin Minsky, 1981, p. 29*

No doubt most researchers experience the same temptation as I do to end a study with a section on "Conclusions" where postulations they believe to have established are gathered together. But this, I think, needs to be resisted in the case of a study on tempo such as this one. Firmly established postulations may be possible with things that are concrete, ossified, or tangible. But when the topic is elusive, intangible, or veiled, as is the case with human time consciousness, then postulations can only impose strictures which run the risk of perfunctory manipulation.

Nonetheless, it may be useful here to summarize the main speculations which have shaped the theoretical framework of this experimental study, and to bring certain empirical evidence together. This will be followed by a discussion of recommendations for music research and music education the study raises.

Additional Reflections

The major purpose of this study was to determine whether listeners are capable of forming judgments, with respect to the right tempo of specific musical examples, that remain stable over a period of time. The question "Do listeners possess a concept of right

tempo for a piece of music, and if so, is this concept consistent?" is the main theme of this study. But there is also a second question, more difficult to answer, that underlines its intent: "Do listeners possess a time sense—a timing ability for the proper pacing of time—which enables them to render stable tempo judgments over a period of time?" In addition, it was of interest to examine what factors might affect listeners' ability to give evidence of temporal consistency. The factors explored were age, musical background, stimulus style/genre, familiarity, and preference.

The time dimension of music is commonly considered a pervasive aspect of musical experience. Music is preeminent among the time-oriented or temporal arts in creating meaning through the structural interplay of its elements as they unfold in time. If time is an inseparable part of musical experience, tempo is seen here as a kind of catalytic agent of time itself, playing a controlling part in shaping or determining the pacing of temporal structure. As soon as music is listened to, all important modes of temporal structure such as rhythm and meter gain concrete dimension in a fixed period of time, at a certain tempo, which, in turn, can be objectively measured in terms of temporal units (e.g., beats per minute).

In evaluating the significance of tempo one may ask: "What happens to music if tempo is suspended, suppressed, or abolished?" The answer is two-fold: first, musical sound is presumably transformed into a mass of successive vibratory densities that have no connection to the crucial dimension of real time, and, hence, lack continuity, motion, or pacing; and second, the human ear automatically supplies its own tempo in order to ensure some coordination of sound relationships through time.

In the first place, then, one might say that without an intrinsic tempo music cannot move. As Epstein (1995) put it:

> Motion, as process—more precisely, the pacing of motion, and the control of that pacing—is served by tempo. Controlled pacing implies structure. Thus tempo is not an ad hoc aspect of music, found or determined by chance or whim. To the contrary, it is shaped and built by its own means—it is indeed structured (p. 11).

In the second place, one can conceive of tempo as being a psychological factor that enables us to relate sound events to a counterbalanced unity with respect to real time, and at the same time to objectively measure music (per temporal units). As Boulez (1975, p. 70) said referring to tempo: "In this, our ear functions as an instrument for measuring time."

This two-fold significance of tempo in music, lending itself to both subjective and objective descriptions, is congruent with the bifurcation between Becoming (virtual, psychological, integral time) and Being (absolute, real, clock time) that has dominated Western philosophical thought about time for centuries, as discussed in Chapter 1. In this light, the musical parameter of tempo has been regarded as a specific unifying relationship in musical experience between the subjective pace of the flow of a musical composition (e.g., the composition's rhythms, harmonic progressions, contrapuntal lines, themes, articulation, etc.) and real time, or between subjectively felt and objectively measured time while listening to music.

While the parameter of tempo is not one we could easily do without in music, it presents us at almost every turn with perplexing paradoxes and largely unresolved issues. For instance, we often find ourselves faced with questions: "What is the right tempo of a piece of music?" "Does a piece have one right tempo or can it survive within a range of tempi?" Unfortunately, the limitations I have necessarily imposed on this study prevent an inquiry into these questions from the perspective of music theory/analysis and performance practice.

However, it was of interest to explore the way listeners perceive how particular pieces should sound in their right tempo, and whether their conception of right tempo is

represented in their mind as a stable musical entity like pitch at repeated listening tasks over a period of time. More specifically, by means of digital technology, listeners just by saying "faster" or "slower" to the experimenter, who manipulated the tempo accordingly, were enabled to examine the influence of tempo on the way the music sounded, until they came to a point when the music sounded "right" to them.

On the one hand, subjects were faced with the technical problem of choice in creative thinking: to choose among the vast number of possibilities (tempi) available to them by means of the computer—something that cannot happen when you play the music due to motor-sensory limitations. On the other hand, listeners were given the chance to dive into the labyrinthine regions of the subjective problem of saying "that's not right" or "that's right," which may be called intuition, but which still remains a choice.

The right tempo has been considered as a perceptual unifying construct of music whose function is the meaningful (rightful) synthesis of finite juxtaposed musical elements in relation to real time. In this light, one might say that selecting the right tempo is an instance of the process of making sense—or constructing the meaning(s)—of a composition, with the composition's tempo serving as a musical point of reference.

Finally, that perception of tempo is an extremely complex parameter of musical time follows from the extensive inventory of philosophical, musical, psychological, physiological, and developmental speculations directly related to time and, hence, musical time that has been reviewed in Chapters 1 and 2. Therefore, it would be well at this point to summarize the grounds within which this study has moved. The summary will conclude with a review of the study and its main findings that have been thoroughly discussed in Chapters 3 and 4, which hopefully can be considered as a gesture towards the objective of understanding the unique qualities of tempo perception.

Summary

Representative Ideas of Time, Musical Time, and Tempo

Time

Tempo plays an essential role in musical time because it materializes the way we perceive the rate of speed of the flow of musical events. However, musical time—that is, "the way in which we experience all musical events" (Boulez, 1976, p. 69)—can only be clarified in intimate connection with what we believe time is. Anyway, strict interpretations of musical terms do not tell the whole story about their essence. Music is a sociocultural phenomenon; therefore subordinate to human intelligence as it searches, questions, construes, and communicates concepts of experience at a given point in history.

In the section of Chapter 1 on *The Problem of Time: A Perennial Issue of Bifurcation*, I discussed that the most fundamental problem concerning the essence of time is the various forms of dualism that continued into our own century. These include the split between *absolute*, *real*, *physical*, or *objective* time, on the one hand, and *relational*, *psychological*, or *subjective* time, on the other, which, in turn, bears close relation to the dual nature of tempo. This split may be roughly formulated by the following questions: "Is time an inherent property of the physical environment, independent of our perception? Or is it a mental disposition based on the way we perceive things and relationships among them?"

As reviewed in the subsection on *Absolute Time*, already in the pre-Socratic period, the nature of time occupied the minds of the Greek philosophers who linked time with the notion of flow, motion, change, and phenomenal reality (Heraclitus) versus constancy, permanence, and immobile Eternity (Parmenides and Zeno). Plato tried to reconcile these

opposing views by maintaining that time belongs to the phenomenal cosmos as a moving image of the immobile Eternity. Aristotle considered time as the criterion for measuring the movement of celestial bodies in the universe. Aristotle's belief about time in which human beings are assumed to solely be passive observers is embedded in early practices of timekeeping. Moreover, clocks are based on the same principle of physical cosmology or the concept of the so called *physical* or *objective* (spatialized) time: the motions of their hands represent the movements of atoms in visible form within a fixed limited space at a fixed speed, enabling us to measure the passing of other "times."

However, time began to pose a psychological problem from the later mediaeval philosophers onwards. Thinkers, such as St. Augustine, Thomas Aquinas, Descartes, Locke, Hume, Leibnitz, and Kant questioned whether time is a relation between the events themselves, a sense impression, an idea, a mere instance of intuition, or an a priori form of our perception ("Anschauungsform"). Among them, however, as has been discussed in greater detail in the subsection on *Relational Time*, Kant will remain the central figure of modern philosophy because of the way he articulated the whole struggle of the physical and mental, conceptual and perceptual, objective and subjective, absolute and relational views with respect to time which face the twentieth century thinkers.

Indeed, in the twentieth century the philosophical problem of time has gained great importance in relation to different fields of scientific inquiry, such as physics, psychology, biology, anthropology, and linguistics, among others, as demonstrated in the subsection on *New Concepts of Time in the Twentieth Century* . The most prominent views of time in our century, however, have been developed along two lines, one within Einstein's general theory of relativity, the other within phenomenology's interpretation of the temporality of being.

These views emphasized the significance of *subjective* or *psychological* time which is irregular, unstable, non-homogenous, ever-fluent, multi-dimensional, relative, experiential or internal, in contrast to the *objective* time which the clock ticks off. In addition, when one looks into the arts and criticism of the recent past, one also finds an increasing realization of time as perhaps the most crucial dimension of human experience.

Musical Time

The application of these philosophical speculations about time reveals an almost complete correspondence with almost every significant debate about musical time, as reviewed in the section on *The Dialectic of Time in Music* in Chapter 1. More specifically, philosophers, musicologists, music theorists, music psychologists, and composers have been challenged by the philosophical conflict between time as Becoming and time as Being.

One writer to whom the issue of time was important is Susanne Langer (1953). She distinguishes between "virtual time," that is, the lived or experienced time which is the only time that music makes "... audible, and its form and continuity sensible" (p. 109-110), and "actual time" which is synonymous with clock time. This assumption arises from her belief that motion is the essence of time. Indeed we experience the movement of music because of the lapse of time.

Igor Stravinky's concept of musical time has also been influenced by the philosophical bifurcation of time. For Stravinsky (1947) it is the interaction of "psychological" and "ontological" time that makes up musical time.

Paul Hindemith maintains that musical time evokes two different kinds of affect. On the one hand, musical time expressed by meter runs parallel to actual time because of its regularity. On the other hand, musical time as expressed by rhythm, due to its incommensurable nature, produces an effect which in normal life is non-existent.

In the same vein, Epstein (1979) considers the distinction between meter and rhythm as a model for the relationship between the mechanistic, evenly spaced "chronometric" time, on the one hand, and "integral" time, on the other, which embraces the unique temporal experience of a piece of music.

Furthermore, from a phenomenological viewpoint, Clifton (1983) distinguishes between the time that a musical composition "takes" (objective time) and the time that it "evokes" (musical time).

Leonard Meyer (1967) considers musical time from the aspect of its linear and causal logic, as "a sequentially orders series, articulated and made manifest by the chain of causally related events" (p. 65).

Finally, the most significant effect of the advent of total serialization, atonality, and electronic music is discerned in the nature of the musical discourse about time. Indeed, the contemporary gradual tendency to suppress beat, pulsation or periodicity in compositions had as a result the reconsideration of important aspects of temporality, such as time as motion versus time as space, continuity versus stasis, regularity versus irregularity, goal-oriented versus directionless time, striated versus amorphous time, time as a sequentially ordered series of events versus time as a perpetual series of "nows." What occurs here, one might almost say, is a modern reinterpretation of ancient concepts of time which, in turn, takes us to the discussion about absolute time which has been reviewed in the beginning of Chapter 1.

Musical Tempo

Inasmuch as the present study is concerned centrally with music, it appeared to be necessary to demonstrate how composers, performers, and music theorists have discussed the concept of tempo in the section on *The Significance of Tempo in Music.* There is near

unanimity in the definition of musical tempo as the pacing of time of a musical composition, hence, the speed at which its performance proceeds.

Nonetheless, does a piece of music have one and only one inherent tempo, and if so, does this concept possess an absolute time framework? Or can a piece of music survive a wide range of tempi? The literature is far from consistent on these questions.

From the perspective of performance practice, some musicians believe that the search for right tempo primarily is determined by the musical structure of a composition and the verbal or metronome designations of tempo as well in a precise and absolute way. This belief is based on the notion of fixed (proportional) relationships of pulse in a single-movement composition or between the movements of large-scale compositions and the concomitant idea of absolute tempo. In other words, if these tempo proportions are violated, then the overall sense of the composition's event-density, rhythmic, harmonic rate, and breathing, among other components of musical activity, gets distorted (Brendel, 1977; Epstein, 1985, Gould, 1982). Other musicians, however, consider a much wider range of possibilities as appropriate for a rightful interpretation (Donington, 1963; Epstein, 1995; Kirkpatrick, 1984). For them the selection of right tempo primarily depends on the interpreter's intuition, sensitivity, personality or chemistry rather than on common relationships of tempo.

Moreover, music theorists diverge in their opinions of whether structural relationships in music—formal characteristics, local-level and more global harmonic relationships, rhythmic and metric relationships—are in some way dependent on it or whether they remain independent of tempo. On the one hand, some theorists find that the overall tempo and the tempo fluctuations within a piece are closely related to its structural characteristics (Berry, 1986; Clarke, 1985; Lester, 1982; Piston, 1978). One of the most

interesting aspect of this view is the introduction of the term of "inner" tempo that can be mathematically calculated using the duration of metric units and the average pulse number within the units as variables of the equation (Margulis, 1984; Reckziegel, 1961).

On the other hand, most theorists find that tempo, though it modifies pulse, meter, and rhythm, cannot be not regarded as a mode of musical organization (Aldwell & Schachter, 1978; Cooper and Meyer, 1966; Forte, 1979; Reinecke, 1974). As part of this argument, theorists maintain that a rhythm or a theme will be recognizably the same whether played faster or slower. Along these lines, tempo has been recognized as a psychological fact that can be objectively measured (Clifton, 1973; Cooper & Meyer, 1966; Kramer, 1988).

Related Empirical Research

General Scientific Considerations

Most explanations of the rate of time's passage seem to take into account the relations between psychological time as duration and (a) the content that fills the time interval, (b) memory, and (c) attention.

Namely, the experience of time and its relationship with the external events is not separable from the context within which they take place and the conditions of their measurement. The comprehensive "contextualistic" model that has been discussed in Chapter 2 includes four types of interacting factors, all or any of which may affect psychological time: characteristics of the subject, contents of the time period, the subject's activities during the time period, and the subject's time-related behaviors and judgments (Block, 1990; Bransford, 1979; Frankenhaeuser, 1959). This general model has been

helpful in speculating and tying together most of the different factors relevant to the consistency of tempo investigated in this study.

With regard to the role of memory in the experience of time, a very important development was Ornstein's (1969) "storage size metaphor," according to which duration experience becomes longer, as storage size increases. Moreover, this assumption elaborates on the value of tempo in duration experience. Namely, since the speed at which time passes is the speed at which information is processed, higher density musical information fills a longer psychological time than more normative information played at the same tempo.

Finally, most evidence relevant to attentional models suggests that temporal experience is positively related to the degree of attention that an information task demands (George, & Reed, 1980; Jones, 1986; Underwood, 1975; Zukay, 1990). The greater the demand on more intense attention due to the processing of more complex information in a given time period, the more irregular or inconsistent are the temporal judgments.

In fact, these psychological approaches to time considered in this section of Chapter 1 tell us little about the psychological significance of tempo in music listening. They offer, however, useful methodological bases for an empirical investigation of musical tempo that embodies aspects of psychological time.

Physiological basis of tempo sense

In Chapter 2 we also discussed the possibility that certain human biological functions, such as heartbeats, breath, body temperature, and neuron oscillations in the brain, play an important role in the individual's experience of musical time.

There is ample and conflicting literature documenting that human pulse serves as a physiological basis of tempo. For instance, a number of music theorists in the Middle Ages through the Baroque period believed that the average human pulse was linked to a "general"

tempo area of M.M. = 60-80. Moreover, in the beginning of our century when the empirical study of psychological time was initiated, researchers have been concerned primarily with the concept of "preferred" tempo in relation to subjects' individual pulse or respiratory rate. (Bank, 1972; Dalcroze, 1921/1980; Sachs, 1953;).

Furthermore, empirical research has found evidence that chemical motions in the cells of the brain act as a chemical clock or pacemaker on the perception of the pacing of time in music (Brown, 1981; Fischer, 1966; Hoagland, 1933, 1966). For instance, clock time seems to pass slower to subjects with higher temperatures and hence accelerated biochemical changes; therefore, they counted or tapped faster in a number of experimental studies, that have been discussed in Chapter 2. In the same vein, researchers also reported that time for the child appears to run much more slowly than time for an adult, due to rapid fall in both circulation and oxygen consumption of the brain from childhood through adolescence followed by a more gradual but progressive descent through the remaining years of life. Perhaps this might be the reason that tempi executed by young performers are commonly faster than those selected by older ones (Epstein, 1995).

Finally, researchers assume that a possible basis for tempo perception in music may rely on neural oscillations in the brain proceeding with a remarkably stable rate. Mental structures might, thereby, display considerable morphological stability of tempo judgments (Pöppel, 1976, 1990). Along these lines, it has been proposed that this neural pacemaker or biological clock tends to cause tempi and tempo relationships in music to be "unbiological" and hence with unpleasant aesthetic consequences for listeners with conventional listening habits, if they are not tuned to this clock in our brain (Clynes & Walker, 1986; Epstein, 1985, 1995; Pöppel, 1990).

Nevertheless, as a number of researchers have noted (Campbell, 1990; Macar, 1985; Michon, 1985a), the internal clock hypothesis represents limited knowledge about cognitive processes involved in temporal judgments. It seems that this is an area which would warrant further investigation.

Tempo in Music Listening and Performance

As discussed in Chapter 2, an increasing amount of experimental literature concentrated on the following topics related to tempo perception: (1) the impact of tempo on affective responses to music, (2) the execution of tempo changes in music performance, and (3) the ability for discrimination of tempo changes in music listening.

As far as the impact of tempo on affective responses of listeners is concerned, findings disclosed that faster tempi were associated with adjectives of a checklist of emotional responses, such as "exciting," "joyous," "happy," "playful," and slower tempi with the opposite adjectives (Behne, 1972; de la Motte-Haber, 1968; Farnsworth, 1954; Gabrielsson, 1973, 1982; Hevner, 1935, 1937; Rigg, 1940).

Moreover, researchers recently attempted to explain tempo fluctuations, such as accelerando, ritardando, and rubato, by objectively measuring them by means of computer programs and other technical advances that allow for accurate registration and timing of the microstructure of musical performances. In most cases there is critical evidence of flexible constraints on such expressive tempo patterns that recur in actual expert performances. In the same vein, empirical examinations concerning perceptual judgments of listeners verify the aesthetic validity of the measured constraints in musical expression (e.g., Friberg, 1991; Feldman, Epstein, & Richards, 1992; Gabrielsson, 1988; 1992; Kronman & Sundberg, 1987; Repp, 1994; Shaffer, 1981; Sundberg, Friberg, & Frydén, 1991; Todd, 1985).

Another problem that tempo research in music education has raised is the sensitivity for discrimination of tempo changes. Nonetheless, the results of these studies are conflicting. For instance, a number of studies have indicated that subjects perceive a decrease in tempo more accurately than an increase (e.g., Ellis, 1989; Kuhn, 1974; Madsen, 1979; and Wang, 1984), while others have generated the opposite findings (e.g., Madsen, Duke & Geringer, 1984; Geringer & Madsen, 1984; and Wang, 1983).

It seems that the reason for such conflicting modes of tempo perception is the dearth of speculation about the degree to which (1) content and context of experimental stimuli, and (2) personal variables, such as age, previous musical experience, familiarity with, or preference for experimental stimuli, influences tempo perception.

Defining Personal Factors of Tempo Perception

Age.

In a number of studies it has been shown that sensitivity to basic changes of tempo in simple sound sequences appears in early infancy, as discussed in Chapter 2. Moreover, observations of preschool children have illustrated that perception of temporal parameters and consistent synchronization of bodily movements with the pulse of music as well proceeds with age. Yet, results of numerous studies (Fraisse, 1982; Friedman, 1990; Piaget, 1969; Pouthas, 1985) seem to be consistent with the postulation that between 6 and 8 years of age there is a transition period with respect to many aspects of temporal awareness. Namely, temporal judgments reach an increasingly stable level at this age.

As far as music in particular is concerned, there seems to be consensus that after the age of 6 or so children begin to listen to and represent musical concepts, such as pitch, melody, harmony, and rhythm, in ways notably similar to adults (Davidson, McKernon, &

Gardner, 1981; Dowling, 1982; Imberty, 1981; Petzold, 1963; Shuter-Dyson & Gabriel, 1981).

Yet research in the area of the development of tempo perception findings are rather patchy and inconsistent (Dorhout, 1979/1980; Petzold, 1969; Taebel, 1974). Nonetheless, there is apparently general agreement among most music researchers that the growth of tempo perceptual ability does not improve dramatically in children ages seven through fifteen (Kuhn & Gates, 1975; Petzold, 1969; Thackray, 1972). In general, the paucity of more comprehensive explanations of how the cognitive mechanisms underlying children's perception of tempo change with age indicates the need for additional research.

Musical background.

Musical experience has long been assumed to influence musical development by enhancing children's attention to the flow of musical events. Although a great deal of work has focused on the relationship between rhythm perception and musical experience, there are relatively few studies that have examined musical experience as a determinant of tempo perception.

Actually, most of the research on tempo perception deals with the ability to detect tempo changes, such as Dorhout (1979/1980), Ellis (1991), Madsen (1979), Sheldon (1994), Wang (1983), Wapnick (1980), and Yarbrough (1987). The combined results of these studies into tempo listening, in spite of their variability in methodology, scope, and types of training investigated, generally imply that perception of tempo change is not precise in both musicians and non-musicians. In the same vein, as far as the consistency of right tempo judgments is concerned, the Lapidaki & Webster study (1991) also revealed no overall, statistically significant results indicating that music background influences consistency of right tempo judgments for selected musical compositions.

Nevertheless, conclusions concerning the relationship of musical experience to tempo perception can only be speculative at this point given the lack of experimentation directed at this question. However, since tempo is regarded as the most important parameter that gives music or rhythm its motional quality, as discussed in Chapter 1, investigations of tempo perceptual abilities in relation to musical training should be considered crucial for music educators.

Preference and familiarity.

While there has been a large number of studies on the effect of tempo on listening preferences, inquiries on the nature of tempo perception have failed to take adequate account of the effect of experimental stimulus preference and familiarity on tempo judgments. One reason for this paucity seems to be that most auditory stimuli used in tempo research either do not represent real music, as is the case with brief rhythmic sequences, metronome clicks, or other stylistically neutral information (Duke, 1994; Ellis, 1991; Holbrook & Anand, 1990; Kuhn, 1974; LeBlanc & Cote, 1983; LeBlanc & McCrary, 1983; Madsen, 1979), or they consist of musical material which are not selected so as to vary widely in their likely preference and familiarity to the subjects (Farnsworth, Block, and Waterman, 1924; Halpern, 1988; Levitin & Cook, 1995; Sheldon, 1994). When stimuli are employed in experiments of tempo perception that represent a wide range of musical styles, familiarity, and preference, the findings may be quite different.

Consistency in Tempo Perception

In the process of exploring the literature on consistency of tempo perception, it was of interest that most experimental investigations concerning tempo choices were performed around the beginning of our century (e.g., Braun, 1927; Frischeisen-Köhler, 1933;

Harisson, 1941; Miles, 1937; Mishima, 1956; Rimoldi, 1951; Wallin, 1911). Most commonly, subjects had to tap their responses on a telegraph key or to listen to metronomic clicks proceeding at different rates, and were asked which tempo was felt to be more appropriate. Generally, findings showed that subjects tended to be relatively consistent in their preferred rates.

In addition to studies that employed listening to stimuli like metronome clicks or tapping tasks, of particular interest were those investigations (Farnsworth, et al., 1934; Behne, 1972; Halpern, 1988; and Lapidaki & Webster, 1991) that asked the listener to make judgments about the correct tempo of musical examples with mechanical or electronic devices (e.g., Duo-Art player piano with a tempo lever, the Springer-machine, or the software interface on computers) that allowed for variable tempo control over the musical stimulus.

More specifically, Farnsworth et al. (1934) and Halpern (1988) investigated the consistency between the "perceived" and the "imagined" correct tempo of stimuli. The perceived correct tempo was set by manipulating the tempo lever of a player piano or the computer interface, respectively, while the stimuli were played in real time. The imagined tempo was demonstrated by tapping in the Farnsworth, et al. study, or setting the metronome to coincide with what the subject imagined to be the correct tempo, in the Halpern study. The findings of both experiments reported relative consistency between the perceived and the imagined correct tempo. Furthermore, results seem to indicate that there is one tempo consistently associated with familiar listening examples.

The Farnsworth et al. and Halpern research were important studies because of their use of real musical stimuli that allowed subjects to have control over tempi. Nevertheless, they were limited in that they merely investigated well-known tunes, such as ballroom

music (e.g., Farnsworth, et al.) or popular songs like "Happy Birthday," "Twinkle, Twinkle, Little Star," "London Bridge is Falling Down," etc. (E.g., Halpern). Moreover, these experiments have been conducted solely with nonmusic major students.

Interesting as their results may be, they do not demonstrate whether judgments of correct tempo are consistent across separate trials over an extended period of time, especially, when subjects are presented with musical compositions chosen because they represent a wide range of musical styles and familiarity. Also of importance would be how tempo judgments might differ among subjects with different musical backgrounds.

To investigate these issues, Lapidaki & Webster (1991) designed a study in which adults with high levels of formal music education who were practicing music professionals (composers, performers, and music educators) and adults with little formal music education had to listen to the same compositions of different musical styles at four separate trials. They were asked to listen to each composition and indicate whether the experimenter should change the tempo by means of a software program until the music sounded right.

Findings showed that when tempo is judged by highly skilled musicians in repeated listening tasks, initial tempo of presentation of the examples had a dominant effect on correct tempo judgments. Simply stated, no single correct tempo emerged as a consistent characteristic of individual or group performance. The sample of adult non-musicians indicated a basis for a similar conclusion. Indeed, these results did not support findings of studies that revealed remarkable tempo stability over a period of time in repeated performances (e.g., Clynes & Walker, 1982, 1986; Wagner, 1974; and Winckel, 1962).

Nevertheless, additional work seemed necessary with larger and more varied samples and with better measures of individual familiarity with, and preference for judged

compositions. Also of interest would be how these judgments may differ among subjects from different age groups.

Review of the Present Study

Research Questions

The purpose of this investigation into tempo perception was to determine:

(1) the extent to which correct tempo judgments for particular musical examples are consistent across four separate trials using varying initial tempi for each trial,

(2) the extent to which differences in correct tempo consistency exist among preadolescent, adolescent, and adult listeners,

(3) the extent to which differences in tempo consistency exist between musicians and nonmusicians,

(4) the extent to which consistency of correct tempo judgments is influenced by the musical style of the listening examples,

(5) the extent to which consistency of correct tempo judgments is influenced by the listener's familiarity with the individual pieces and their overall style, and

(6) the extent to which consistency of correct tempo judgments is influenced by the listener's preference for a particular piece.

Design

To answer the six research questions, a computer sequencing program was employed which had the capacity to precisely vary the tempo of the listening examples in real time, without altering any other musical attributes, such as pitch, articulation, timbre, etc.

In all trials subjects listened to the following six musical examples: C-major and A-minor *Two-Part Inventions* by J. S. Bach, *Clair de Lune* by Claude Debussy, *Piano Piece* by Michalis Lapidakis, *Yesterday* by the Beatles, and *The Children of Piraeus* (*Never on Sunday*) by Manos Hadjidakis. These works were chosen because they represented a wide range of musical styles, familiarity, and potential preference. Moreover, each session for a subject systematically varied the order and the initial tempo of the musical examples.

The 90 subjects utilized for this study were grouped by age levels (30 adults, 30 adolescents, and 30 preadolescents). Individuals of each age group were selected on the basis of musical background and willingness to participate.

Musical background represented the subject's level of formal or private music education and/or participation in different areas of musical activity. For uniformity's sake, subjects with adequate music education were referred to as "musicians," and subjects with little or no musical education as "nonmusicians".

Subjects were asked to listen to each composition and tell the experimenter to alter the tempo upwards ("faster') or downwards ("slower") until the tempo was right; that is, the most appropriate tempo for that composition, in the opinion of the listener. Subjects performed this task four times, at least four days apart. Further details of the research design were presented in Chapter 3.

Findings

The report of the findings was presented in the beginning of Chapter 4. Following this, the various effects on consistency of right tempo judgments were discussed both with specific reference to the findings, and with general reference to understanding the mental processes involved in tempo perception. Results supported this following summary of findings:

Consistency of tempo judgments across trials.

When looking at group performance in the aggregate, the study shows little evidence to support the claim that correct tempo judgments are consistent in the face of initial tempo changes. It is quite clear that when tempo is judged in repeated listening tasks of the same compositions, initial tempo of stimuli has a dominant effect on judgments of correct tempo: the slower initial tempo generally evokes slower tempo selections, and so on.

However, it should be stressed, in this respect, that a relatively small number of adults, mostly musicians, were remarkably consistent in their tempo judgments across all four trials. It appears that these individuals possess an exceptional ability with respect to acute stability of large-scale timing in music that is labeled *absolute tempo* as analogous to absolute pitch.

Another proposal is that absolute tempo is an implicit form of cognition. Typically, subjects reported that they were surprised when they heard that their right tempo choices were virtually precise across trials. In addition, it seems that physical, psychological, and environmental factors, such as, fatigue, mood or time of day, do not have an effect on the ability to give over time consistent tempo judgments.

Finally, absolute tempo has been noticed with regard to musical examples with which listeners were utterly familiar. Nevertheless, as I pointed out in Chapter 4, taken in isolation, this result should be interpreted with caution for a number of reasons. The major one is that these subjects did not exhibit absolute tempo with respect to all pieces with which they had the same level of familiarity. Therefore, one might suppose that the same person seems to follow different cognitive strategies of timing for each individual piece of

music, which leaves one wondering whether the stability in viewpoint is to some extent discrete more than continuous.

The variable of age.

There is evidence that the degree of consistency in right tempo judgments gradually increases from preadolescence through adulthood. This should lead to the assumption that fluctuations among tempo judgments of the same pieces of music become smaller, as awareness of tempo is attained with age. The interesting aspect of such an assumption is that tempo awareness does not appear to "plateau" after the age of 10, as is the case with the perception of other musical parameters. (For an interesting discussion on the issue of acculturation, see Imberty, 1982.)

More specifically, when listeners, between the ages of 10-12, are asked to choose the right tempo of a piece of music, they tend to demonstrate an awareness of tempo, which does not reflect simultaneous perceptual organization and integration of other relevant musical features, such as harmonic, rhythmic, and metric relationships. Therefore, preadolescents are experimenting with their right tempo selections with greater ease which leads to greater tempo fluctuations across trials. In adolescence, tempo fluctuations become smaller. Finally, by adulthood, tempo perception is rather finely detailed, and thus tempo consistency greater. It is therefore likely, though not essentially certain, that only when the representation of music has stabilized in the mind through maturation, is the corresponding temporal consistency noticeable.

The variable of musical background.

The musical background of the subjects may have some bearing on consistency of tempo judgments, but this study reveals no overall statistically significant results to support

this contention. In fact, it seems that the musician's grasp of tempo behavior is initially very much like the non-musician's in the listening task in question. A possible explanation—not a parsimonious one, but compatible with neuropsychological data as well as with Davidson's conclusions (1994) about song singing—is that ability for consistent tempo judgments in listening tasks is probably a maturational one that is independent of music education. Nonetheless, this explanation is not necessarily true at high levels. Actually, results clearly indicated that adult musicians showed the smallest fluctuations in their tempo judgments and, thus, the highest degree of consistency.

Indeed, it must be acknowledged that musicians and non-musicians of all age groups significantly differed in consistency of most appropriate tempo judgments with regard to *Clair de Lune* by Claude Debussy. It should be noted that this particular piece is the only case among the musical examples in which one notices a slow overall tempo and rapid movements within this slow tempo at the same time. Thus, tempo becomes a function not only of the beat rate but also of the number of unfolding events per unit of time, as explained in Chapter 4.

This leads to the assumption that musically experienced listeners use an integrative cognitive strategy that enables them to control and synthesize local-level temporal relationships into the large-scale, complex (yet hierarchic), and coherent musical structure when they chose the right tempo of a piece of music. It is therefore crucial to seriously entertain the possibility that musical training increases performance in listening tasks by alerting listeners' perceptual organization of stimuli, especially when the regularity of stable musical patterns breaks down.

The variable of style

Findings strongly suggest that the style of the musical examples influenced the degree of tempo consistency across trials. Indeed, it becomes obvious that individual innate structural characteristics of the styles facilitate listeners to extract criteria for determining the right tempo of the particular musical examples. As far as the specific styles of the listening examples are concerned, the style of rock ballad exhibited the highest degree of consistency. Tempo judgments for the contemporary idiom were the less consistent among all styles. Specifically, the following consistency scale with respect to the musical styles was observed in subjects' tempo judgments: Rock ballad < Greek dance music < Impressionism < Baroque < Contemporary idiom.

Chapter 4 contains information that explains the intrinsic sonic distinctiveness of the listening examples as defined by their stylistic context. Moreover, it attempted to demonstrate how this scale of consistency in the selection of the right tempo may provide us with a plausible and useful initial description of the temporal, melodic, and harmonic implications of the different styles and genres within which the whole perceptual construction of the experimental stimuli can function.

To sum up, this discussion supports the belief that tempo is not perceived entirely independently of the temporal, melodic, and harmonic elements of a piece, but rather is part of its integrated sonic structure. On the one hand, regularity or consonance in both rhythmic and melodic stylistic implications facilitate tempo perception, as is the case of the rock ballad. On the other hand, if the stylistic constraints of the piece are perceptually too demanding (complex) or unconventional in terms of typical rules of the tonal Western tradition, as is the case of the contemporary idiom, listeners may not be able to develop a

stable mental representation of the musical structure that results in a corresponding temporal instability.

The variable of familiarity.

There is statistically significant evidence that an increase of familiarity with the musical examples resulted in an increase of consistency of right tempo judgments for all examples The straightforward implication of this evidence is that familiarity gained from formal or informal exposure to music, on the one hand, highlights the ability to form a stable mental representation of music that enables the listener to render fairly stable tempo judgments across trials. On the other hand, novelty yields the opposite results in terms of temporal stability of judgments. One may say that only when the representation of music has stabilized in the mind through familiarization is the corresponding temporal consistency noticeable.

Moreover, there is statistically significant evidence that an increase of familiarity with the styles in question, except for the contemporary idiom, significantly influenced the degree of consistency of tempo judgments. It is interesting that greater familiarization with the contemporary idiom did not lead into more consistent choices of most appropriate tempo for the *Piano Piece* by Michalis Lapidakis. Thus, one could argue that the contemporary idiom does not set up a strong context that facilitates the formation of the concept of right tempo for individual compositions.

The variable of preference.

In Chapter 4 we have also discussed the evidence that tempo judgments across trials were significantly affected by subjects' preference with respect to the listening examples. This evidence implies that listeners tend to render more stable tempo judgments for the

pieces they like than for the ones they dislike. A possible explanation is that listeners seemingly pay greater attention to the music of their preference noticing relationships within the large-scale musical organization more thoroughly during the task of selecting the right tempo. Thus, their tempo choices reflect a rather decisive representation of how the music should sound in its correct tempo.

This explanation, however, does not imply that we cannot exhibit higher degrees of tempo consistency or that we cannot listen attentively to something we do not like. For instance, it is quite likely that it was not necessary for listeners to like *Yesterday* by the Beatles, or *The Children of Piraeus* (the Greek dance) by Manos Hadjidakis (e. g., examples which received the highest ranking in familiarity), in order to exhibit great stability in their judgments for these pieces. Thereby, one might assume that familiarity or novelty have clearly a stronger effect than preference on tempo judgments here. However, it is obvious that many questions remain open at this point. It would therefore be premature to draw any firm conclusions.

Recommendations

Recommendations for Future Research

The findings of this study have to be considered tentatively, as pointed out at the outset of this chapter. However, some implications are clear:

1. It would be worthwhile to replicate this study with (1) a more representative random sample of subjects, (2) children from kindergarten through sixth grade, or (3) with other styles and genres of music. This would heighten our insight into the over time stability of the mental concept of right tempo in music listening.

2. Tempo cannot be regarded as isolated from other aspects of music, but as being in a continuous interaction with pitch, rhythm, timbre, and dynamics, to name some of the musical parameters involved. It would be interesting to determine the influence of these interactions on consistency of right tempo judgments. To do this, it would be necessary to use musical examples that are played in different pitch registers, on different instruments, or with different dynamics in each trial.

3. More interdisciplinary contacts between music psychologists, ethnomusicologists, and physiologists, among others, would enrich our research base. The interdisciplinary study of tempo would permit a more complete measuring of the capacities and limits involved in temporal stabilities observed in the listening process. For instance, it would be interesting to study whether neurobiological timing mechanisms affect the manner and degree to which we control timing and pacing in concrete musical contexts. In addition, it would be of interest to conduct an ethnomusicological study in order to examine whether tempo is accurately maintained over a considerable period of time in musical practices of various cultures.

4. As far as the observed ability of absolute tempo is concerned, among the questions that need answering is its relation to absolute tempo. To do this, it would be worthwhile to test listeners with absolute pitch versus listeners with relative pitch.

5. Researchers would be well-advised to consider subjects with specific types of musical training in relation to absolute pitch. For example, it would be interesting to explore whether percussionists tend to be more stable in their right tempo judgments than singers.

6. It would be useful to examine whether musicians are more consistent with respect to their tempo choices when they play a piece in repeated performances than when they

judge the right tempo of the same piece in repeated listenings. Such a comparison of tempo consistency could shed light on similarities and/or differences in the ways we experience the passage of time in music performance as well as in listening.

7. As far as the methodology of the study is concerned, the construction of an apparatus that would enable the manipulation of tempo by the subject without the experimenter's intervention would be well-advised when designing future work. The manipulation of a small wheel, dial, or pedal to change the tempo would not require any special training on the part of the subjects, as is the case with a computer mouse. In addition, it would facilitate the listening process, as opposed to the subjects having to verbally communicate their tempo choices to the experimenter.

Recommendations for Music Education

I shall conclude the chapter with recommendations for music education. After all, most studies of music cognition have a limited relation to real musical experience. As helpful and suggestive for music listening as they may be, a common feature of much of this work is that musical experience is not represented authentically. Music education, in contrast, touches the heart of the phenomenon of musical experience in its attempts to translate the insights gained in music research into fertile practice that helps students to experience music fully.

This study is based on the premise that tempo is a general cognitive constraint influencing the way we organize long-scale musical events in real time and, thus, make sense of them. Tempo constitutes an important meaning-bearing element of music by enabling various sound events to be woven together at a fixed pace in time. In turn, this temporal pacing is what gives music its unique motional, emotional, and sensuous

character, as has been acknowledged in most discussions concerned with music aesthetics, theory, and compositional or performance practice.

If such is truly the case, then the development of a more refined or discerning concept of tempo in students should be considered crucial for a thorough understanding of the expressive qualities of music. Instead of focusing solely on reading of notated structural parameters of music (e.g., melody, rhythm, meter, and the like), music instruction should promote the development of listening skills, especially, with reference to the imprecisely represented in conventional notation, motional, and emotional aspects of music, as is the case with tempo.

Everybody can sense tempo when listening to music. A change in tempo provides highly important changes in the listeners' impression and feeling of music that often enable them to appreciate the musical intention of a composition. For instance, thinking along these lines, Gabrielsson (1988) noted: "... frequently the difference in tempo is what you notice first, when you compare different performances of the 'same' piece of music" (p. 148). In this context, Farnsworth (as cited in Kuhn, 1974) made a similar observation:

> ... of the variables which give meaning to music, tempo plays the largest role .... The listener is most likely to change the affective terms with which he describes a piece of music whenever its tempo is appreciably slowed or hastened. Other alterations of the musical matrix change less strikingly how he will describe the music he is hearing (pp. 270-271).

Nevertheless, tempo should not be necessarily taught as a vehicle for the transmission of programmatic verbal conceptual meanings of the kind: fast tempi communicate joyous, cheerful, or bright moods, and slow tempi communicate depressing, heavy, or dark moods. The verbal-logical type of symbolism is not characteristic of music. Musical sounds are more accurately communicated by means of the semiotics implicit in their structure, although tempo designations on the score, such as allegro, grazioso,

andante, tranquillo, etc., often show traces of denotative principles of linguistic discourse. These tempo designations on a score may be to some extent helpful to performers; most of the times, however, there may not even be a score while listening to music.

Perhaps the most important insight gained from this study is that right tempo judgments lie deeply within the human mind which intuitively attempts to supply its own right tempo to music in order to ensure the meaningful coordination and motion of sound relationships through time. In other words, it is the relation of melody, phrasing, harmony, rhythm, timbre, dynamics, style, and other musical features, to tempo that imbues them with a new and exciting perceptual dimension.

It is somewhat surprising to find, however, that tempo is commonly being treated in music instruction of all levels as if it were solely applied to the metronome or to verbal designations. This leads us to believe that students are not supposed to have an awareness that musical elements and relationships among them are experienced at a certain pace in real time. Music educators can help students to gain a deeper sense of musical elements by showing them the power that tempo exerts on their synthesis. What Epstein (1985) rightly pointed out regarding the mastery of tempo as a clue for a better affective grasp of music in performance also relates to music teaching and learning:

> It is not uncommon for an experienced performer to "know" a piece in all obvious respects—its technical hazards no longer hazardous, its structure understood on a sophisticated level, its style, phrasing, shaping integrated and "right"—and yet find that the piece in some way remains unknown, its inner content elusive.... motion is found to be the clue. Within the sense of motion—a sense that can be delineated, grasped with precision—there seems to lie that confluence of form, structure, and affect (p. 458).

Music educators can help students to achieve a better sense of recognition and mastery of all kinds of relations in a piece of music by teaching them the concept of tempo. To help students of all ages find a use for the concept of tempo in music, music educators

may consider the design of this research which proposes a fascinating, creative, and—most importantly—an intrinsically musical activity reflecting our need to organize and control the passage of time in music. It is hoped that the play with musical tempo and time that this activity involves may provide students with another source of knowledge, fulfillment, and gratification while learning about music.

In this design, listeners were given the active task to manipulate the tempo of a piece of music in real time while examining its influence on the way the music sounds. The ultimate objective was to come up with a tempo in which all elements of the piece would fit together naturally, in a right pace. On the one hand, listeners were provided with the opportunity to choose the most appropriate tempo in their opinion among a vast number of tempi available to them by means of the computer, something that cannot happen when you perform music due to motor-sensory limitations of the performer. On the other hand, listeners were faced with the technical problem of saying "this tempo is not right" or "that tempo is right" which is an important aspect of the creative process in music (Webster, 1987).

However, in a real educational setting, students' musical decisions about right tempo have to also rest on the teacher's guidance. The skillful music teacher will use musical materials which are appropriate for each particular age level but will attempt to demonstrate how musical parameters are integrated and flow with a rightful pace in all music. The thoughtful use of examples— particularly, from contemporary music and from music of various genres and cultures—may also help students to understand the different roles tempo fulfills within the musical structure, from aesthetic fulfillment, to inspiration of dance and song, to arousal of a certain emotional ambience. In addition, the teacher's recommendation that tempo is the parameter with the greatest degree of variability and

possibilities in music will give students the freedom to experiment with music with greater ease and curiosity while focusing on the pacing of musical events.

Finally, I strongly believe that by using tempo as a reference point in order to teach other musical elements in their proper motion, we can open a new and intriguing dimension for listening. As Stockhausen (Cott, 1973) said referring to the importance of manipulating tempo in compositional practice: "... a person who experiences this music becomes as much slower and as much faster in his reactions and experiential time as the music. This expands man and also his awareness of what music can be" (p. 193).

In this context, the finding that most listeners did not prove to be precisely consistent in their right tempo judgments over a period of time becomes a secondary issue. Indeed we all vary in the abilities with which our aesthetic perceptions operate. After all, we are not metronomes.

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APPENDIX A

Musical Background Survey

Name: .....

School Grade (if applicable): .....

Birthday: .....

Date: .....

1. Not counting school general music classes, are you currently involved in the following musical activities? If so, for how long? (One check for each activity and one for length of time)

			HOW LONG?			
MUSICAL ACTIVITY	YES	NO	0-2 Years	3-5 Years	6-10 Years	11+ Years
Regular vocal or instrumental lessons:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Regular lessons in music theory, history, or composition:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Perform instrumental or vocal solos:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Perform in vocal and instrumental groups:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Compose music:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Teach music:	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Involvement in other musical activity: (Please specify)	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

2. Do you currently study or have studied in a higher educational institution? (Please specify the field of study):

.....

APPENDIX B

Parent Consent Form

Dear Parent,

In cooperation with the School Principle and the classroom teacher, I will be conducting a research study for my doctoral dissertation on the fifth and sixth grader's perceptual behavior when listening to music. I am seeking volunteers to participate in the study and hope that you will consider my request.

The 30 to 35 students that will be involved in this study would be randomly selected from those willing to participate. Each student will meet me individually four times for approximately 20 minutes over a period of a month after her/his regular class period.

Before you decide whether or not to have your child participate, it is important that you understand the following four points:

- Participation is voluntary; a student may withdraw at any time.
- All records will be kept confidential and will be used for research purposes only.
- All personal identification such as names will be deleted from the research report.
- Upon request, a copy of the results of the study will be made available.

If you are willing to have your student be a possible participant in this study, please sign and return the attached consent form and return it to the classroom teacher NO LATER THAN FEBRUARY 10, 1993. If you do not wish to have you child participate, please fill in the appropriate space on the form and return it.

If you have any questions concerning this project, please feel free to call me at (708) 491-7575. Thank you for your consideration.

Sincerely,

Eleni Lapidaki
Ph.D. Candidate
Northwestern University
School of Music
Evanston, IL

Consent Form

By signing below, I give permission for my child to participation the music listening study conducted by Ms. Eleni Lapidaki. My child's signature indicates her/his willingness to participate.

30-35 students will be randomly selected from those willing to participate in the study.

If my child is selected to participate, I understand that

- Participation is voluntary; a student may withdraw at any time.
- All records will be kept confidential and will be used for research purposes only.
- All personal identification such as names will be deleted from the research report.
- Upon request, a copy of the results of the study will be made available.

Student's Name (Please print) .....

Student's Signature .....

Parent's Name (Please print) .....

Parent's Signature .....

****

I do not want my child .....

to participate in this study. (No signature necessary)

****

APPENDIX C

Musical Familiarity Questionnaire

Name: .....

School Grade (if applicable): .....

Date: .....

MUSIC EXAMPLE Nr. 1:

1. Are you familiar with this particular musical example? [Check one box only]

❑ **YES** ❑ **NO**

2. If **YES**: Approximately how many times have you heard this piece either in live performance or on recordings? [Check one box only]

❑ **Once** ❑ **2-5 times** ❑ **6-10 times** ❑ **more than 10 times**

3. I am interested in how familiar you are with the **musical style** of this example.

On a scale from **1** to **3**—with

1 representing ***"I just do not know this style at all"***

2 representing ***"I have heard music of this style, but not very often"***

3 representing ***"I really know this style of music"***

how would you rate your familiarity with the musical style of this example? [Check one box only]

❑ **1** ❑ **2** ❑ **3**

MUSIC EXAMPLE Nr. 2:

1. Are you familiar with this particular musical example? [Check one box only]

❑ **YES** ❑ **NO**

2. If **YES**: Approximately how many times have you heard this piece either in live performance or on recordings? [Check one box only]

❑ **Once** ❑ **2-5 times** ❑ **6-10 times** ❑ **more than 10 times**

3. I am interested in how familiar you are with the **musical style** of this example.

On a scale from **1** to **3**—with

1 representing ***"I just do not know this style at all"***

2 representing ***"I have heard music of this style, but not very often"***

3 representing ***"I really know this style of music"***

how would you rate your familiarity with the musical style of this example? [Check one box only]

❑ **1** ❑ **2** ❑ **3**

MUSIC EXAMPLE Nr. 3:

1. Are you familiar with this particular musical example? [Check one box only]

❑ YES ❑ NO

2. If **YES**: Approximately how many times have you heard this piece either in live performance or on recordings? [Check one box only]

❑ Once ❑ 2-5 times ❑ 6-10 times ❑ more than 10 times

3. I am interested in how familiar you are with the **musical style** of this example.

On a scale from **1** to **3**—with

1 representing ***"I just do not know this style at all"***

2 representing ***"I have heard music of this style, but not very often"***

3 representing ***"I really know this style of music"***

how would you rate your familiarity with the musical style of this example? [Check one box only]

❑ 1 ❑ 2 ❑ 3

MUSIC EXAMPLE Nr. 4:

1. Are you familiar with this particular musical example? [Check one box only]

❑ **YES** ❑ **NO**

2. If **YES**: Approximately how many times have you heard this piece either in live performance or on recordings? [Check one box only]

❑ **Once** ❑ **2-5 times** ❑ **6-10 times** ❑ **more than 10 times**

3. I am interested in how familiar you are with the **musical style** of this example.

On a scale from **1** to **3**—with

1 representing ***"I just do not know this style at all"***

2 representing ***"I have heard music of this style, but not very often"***

3 representing ***"I really know this style of music"***

how would you rate your familiarity with the musical style of this example? [Check one box only]

❑ **1** ❑ **2** ❑ **3**

MUSIC EXAMPLE Nr. 5:

1. Are you familiar with this particular musical example? [Check one box only]

❑ YES ❑ NO

2. If **YES**: Approximately how many times have you heard this piece either in live performance or on recordings? [Check one box only]

❑ Once ❑ 2-5 times ❑ 6-10 times ❑ more than 10 times

3. I am interested in how familiar you are with the **musical style** of this example.

On a scale from **1** to **3**—with

1 representing *"I just do not know this style at all"*

2 representing *"I have heard music of this style, but not very often"*

3 representing *"I really know this style of music"*

how would you rate your familiarity with the musical style of this example? [Check one box only]

❑ 1 ❑ 2 ❑ 3

MUSIC EXAMPLE Nr. 6:

1. Are you familiar with this particular musical example? [Check one box only]

❑ YES ❑ NO

2. If **YES**: Approximately how many times have you heard this piece either in live performance or on recordings? [Check one box only]

❑ Once ❑ 2-5 times ❑ 6-10 times ❑ more than 10 times

3. I am interested in how familiar you are with the **musical style** of this example.

On a scale from **1** to **3**—with

1 representing *"I just do not know this style at all"*

2 representing *"I have heard music of this style, but not very often"*

3 representing *"I really know this style of music"*

how would you rate your familiarity with the musical style of this example? [Check one box only]

❑ 1 ❑ 2 ❑ 3