



YOUNG PEOPLE'S AND ADULTS' LARGE-SCALE TIMING IN MUSIC LISTENING

Eleni Lapidaki, Ph.D., Department of Musical Studies, Aristotle University of Thessaloniki

E-mail: lapidaki@mus.auth.gr

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Perception of tempo in music is an extremely complex phenomenon. Although we can begin to comprehend the dimensions of this topic from our general musical experience, it is only recently that advances in digital technology have allowed the opportunity to empirically study perception of time and tempo. Yet, the unavailability of highly controllable test apparatus may not have hindered the experimental study of tempo as much as has a general lack of understanding of the relationship of tempo to other aspects of musical organisation.

The Notion of "Absolute" Tempo

There is near unanimity in the definition of musical tempo as the "time" of a musical composition, hence, the speed at which its performance proceeds (Donington, 1980). However, does a piece of music have one and only one inherent tempo, and if so, does this concept possess an "absolute" time framework? On the other hand, can a piece of music survive a wide range of tempi? The literature is far from consistent on these questions.

Music theorists diverge in their opinions of whether structural relationships in music such as local-level and more global harmonic relationships and rhythmic and metric relationships remain independent of tempo (Cooper & Meyer, 1966; Aldwell & Schachter, 1978; Forte, 1979), or whether they are in some way dependent on tempo (Lester, 1982; Berry, 1986). Piston, for example, believes that the speed of music justifies a broader view of the harmony than would be indicated merely by root changes (Piston, 1978, p. 208).

Perhaps the most dramatic contrast of opinion about absolute tempo may be seen in the positions of Reckziegel (1961) and Reinecke (1974). Reckziegel 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" which has been already used by ethnomusicology for some time (p. 215).

Reckziegel concluded: "The attempt to determine an inner tempo results in making measurable the musical time dimension, which is seemingly only comprehensible in a sensory way" (1961, p.223). Conversely, Reinecke (1974) stated that "no evidence has been found to prove that one specific musical piece has only one 'right' tempo"(p.414). 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 be constant and in a definite and unambiguous relationship to an "inner" or "base" (Margulis, 1984) tempo, which, on the other hand, cannot be determined by the musical structure in a precise and absolute way. This perhaps may be the reason why composers set metronome marks 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. 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 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 and Meyer (1966), on the other hand, criticised the notion of fixed relationships of pulse and the concomitant belief in an absolute tempo:

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. 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 and Meyer, 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."

Physiological Basis of Tempo Consistency

The histories of performance practice and psychology teach us that people have long attempted to define relationships between "real" time (physical, actual or clock-time) and "musical" time (psychological, psychical or virtual time). For example, 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 musical tempo. As early as 1696, Loulie constructed a pendulum with 72 different swing durations in an attempt to measure the musical effect according to an average number of pulse strokes. Winckel (1967) stated quite explicitly that this kind of measurement would not do. Jacques-Dalcroze (1912) also supported the view that human heart provides a basis of rhythm. Jones (1976) noted that with increased arousal by means of stimulants, familiar patterns of music unfold more slowly than usual. Conversely, reporting on his experimentation with mescaline, Huxley (1960) found that music perception did not distort. Further, when Fuchs (1953) "metronomized" Bach's Mass in B Minor--each movement separately and on various days--he found that his beat was consistently near 80 beats per minute. Fuchs concluded: "the pulse can certainly measure music. But just as certainly it does not rule it." (p. 34).

Conversely, Radocy (1980) pointed out that people perceive music of varying rhythmic regularity and tempo regardless to the speed of physiological processes. 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 on one fundamental psychological tempo range between 60 and 70 beats per minute, and it is this psychological range that largely governs our decisions about musical tempo. From a

phenomenological point of view, Clifton (1984) made the following comment: "The "time sense" cannot be 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).

Empirical Studies of Tempo Consistency

Empirical investigations concerning tempo consistency were performed around the first half of the century (Wallin, 1911; Frischeisen-Köhler, 1933; Miles, 1937; Harrison, 1941; Rimoldi, 1951; Mishima, 1956). Most commonly, subjects were asked either to tap a telegraph key as their response task or to use a metronome to indicate tempo. 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.

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

With respect to this point about tempo consistency, Epstein (1985), claimed:

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).

In addition to these studies that employ traditional listening and performance tasks, of particular interest are those investigations that ask the listener to make judgements about tempo with hardware that allows for variable-speed control over the musical stimulus. Farnsworth, Block, and Waterman (1934) designed a study, interestingly entitled "Absolute tempo," that examined whether there is one tempo consistently associated with familiar waltz and fox-trot tunes. In that study, subjects (college students unselected for musical ability) 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 Duo-Art 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 results, the variations of the means for the proper waltz tempo were slight but for the fox-trot were equivocal in some degree. Results seem to suggest a mean of a controlling "absolute tempo" of about 120 beats per minute. In addition, the findings reported positive correlations between the tapping behaviour and the setting of the Duo-Art tempo lever, i.e. "between the more motor and the more sensory aspects of tempo" (p. 233). Five years later, Lund (1939) repeated the above mentioned study and arrived at similar findings, although in his experiment tempi for the waltz and fox-trot were slightly faster.

The Farnsworth, et. al. and Lund research were important studies because of their use of real musical stimuli 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) claims, "Dance steps can only be performed correctly within narrow margins of speed." (p.392) Another criticism of this work must be directed at the impreciseness of the apparatus, although it is obvious that the researchers did the best they could with the tools available at the time.

Fifty-four years later, Halpern (1988) conducted a similar two-part study with college students unselected for musical ability. 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 synthesiser (Study 1). 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." Moreover, 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, i.e. 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 utilised 10 of the tunes of Study 1 and only the "imagery" task (i.e. 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 Farnsworth et al. study. Both parts of Halpern's research suggest that familiar, popular tunes are represented in our mind with a particular tempo.

Interesting as these results may be, they do not demonstrate whether judgements 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. It also seemed important to investigate how tempo judgements 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 School of Music in the Midwestern United States and 5 nonmusicians 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. All subjects were tested individually at three sessions at three-day intervals. For each of the three testing sessions, subjects were asked to make correct tempo judgements of each of the three compositions. The initial tempo of the presentation of the compositions was systematically in each session.

The findings of Lapidaki & Webster's study (1991) showed that when tempo is judged by highly skilled musicians in repeated listening tasks of the same compositions, initial tempo has a dominant effect on correct tempo judgements. Simply stated, no single correct tempo emerged as a consistent entity of individual or group performance across the three trials. The sample of adult nonmusicians indicated a basis for a similar conclusion. Nevertheless, this tended to vary according to the composition in question. These results did not support the observations reported by Farnsworth, et. al. (1934), Halpern (1988), and Levitin & Cook (1996) that one tempo is consistently associated with particular listening examples. On the contrary, listeners' perceptions of correct tempo for a particular composition varied dramatically from trial to trial. Few statistically significant differences in consistency of tempo judgements were found as a result of musical background and compositional style. Many of these tendencies suggested important questions for further study.

It was obvious, however, that additional work was 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 judgements may differ among subjects from different age groups and musical background.

The majority of empirical studies on tempo perception have been carried out on adults (Farnsworth et. al., 1934; Halpern, 1988; Hodgson, 1951; Lapidaki & Webster, 1991; Levitin & Cook, 1996; Lund, 1939). However, there is general agreement that the experience of musical time is not separable from the subjects' age (Bamberger, 1994; Petzold, 1966; Shuter-Dyson & Gabriel, 1981; Zenatti, 1993). To counter this deficiency, it has proved necessary to investigate the following question: Is the capacity for consistent tempo judgements for particular pieces of music affected by the age of listeners (e.g., preadolescents, adolescents, and adults)? 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.

Furthermore, the capability to perceive different musical parameters, such as tonality, harmony, form, and rhythm, without being able to identify and analyse them, is considered to be the outgrowth of implicit musical knowledge or acculturation (Hargreaves, 1986; Francès, 1988; Bigand, 1993). In other words, 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 ability to possess 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). The study was therefore concerned whether the musical background of listeners, that is, the level of formal music education and/or participation in specialised musical activities, affected the consistency in the perception of the correct tempo.

Purpose

The present study was designed to investigate the consistency of "correct" tempo as it might exist in compositions of various musical styles among when evaluated by subjects with differing musical background, age, familiarity with, and preference for selected music. It should be noted that the study was about the extent to which individuals can set consistent tempi across four separate trials: no attempt was made to establish whether or not these tempi were correct as compared with those set by the composers in the original pieces. Along these lines, it was reasoned that if a correct tempo did exist, subjects ought to be able to arrive at consistent judgements about the tempo of examples despite the examples being presented with differing initial tempi in every session.

Is there an "absolute" or "right" tempo" which may be considered as a unifying construct of the music examples chosen and whose function is the synthesis of finite, juxtaposed musical elements in relation to "real" time? Is the concept of a particular tempo represented in the mind as a consistent musical entity like pitch, perhaps due to a distinct, yet unconscious, psychobiological clock "programmed" during the listening process?

To investigate these issues, we reasoned that if an "absolute" tempo did exist, subjects ought to be able to arrive at a consistent decision about the tempo of examples if these judgements occurred over a period of several days and if the initial tempo of each hearing was varied systematically. We also wondered whether listeners from different age groups with high levels of formal music education and listeners with little formal music education would demonstrate different levels of consistency. Finally, what effect would the style of the listening examples have on consistency of judged tempo?

Research Questions

- (1) Is there a consistent judgement 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 judgement affected by the age of the listener?
- (3) Is the consistency of tempo judgement affected by the musical background of the listener?
- (4) Is the consistency of tempo judgement affected by the style of music?
- (5) Is the perception of tempo affected by the familiarity with
 - a) the individual pieces and
 - b) their overall style?
- (6) Is the consistency of tempo judgement affected by the listener's preference/liking for a particular musical example?

Methodology

Apparatus

The software program employed for both recording and playback of performance data was the professional MIDI sequencing program Performer from Mark of the Unicorn. This program was chosen in large part because of its ability to alter the graphic window display on the computer screen 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. Set in manual tempo mode, the tempo slider of the graphic window display on the Macintosh 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.

Selection of Musical Examples

In all trials subjects listened to the following six compositions: C-major and A-minor *Two-Part Inventions* by J. S. Bach (Bach I and II, respectively), *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 (e.g., Baroque, Impressionistic, contemporary idiom, rock ballad, and dance music), familiarity, and preference.

Subjects

Subjects ($n=90$) were recruited from different age groups—30 adults (25-52 years), 30 adolescents (junior and senior high school students), and 30 preadolescents (fifth and sixth grade children). Individuals

of each age group were selected on the basis of musical background and willingness to participate. Within each age group, half the subjects were musicians, half were nonmusicians.

Procedures

For the four testing sessions, 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. Once the six compositions were judged, the subject was asked to return in 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 (I.T.) of the listening examples in order to eliminate the possibility on contextual cues. Two initial tempi have been used: M.M. $q = 20$ (slow I.T.) and M.M. $q = 200$ (fast I.T.); all tempo judgements 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.

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. Subjects had to answer questions concerning their familiarity with the particular example and its relevant musical style, after they judged the correct tempo of each example.

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.

Results

To test the hypothesis that listeners would render consistent tempo judgements, independently from the initial tempi, a one-way repeated ANOVA for each musical example was performed using tempo judgements 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 show that listeners did not exhibit significant consistency in their judgements of the most appropriate tempo of the musical examples across the four trials (Bach I, $F = 84.43$, $p < .0001$; Bach II, $F = 86.27$, $p < .0001$; Debussy, $F = 80.37$, $p < .0001$; Lapidakis, $F = 139.07$, $p < .0001$; Beatles, $F = 59.02$, $p < .0001$; Greek dance, $F = 78.856$, $p < .0001$).

Further examination of the results revealed that both means of tempo judgements 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: the slower initial tempo generally evoked slower preferences, and so on.

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 judgement consistency for each musical example. IDS reflects the standard deviation of the four different tempo judgements (Y1, Y2, Y3, and Y4) at the four trials for an individual. IDS gives a more global sense for the deviations of each group. IDS was used as a 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 1, results clearly indicated that adults were the most consistent and preadolescents the most inconsistent with regard to all musical examples ($p < .001$). In other words, the following consistency scale for all musical examples was observed with respect to the three age groups: preadolescents < adolescent < adults.

Table 1

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

MUSICAL EXAMPLES	AGE GROUPS					
	PRE-ADOLESCENTS ^a		ADOLESCENTS ^a		ADULTS ^a	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
BACH I	51.168	35.200	39.592	35.200	18.592	25.733
BACH II	49.654	26.973	37.046	21.557	22.769	23.376
DEBUSSY	48.962	23.336	42.058	22.661	15.511	20.434
LAPIDAKIS	64.351	28.047	55.758	30.590	37.551	30.765
BEATLES	43.466	21.085	15.260	12.264	11.094	17.947
GREEK DANCE	41.404	26.969	36.685	20.589	14.613	18.628

Note. $N=90$. ^a $n=30$.

$P < .001$

To examine the effect of musical background, a repeated measures MANOVA for each musical example was employed using tempo judgements of each trial and musical background as variables. The reason that the regular repeated measures univariate analysis of variance (ANOVA) was not performed was that data did not exhibit sphericity. The results showed that the musical background of the listener did not significantly affect consistency of tempo judgements for all six pieces (Bach I, $F=0.79$, $p < .01$; Bach II, $F=0.73$, $p < .01$; Lapidakis, $F=0.73$, $p < .01$; Beatles, $F=0.47$, $p < .01$; Greek dance, $F=0.97$, $p < .0001$), with the exception of the Debussy composition ($F=4.00$, $p < .01$).

Furthermore, 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 judgement consistency. The results clearly indicated that the only time musicians and non-musicians differed in consistency of tempo judgements was in Debussy ($p < .01$).

To answer the fourth question regarding differences between compositional styles, a repeated measures ANOVA 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. The results revealed that the style of rock ballad exhibited the highest degree of

consistency ($M=23.27$, $SD=22.54$) followed by the styles of Greek dance music ($M=30.90$, $SD=25.02$), Impressionism ($M=35.510$, $SD=26.29$), and Baroque ($M=36.51$, $SD=29.53$ (Bach I, $M=36.53$ & Bach II, $M=36.49$)), respectively ($F=13.68$, $p < .0001$). The tempo judgements for the contemporary idiom were the less consistent among all styles ($M=52.55$, $SD=31.56$). In other words, the following consistency scale with respect to the musical styles was observed in subjects' tempo judgements: Rock ballad < Greek dance music < Impressionism < Baroque < Contemporary idiom.

A repeated measures MANOVA was performed using tempo judgements 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 judgements ($p < .001$).

Furthermore, a repeated measures MANOVA was employed using tempo judgements averaged over the four trials and preference levels as variables. Results revealed that tempo judgements were significantly affected by subject's preference for the musical examples ($p < .05$).

The musical ability of 'absolute tempo'

A closer look at the range separating the fastest from the slowest tempo judgements of individual subjects for each piece often revealed strikingly small discrepancies. 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 judgements 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 the ability of absolute tempo with respect to all pieces for which they had the same level of familiarity. Contrary to absolute pitch, one 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 judgements. 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.

Recommendations for Music Education

Perhaps the most important insight gained from this study is that right tempo judgements lie deeply within the human ear which intuitively attempts to supply its own right tempo to melody, phrasing, harmony, rhythm, and other long-scale musical events, in order to ensure their meaningful coordination and motion through real time. Along these lines, it becomes obvious that music educators can guide students to achieve a better sense of recognition and mastery of all kinds of relations in a piece of music by helping them develop a more refined or discerning concept of tempo (Lapidaki, 1992 & 2000).

To help students of all ages to 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 organise and control the passage of time in music by means of digital technology (Lapidaki, 1990).

In this context, the finding that most listeners did not exhibit the musical ability of absolute tempo 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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SHORT NOTE OF BIOGRAPHIC DETAILS

Eleni Lapidaki is a professor of music education and psychology at the Department of Musical Studies, Aristotle University of Thessaloniki, Greece, and a research fellow at the Center for the Study of Education and the Musical Experience (CSEME), School of Music, Northwestern University, U.S.A. Her dissertation from Northwestern University has been given the "Outstanding Dissertation in Music Education Award" by the Council for Research in Music Education (CRME) at the 1998 Music Education National Conference (MENC) in Phoenix, AZ. Her research concerns a closer interaction between the artistic, scientific, and pedagogical aspects of temporal experience in music. It was published in the book *On the Nature of Musical Experience* (Eds. Bennett Reimer & Jeffrey Wright), in *Psychomusicology*, co-authored by Peter Webster, and *Music Education Research* (Vol. 2, No.1, 2000). She also presented her research at the 1999 "Research in Music Education: An International Conference," University of Exeter, and at the 1999 Conference of the Society of Music Perception and Cognition (SMPC).



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