

CONSISTENCY OF TEMPO JUDGMENTS WHEN LISTENING TO MUSIC OF DIFFERENT STYLES

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This study was designed to determine whether adult musicians and nonmusicians could consistently set tempi when listening to music examples drawn from Western art music of different styles. Three specific questions were posed: (a) is there a consistent judgment of tempo across three separate trials of the same music excerpt using varying initial tempi for each trial; (b) is the judgment of tempo affected by the music background of the subjects; and (c) is the judgment of tempo affected by the style of the excerpt? Subjects ($n = 20$) heard the same three music examples on three separate occasions. Each session systematically varied the order of the presentation and the initial tempo of the examples. Each was recorded digitally and performed in real time with a computer controlling a MIDI synthesizer. Results of a repeated measures ANOVA indicated significant differences from trial to trial for each music example. The initial tempo was shown to dominate the final, "correct" judgment. Few statistically significant differences in tempo judgment were found as a result of music background and compositional style.

There is near unanimity in the definition of music tempo as the "time" of a 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 or "correct" 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.

Empirical research on the broad subject of tempo has taken many directions. There has been extensive inquiry into the effect of tempo on listener preference (Geringer & Madsen, 1987; LeBlanc, 1981; LeBlanc & Cote, 1983; LeBlanc & McCrary, 1983; Sims, 1987), on preferred tempi in music performance (Brown, 1981; Wapnick, 1980, 1987), and on discrimination of tempo changes in music listening (Wang, 1983; Kuhn, 1974). 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.

Investigations concerning tempo consistency in music and nonmusic environments were performed around the first half of the century and were often referred to as "personal" tempo studies (Wallin, 1911; Frischeisen-Kohler, 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

Editorial and
Business Offices: Psychomusicology
Illinois State University
College of Fine Arts
CVA 116
Normal, IL 61761

Published by: The Office of Research in
Arts Technology
Illinois State University

Psychomusicology abstracts appear in *The Music Index*, *Psychological Abstracts*, *Music Psychology Index*, *CAIRSS™ Project*, and the *International Repertory of Music Literature (RILM)*.

Psychomusicology is produced using an in-house system of: Apple Macintosh microcomputers and LaserWriter II NT printer networked on an AppleShare LAN with software including *Microsoft Works*, *Aldus PageMaker*, and *Silicon Beach SuperPaint*.

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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 music performance 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 psychobiologic clock or clocks which functioned sub-consciously 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).

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).

In addition to studies that employ traditional listening and 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 music 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 (nonmusic 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 results, the variations of the means for the proper waltz tempo were slight but for the fox-trot were equivocal in some degree. Results seemed 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 behavior 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 this 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 music 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).

Fifty-four years later, Halpern (1988) conducted a similar two-part study with nonmusic 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). 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 et al. 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, which used 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 judgments of tempo are consistent over an extended period of time, especially when subjects are presented with compositions from Western art music of different style periods. Also of importance would be how these judgments might differ among subjects with different music backgrounds.

The present study was designed to investigate the consistency of "correct" tempo as it might exist in compositions of Western art music when evaluated by adult listeners with both music and nonmusic background.

To investigate these issues, we reasoned that if a "correct" tempo did exist, subjects ought to be able to arrive at a consistent decision about the tempo of examples if these judgments occurred over a period of several days and if the initial tempo of each hearing was varied systematically. We also wondered whether 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 but who profess to listen to music regularly would demonstrate different levels of consistency. Each of these groups interacts with music in different ways and each might have developed different cognitive abilities for tempo judgments. Finally, what effect would the style of the examples of Western art music have on consistency of judged tempo?

Three specific questions were posed:

1. Is there a consistent judgment of tempo across three separate trials of the same music excerpt using varying initial tempi for each trial?
2. Is the judgment of tempo affected by the music background of the subjects?
3. Is the judgment of tempo affected by the style of the excerpt?

Methodology

Subjects

Subjects ($n = 20$) were recruited from a pool of adults at a university in the midwestern United States and ranged in age from 25 to 57. Individuals were selected on the basis of music background and willingness to participate. The musicians were 15 professors and graduate students in the School of Music (five composers, five performers, and five music education specialists). This group represented a wide array of significant experience in music. The nonmusicians were professors and graduate students from other departments of the university. These individuals had little formal training in music, but did have wide ranging backgrounds in music listening consistent with what might be expected for well-educated adults.

Apparatus and Music Examples

Music examples were recorded on a Macintosh SE computer linked via MIDI to a Casio CZ-1 synthesizer. The timbre used for all examples was the classical piano preset. The software program employed for both recording and for use by the subjects was the professional sequencing program *Performer* (version 2.2) from Mark of the Unicorn. This program was chosen because of its ability to alter the graphic window display on the Macintosh so that the metronome controls could be easily manipulated without revealing the beats per minute. Figure 1 displays the Macintosh screen for one of the music examples in the test series.

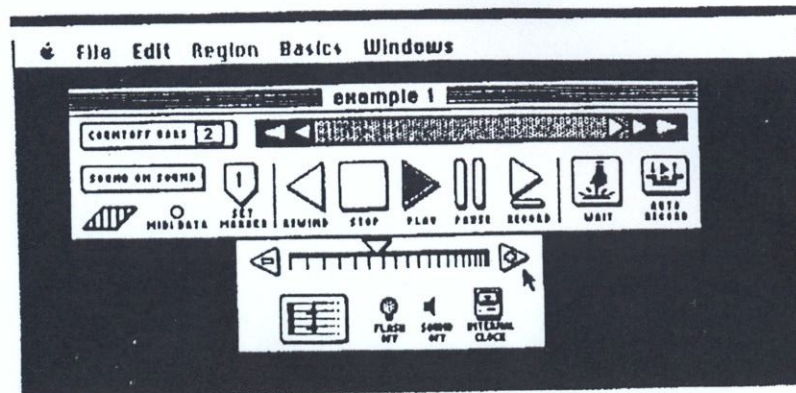


Figure 1. Computer screen display used to indicate tempo.

The tempo of each music example could be easily set by the experimenter prior to each trial of each music example. The mouse was used by the experimenter to manipulate the tempo, following the explicit directions of each subject. Subjects were not asked to use the mouse themselves, since to do so would have required training for a number of subjects. However, it was felt that the subjects ought to be able to view the computer screen during the judgment process in order that they could quickly grasp the preciseness and ease with which the tempi could be changed by the technology.

Three music examples were used: J.S. Bach's "Air in D Major" from Suite No. 3 in D major; Chopin's Prelude No. 7, Op. 28, and Schoenberg's second piece from *Sechs Kleine Stücke*, Op. 19. These works were chosen because they represented a wide range of music style and familiarity.

Procedures

All subjects were tested in a private room, isolated from outside noise. The computer was placed on a table facing the subject and the experimenter, with the synthesizer and amplification/speaker system mounted at a comfortable distance away. For the three testing sessions, subjects were asked to make tempo judgments for each of the three compositions. They were asked to listen to each composition and indicate whether the experimenter should 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. When the subject indicated that the tempo was correct, the experimenter turned the computer screen in such a way as to shield its view from the subject, revealed the portion of the metronome window on the computer screen that contained the tempo indication, recorded the value, and then reset the computer for the next music example in the session. Once the three music examples were judged, the subject was asked to return in three days for the next session.

Each session for a subject systematically varied the order of the music examples and the initial tempo of the examples to eliminate the possibility of contextual cues. In the first session the initial tempi and the order of the examples were as follows: Bach (MM $J=108$), Chopin (MM $J=45$), Schoenberg (MM $J=108$). In the second session, the order was: Schoenberg (MM $J=45$), Chopin (MM $J=108$), and Bach (MM $J=45$). In the third session, the initial tempo of each piece was set individually as the average of the subject's two previous trial tempo judgments and the order was set as: Chopin, Schoenberg, and Bach.

All judgments were recorded by noting the beats per minute, usually referenced as the metronome marking (MM). These values were used as continuous scales for appropriate statistical measures, including means, standard deviations, ranges, and a repeated measures ANOVA. The .01 level of significance was adopted as the alpha level.

Results

To help answer the first question which dealt with consistency across trials, graphs of the judged tempi were constructed for each music example (see Figures 2, 3, and 4).

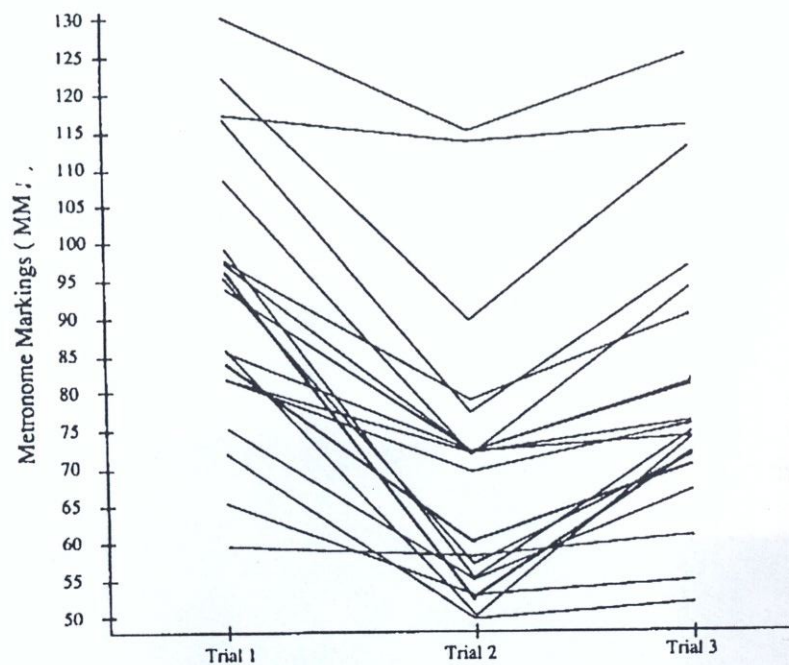


Figure 2. Individual judgments ($n = 20$) of correct tempo across three trials of the Bach, "Air in D Major." Trial 1: initial tempo, $MM = 108$, $M = 92.9$, $SD = 19$; Trial 2: initial tempo, $MM = 45$, $M = 69.7$, $SD = 18.9$; Trial 3: initial tempo set individually as average of first two trials, $M = 80.1$, $SD = 19.9$; $F(2,32) = 57.5$, $p < .01$.

Each line represents one of the twenty subjects. Average MM judgments for each trial for each music example are noted. For each music example, a few subjects were quite consistent (as noted by the straight lines); however, the vast majority of subjects were clearly influenced by the initial tempo of the trial. The influence of the faster and slower initial tempi in the first two trials is quite clear. Note, too, that in the third trial—which had an initial tempo set individually as the average of the first two trial judgments—the tendency of subjects was to stay close to this average.

To further analyze these results and to provide an answer to the second question which dealt with the effect of the subjects' background, three 3×4 repeated measures ANOVA were performed using trial and music background as the independent variables. Table I displays the cell means noting significant F ratios. There were no significant interaction effects.

Table I
Cell Means for Tempo Decisions from each Trial Arranged by Music Example and Subject Group

	Composers	Performers	Groups			Trial Average
			Music Educ	Nonmusic		
Bach	85.4	91.2	87.6	107.2	92.9	$F(2,32) = 57.5^*$
Trial 1: Fast		62.4	73.4	82.4	69.7	
Trial 2: Slow		73.2	77.4	97.8	80.1	
Group Average	72.7	75.6	79.5	95.8		
Chopin	76.8	96.2	91.6	101.0	91.4	$F(2,32) = 8.8^*$
Trial 1: Fast		75.2	78.2	96.6	80.8	
Trial 2: Slow		86.2	83.4	102.2	87.9	
Group Average	76.5	85.9	84.4	99.9		
Schoenberg	65.2	120.2	110.8	104.0	100.1	$F(2,32) = 23.9^*$
Trial 1: Fast		90.8	98.8	57.2	75.3	
Trial 2: Slow		105.0	105.8	79.4	87.0	
Group Average	59.0	105.3	105.1	80.2		
						$F(3,32) = 6.5^*$

Note. Total $n = 20$; Group $n = 5$; $*p < .01$

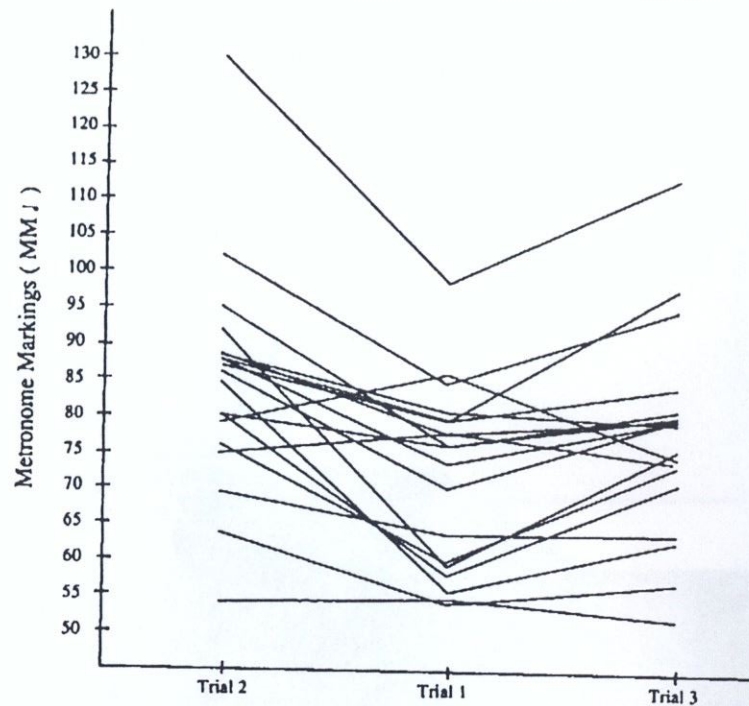


Figure 3. Individual judgments ($n = 20$) of correct tempo across three trials of the Chopin, "Prelude No. 7, Op. 28." Trial 1: initial tempo, $MM = 108$, $M = 91.9$, $SD = 19.9$; Trial 2: initial tempo, $MM = 45$, $M = 80.8$, $SD = 24.9$; Trial 3: initial tempo set individually as average of first two trials, $M = 87.9$, $SD = 27.4$; $F(2,32) = 8.8$, $p < .01$.

The table documents statistically significant differences across trials for all three examples (Bach, $F[2,32] = 57.5$, $p < .01$; Chopin, $F[2,32] = 8.8$, $p < .01$; and Schoenberg, $F[2,32] = 23.9$, $p < .01$). This confirms statistically the visual inspection of the figures.

With reference to the second question regarding music background, the analyses also revealed no group effects, except for the Schoenberg example ($F[3,32] = 6.5$, $p < .01$). Composers, as a group, heard this example slower than the other groups, in fact over 46 beats per minute slower than the other musician groups. An inspection of the pattern of response of the composers for this example across each trial also revealed very consistent tempo judgments.

To answer the third question regarding differences between compositional styles, average range differences were used. Rather than treating trials as an independent variable, a repeated measures ANOVA with the totals of each mu-

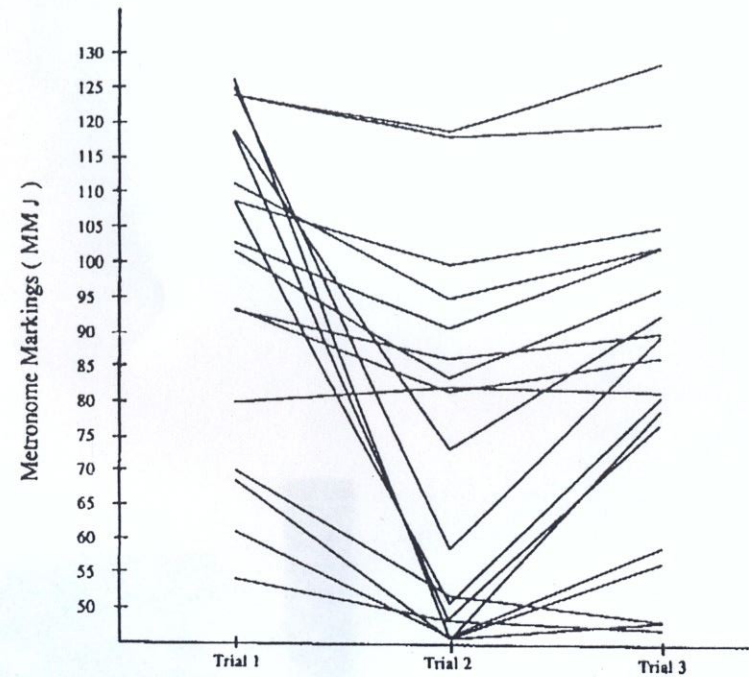


Figure 4. Individual judgments ($n = 20$) of correct tempo across three trials of the Schoenberg, *Sechs Kleine Stücke*, Op. 19. Trial 1: initial tempo, $MM = 108$, $M = 100.1$, $SD = 29.8$; Trial 2: initial tempo, $MM = 45$, $M = 75.3$, $SD = 28.7$; Trial 3: initial tempo set individually as average of first two trials, $M = 87$, $SD = 27.8$; $F(2,32) = 23.9$, $p < .01$.

sic example as an independent variable was performed. The unit of measure was the range (highest minus the lowest metronome marking).

This analysis showed no statistically significant differences between styles. Mean tendencies showed that the Chopin was the more consistently judged example and that the music educators and composers were the more consistent groups, but these were not statistically significant findings. Future research with larger samples might reveal more definitive results.

Conclusions

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 of music examples taken from the literature of Western art music, especially if the judges were drawn from a population of highly experienced musicians. 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 by highly skilled musicians in repeated listening tasks of the same music examples, initial tempo has a dominant effect on "correct" tempo judgments. Simply stated, no single "correct" tempo emerges as a consistent characteristic of group performance. Our sample of adult, nonmusicians indicated a basis for a similar conclusion. These results do not support the observations reported by Farnsworth et al. (1934), Lund (1939), and Hodgson (1951) that there exists a correct tempo associated with a particular piece.

Listeners' perceptions of correct tempo for a particular music example varied dramatically from one individual to another. It is important to note the remarkable parallel between this observation and the individual differences that result when different performers interpret the same music example through a broad range of tempi (Lester, 1982; see especially page 278). Future research might well explore this.

Music background of the subjects and the style of music examples may have some bearing on consistency judgments, but this study revealed no overall, statistically significant results to support these contentions. For the Bach and the Chopin examples, subjects without music background differed from the musicians by adopting generally faster tempi. This was not a statistically significant difference, but the tendency is worth noting when designing future work.

The particularly slow and quite consistent judgments by the composers for the Schoenberg example was an interesting finding. One reason might be that either the example itself or the general, atonal quality of the example was highly familiar to or highly preferred by the composers. Further research studies should take careful steps to assess familiarity and preference of music examples so that the role of these important variables might be more clearly understood.

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