

## Effects of articulation styles on perception of modulated tempos in violin excerpts

By: John M. Geringer, Clifford K. Madsen, and [Rebecca B. MacLeod](#)

Geringer, J. M., Madsen, C. K., MacLeod, R. B. (2007). The effect of articulation style on perception of tempo in solo violin playing. *International Journal of Music Education*, 25 (2), 165-175.

Made available courtesy of Sage Publications: <http://www.sagepub.com/>

**\*\*\*Reprinted with permission. No further reproduction is authorized without written permission from Sage Publications. This version of the document is not the version of record. Figures and/or pictures may be missing from this format of the document.\*\*\***

### **Editor's introduction:**

In traditional music cognition research, pitch and rhythm are often viewed as the primary dimensions of music. Not surprisingly, it is possible to find many studies regarding the perception, processing and memorization of these two musical dimensions in the literature. These studies are important because they shed light on the ways in which the human mind perceives, processes, memorizes and makes sense of music. And these, in turn, are central to music education.

In this well-designed experimental research paper, Geringer, Madsen and MacLeod studied the effect of three articulation styles on the ability of musicians to perceive tempo modulation. They subjected American university students to a perception task that included listening to 18 violin excerpts (taken from a piece by Kreisler and one by Papini) and rating them according to tempo modulations and articulations. In other words, they provided student listeners with musical examples played in *pizzicato*, *legato* and *staccato* that became faster, slower or remained in tempo.

The data analysis revealed clear and conclusive results. The authors found that the articulation styles and the direction of modulations affected listeners' perception of tempo, and, moreover, that these two factors interacted significantly. For example, legato examples were judged as increasing in tempo more (and decreasing less) than staccato and pizzicato excerpts for both pieces. They also found that differences between articulation styles were not as large in the example with greater rhythmic activity. When listener preferences were assessed, Geringer, Madsen and MacLeod also found a significant preference for the no-change and tempo increase than for the tempo-decrease modulations.

These results raise some very interesting questions that have clear implications for music teaching and learning. One important question refers to the issue of context. Although here the authors were not making a comparison between the two pieces per se, the contrasting results for each piece were quite remarkable, which leads one to ask: Does the context of a piece (i.e. style articulation, performance and ornamentation) affect how listeners perceive tempo modulation in music? Another important question raised by this study refers to the performance of a solo instrument versus an ensemble. What roles do timbre and texture play in the perception of tempo modulation in music? This study also elicits questions regarding listener preferences for some specific combinations of articulation and tempo. Listeners preferred staccato passages that were kept on tempo, and legato passages that were played on either steady tempi or accelerando. By contrast, they did not show preferences for decreased tempi. Why did this occur, given that all excerpts included complete musical phrases? What are the implications of these results for the perception of cadences and musical phrase endings? These are questions that certainly need to be addressed by future research.

We are certain that those *International Journal of Music Education: Research* readers who play in or conduct ensembles will find some connection between these findings and their own performance experiences. Although future research in the area is urgently needed, findings from this particular study may well indicate some tacit

knowledge that many conductors, composers and educators already have. As editors, we certainly hope to see further studies of this nature in future issues of our journal.

### **Abstract:**

We investigated effects of legato, staccato and pizzicato articulation styles on the perception of modulated tempos. Seventy-two music majors served as participants. Two solo violin excerpts were chosen with contrasting rhythmic rates and were recorded in all three articulation styles. Examples were presented to listeners in three conditions of tempo modulation: gradual increase, gradual decrease or no change. Tempo changes were produced gradually so that listeners would not notice abrupt changes. Analysis of results showed that articulation style and the direction of modulation affected listeners' perception of tempo, and, importantly, these two factors interacted significantly. Legato examples were judged as increasing in tempo more (and decreasing less) than staccato and pizzicato examples in both excerpts. Differences between articulation styles were not as large in the example with greater rhythmic activity. Listeners preferred the no-change and tempo-increase modulations to the tempo decreases. Implications for further research, performance practice and teaching are discussed.

**Key words:** legato, performance practice, pizzicato, staccato, style, tempo

### **Article:**

Tempo and pulse are essential elements in music. The character or mood of an entire piece is dependent on a tempo that facilitates appropriate style and energy, and a pulse that is regular and easily anticipated is required for cohesive ensemble performance. Performers spend hours of practice with a metronome to regulate tempo and maintain a constant pulse. However, music is perhaps never performed without some degree of temporal deviation. It may be argued that slight increases or decreases in tempo help to create an artistic sound. Expressive timing has been studied in a variety of music contexts, including jazz (Rose, 1989), waltzes (Gabrielsson, 1999) and western art music (Gabrielsson, 1999; Johnson, 2003; Repp, 1990). The amount and direction of tempo deviation that is acceptable may be influenced by a number of variables, including listener discrimination, style, period and specific musical context.

Perceptual aspects related to tempo have influenced theories of preference. A large body of research has found that when given a choice, subjects frequently prefer faster tempi to slower tempi (Geringer, 1976; LeBlanc, 1981; LeBlanc & Cote, 1983; LeBlanc, Colman, McCrary, Sherrill, & Malin, 1988; Sims, 1987). LeBlanc et al. (1988) studied the effect of tempo on preference of third grade through college-aged students and found a strong correlation between increased tempi and increased preference when listening to jazz excerpts. Yarbrough (1987) used Chopin and Mozart examples and assessed the tempo preference of 400 musicians and non-musicians. Both groups preferred slower tempi for fast pieces and faster tempi for slow pieces. Additionally, Geringer and Madsen (1987) asked 500 participants to listen to familiar popular music that had been altered in tempo and pitch. Listeners preferred excerpts at their original tempo. The disparate results in tempo preference research does not seem surprising when one considers the many variables that affect preference, such as familiarity, genre or musical context.

Listener ability to discriminate tempo modulation has been investigated by a number of researchers. Madsen, Duke and Geringer (1986) found that both musicians and non-musicians demonstrated a tendency to overestimate tempo when asked to assign a metronome marking to a musical excerpt. Tempo decreases have been identified with greater accuracy than tempo increases, in multiple studies that investigated tempo discrimination (Geringer, Madsen, & Duke, 1993; Kuhn, 1974; Madsen, 1979). Kuhn (1974), for example, found that professional musicians were more accurate in identifying decreases in tempo modulation than increases, and identified examples that decreased significantly faster than those that increased in tempo.

In other research studies, participants demonstrated greater accuracy in identifying increases in tempo than decreases (Geringer & Madsen, 1984; Wang, 1983). Duke (1994) investigated listeners' ability to recognize the same rhythm under different tempo conditions and found that rhythmic discrimination was more accurate when the second example was performed at a faster tempo than the first example. Wang (1983) suggested that style

may have influenced tempo perception in detection of tempo increases in an example by J. S. Bach. Subsequent research revealed that participants detected tempo modulations at different rates for different compositions (Wang & Salzberg, 1984).

The effect of melodic rate or rhythmic activity may provide an explanation for seemingly conflicting results in research on tempo discrimination. Melodic rate refers to the amount of melodic material that occurs in a measure or specific unit of time. Investigation of melodic rate and ornamentation found that subjects perceive changes in rate as an increase or decrease in tempo regardless of the underlying pulse (Duke, 1989; Duke, 1994; Kuhn, 1987; Kuhn & Booth, 1988).

Age and training also affect tempo perception. When given an audible pulse and asked to select a beat-note pulse, musicians chose a tempo between 70 and 120 bpm incorporating subdivisions, while non-musicians or students with less training simply tapped the audible pulse at its given rate (Duke, Geringer, & Madsen, 1991). Musical training given to elementary students significantly affected performance accuracy though not perception of tempo (Ellis, 1992), and an increase in tempo discrimination skills has been noted between the ages of 7 and 13 (Wang & Salzberg, 1984).

The effect of articulation style on the discrimination of tempo has been infrequently studied. Possible effects of style or context on perception were discussed in previous research but not investigated directly (Duke et al., 1988; Geringer & Madsen, 1984; Wang, 1983; Wang & Salzberg, 1984). Recently, Geringer, Madsen, MacLeod and Droe (2006) investigated the effect of legato and articulation styles on the perception of modulated tempos using instrumental ensemble excerpts. Analysis of the 90 music majors' responses showed that both articulation style and direction of modulation affected perception of tempo, and that these two factors interacted significantly. Although staccato stimuli were judged as increasing in tempo more than legato stimuli, differences between the two styles were larger in tempo-increase examples compared to no-change and tempo-decrease examples.

The purpose of the present study was to extend the research of Geringer et al. (2006) by examining responses to different articulation styles of a solo instrument, violin, rather than using ensemble excerpts. We studied the effect of three articulation styles on the ability of musicians to perceive tempo modulation. The following specific questions were asked: Will solo violin excerpts performed with staccato, legato and pizzicato articulation affect music majors' perception of tempo in presentations that increase gradually, decrease gradually, or do not change in tempo? Will the three articulation styles differentially affect listener preferences regarding tempo modulation?

## **Method**

Upper-division undergraduate and graduate students ( $N = 72$ ) enrolled in music degree programs at a large state university in the USA voluntarily participated. Students were tested in four groups in the same room that is used daily for music classes seating approximately 25 students. The classroom sound system was used to present stimuli (Sony STR DE598 amplifier, Sony CDP361 CD player, and Paradigm speakers).

### ***Music stimuli***

We searched for examples that could be performed musically on violin using each of the three articulations under study: staccato, legato and pizzicato. We also sought examples with differing rates of rhythmic activity in the melody, since this factor has been shown to influence judgments of beat speed (see earlier). After discussing the sorts of examples we were seeking with experienced violin studio teachers and performers, two works were identified that contained appropriate sections: the first eight measures of the *Rigaudon* from Kreisler's *Sicilienne and Rigaudon*, and Papini's *Theme and Variations*, measures 9–24. The Kreisler excerpt consists almost entirely of 16th notes, primarily on successive scale degrees. We set the tempo for this excerpt at quarter note = 88. The Papini example contains quarter notes (on more than half of the beats), eighth notes, and half notes at the end of each four-measure phrase, also with mostly conjunct intervals. Performed tempo for this excerpt was quarter note = 176. The Kreisler example thus was more rhythmically active (e.g. constant 1 6th

notes) than the Papini (mostly quarter notes). Both of the excerpts were 22 seconds in duration when performed at the designated tempos, and contained complete musical phrases.

Two professional violinists performed the excerpts. One performer has been a member of several major symphonies in the USA and is on the violin faculty at a large university in the southeastern USA. The second violinist also has extensive performance experience and is currently a doctoral performance student at the same institution. Multiple recordings by each of the violinists were made until satisfactory versions were attained with steady tempo and consistently correct articulations. Recordings were made in a studio designed for small ensembles and solo performers. Recording equipment included two Shure 57A microphones and a Sony 59ES digital audio tape recorder. An audible metronome was used to give the tempo for the practice trials. During the recorded trials, performers used either the flashing light setting on the metronome, or a click track with the beat audible only using headphones. A tuning meter calibrated to  $A_4 = 440$  Hz was also provided.

Digital tape recordings were transferred directly to computer files via coaxial cable and a 24-bit, 96 KHz sound card (M-Audio Audiophile 2496). We tested each overall excerpt, individual phrase, and note-to-note durations of the final examples of each articulation and found no consistent tempo increases or decreases. The six recorded examples (three articulations of the two excerpts) were then modified to create three versions of each: examples that gradually increased in tempo, examples that gradually decreased in tempo, and examples that did not change in tempo from the original version. We wanted both the tempo increases and decreases to be gradual enough so that musician listeners would not be able to hear any particular increment of change, but sufficient enough so that during the duration of the excerpt it would be noticeable with careful listening that the example had sped up or slowed down. Based upon previous research that utilized abrupt tempo changes of  $\pm 12$  percent (Duke et al., 1988; Geringer & Madsen, 1984), incremental change during an extended listening example (Geringer & Madsen, 2003) and a recent similar study (Geringer et al., 2006), we modulated the increased or decreased examples by 6 percent from the original tempo. Using computer software (Amazing Slow Downer v. 2.7.8, Roni Music, Malmö, Sweden), the tempo was changed (without changing pitch levels) in six discrete increments of 1 percent. During the first six seconds of each example, no changes were made, so that listeners could establish the unchanged original tempo. Following second 6, a 1 percent change (increase or decrease) was made, then another change of 1 percent following second 8, again after second 10, and after seconds 12, 14 and 16. During the remainder of the excerpts (approximately six seconds), no further changes in tempo were made.

### *Procedure*

The six examples (two pieces, each performed with the three articulations) were presented to listeners in three tempo modulation conditions: tempo increase, tempo decrease and no change in tempo. This resulted in a total of 18 experimental stimuli. An additional example (a 20-second excerpt from Mozart's *Serenade in B flat, K361, movement 7*) was added and presented at the beginning to all listeners as a practice excerpt to help ensure that the procedures were understood. The 18 experimental examples were presented on CD to listeners in four separate groups in different counterbalanced orders to distribute probable effects of presentation order. Kreisler and Papini excerpts were presented alternately, to prevent the ending tempo of a given example from influencing the initial perception of a subsequent example from the same piece. The following instructions were read to listeners:

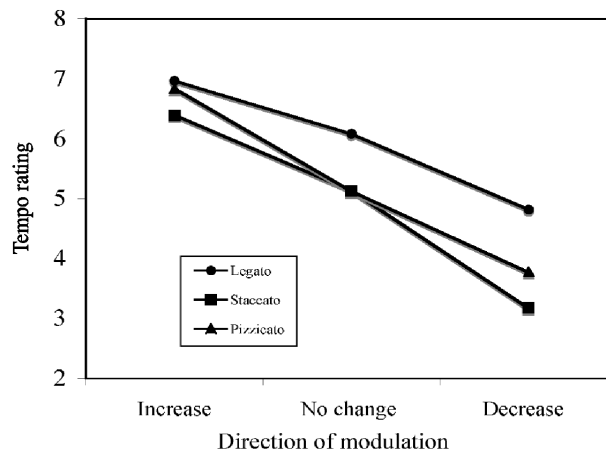
This is a project regarding the perception of tempo. You will hear one practice example followed by 18 short music excerpts. For each excerpt indicate whether you hear the tempo increase, decrease or remain the same. Some of the examples do not change, others may have subtle changes and others may be more obvious. Indicate the direction and amount of change that you perceive by circling the appropriate number. For example, if you hear a large increase in tempo, you would circle +4 or +5, or, if you perceive a subtle decrease in tempo, then you would circle -1 or -2. The examples are presented fairly quickly, so you won't have much time to think about your answer – we are interested in your immediate feeling about the tempo, not whether you are right or wrong. Just determine whether or not the tempo changes, mark the degree to which it

changes, and then indicate your degree of liking or disliking for the performed tempo (not whether you liked the piece but whether you liked the tempo as performed). As you listen, please do not keep time visibly or audibly. Are there any questions? I will stop after the first example to see whether you have any additional questions.

Participants indicated responses on prepared forms that consisted of two 11-point rating scales for each stimulus. The first scale was designed to assess perceived changes in tempo, if any, and ranged from -5 (labeled as 'extreme decrease in tempo') to +5 (labeled as 'extreme increase in tempo'). The spaces between points 1 and 2 on the negative and positive sides of the midpoint were labeled as 'subtle decreases' (increases) in tempo. The zero rating was labeled 'no-change'. The second rating scale was designed to assess listener preferences for the tempo performed, not for the excerpt itself. This scale also included points ranging from -5 (labeled as 'strong dislike'), through -1 (labeled as 'mild dislike'), 0 ('no preference'), +1 ('mild like'), to +5 ('strong like').

## Results

We used separate multivariate analyses of variance for the listener judgments of tempo change and for tempo change preferences, with the two excerpts as the variates. Both analyses included one between-subjects factor (the four orders of presentation) and two within-subjects factors (the three articulation styles and the three conditions of tempo change). We used an alpha level of .01 for rejection of null hypotheses in all statistical tests.



**Figure 1** Significant interaction between articulation style and direction of modulation for Papini tempo ratings.

### Perception of tempo modulations

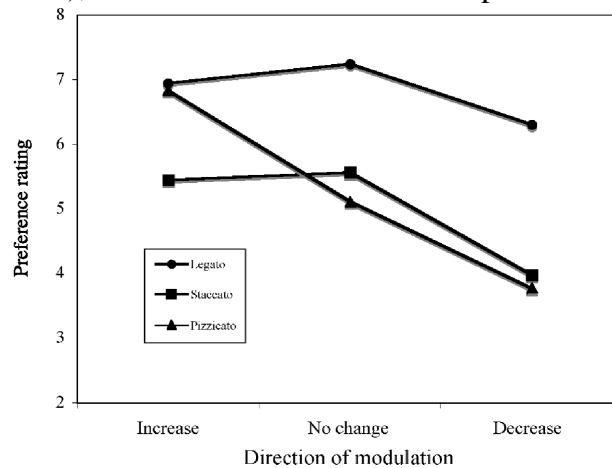
In the analysis of the tempo ratings, there were no significant multivariate main effects for presentation order or interactions with order. Significant multivariate main effects were found for the variables of articulation style,  $F(4, 65) = 22.64, p < .001, \text{partial } \eta^2 = .582$ , and direction of tempo change,  $F(4, 65) = 174.71, p < .001, \text{partial } \eta^2 = .915$ . However, there was a significant multivariate interaction between articulation style and direction of tempo change,  $F(8, 61) = 4.54, p < .001, \text{partial } \eta^2 = .373$ . There were no other significant interactions.

Subsequent univariate analyses showed significant effects of articulation style as well as direction of tempo change for both the Papini and Kreisler excerpts. A significant univariate interaction was found for the Papini example,  $F(4, 272) = 6.57, p < .001, \text{partial } \eta^2 = .088$ , but not for the Kreisler example,  $F(4, 272) = 2.02, p > .09$ .

Figure 1 shows the interaction between the direction of modulation and the three articulation styles for tempo ratings of the Papini excerpt. Mean responses to tempo increases were higher than to the no-change examples, which were higher than ratings for the tempo-decrease examples. Legato style received higher mean tempo ratings in all three conditions of modulation than the other two articulation styles (overall legato  $M = 5.95$ , pizzicato  $M = 5.23$ , and staccato  $M = 4.90$ ). Pizzicato articulation was rated as increasing more than staccato in

the tempo-increase condition and the tempo-decrease condition, but they were rated the same in the unchanged tempo condition. Pizzicato ( $M = 6.83$ ) and legato ( $M = 6.96$ ) were rated similarly in the tempo-increase condition.

Mean tempo ratings for the Kreisler excerpt were higher than for those of the Papini excerpt. Tempo-increase examples were rated significantly higher ( $p < .001$  using the Bonferroni adjustment for multiple comparisons) than the no-change examples, which were higher ( $p < .001$ ) than the tempo-decrease examples. Kreisler legato style examples again received higher mean tempo ratings in all three conditions of modulation than the other two articulation styles (overall legato  $M = 6.85$ , staccato  $M = 6.52$ , and pizzicato  $M = 6.42$ ), although the ratings were much closer together for this excerpt compared to Papini. Mean differences between legato and pizzicato were significantly different ( $p < .01$ ), but other differences between pairs of means were not.



**Figure 2** Significant interaction between articulation and direction of tempo change for Papini preference ratings.

### Preferences for tempo modulations

Analysis of preference ratings for the stimuli showed no significant difference between presentation orders or in any interactions with order. There was a significant multivariate difference between the articulation styles,  $F(4, 65) = 24.04, p < .001, partial \eta^2 = .597$ , and between the direction of change,  $F(4, 65) = 37.68, p < .001, partial \eta^2 = .699$ . However, there was a significant multivariate interaction between articulation style and direction of tempo change,  $F(8, 61) = 9.62, p < .001, partial \eta^2 = .558$ . There were no other significant interactions.

Subsequent univariate testing showed that there were significant differences in preference ratings between the articulation styles in the Papini excerpt,  $F(2, 136) = 53.94, p < .001, partial \eta^2 = .442$ , but not for the Kreisler excerpt,  $F(2, 136) = 3.90, p > .02$ . Differences were significant in both excerpts for the three modulation conditions. There were no significant univariate interactions with the exception of the articulation style and direction of change interaction in the case of the Papini example,  $F(4, 272) = 16.14, p < .001, partial \eta^2 = .192$ , but not for the Kreisler example,  $F(4, 272) = 2.25, p > .06$ .

Figure 2 shows the significant interaction between the direction of modulation and the three articulation styles for tempo change preferences of the Papini excerpt. The overall preference mean for legato ( $M = 6.83$ ) was higher than means for pizzicato ( $M = 5.23$ ) and staccato ( $M = 5.00$ ) styles. Listeners in the no-change and tempo-decrease examples preferred legato articulation to the other two styles. In the tempo-increase examples, legato and pizzicato styles were preferred more than the staccato examples. In the no-change and tempo-increase conditions, preferences for legato and staccato styles were stable, but were lower for the tempo decreases. In contrast, pizzicato preferences decreased steadily from the increase to no-change to decrease examples. Highest preference ratings were given to legato style in no-change and tempo-increase conditions, and to pizzicato style in the tempo-increase condition. Lowest preferences were shown for the tempo decreases with both pizzicato and staccato articulations.

Preference ratings in the Kreisler excerpt were not consistently different between the three articulation styles, and the interaction between styles and direction of change was not significant. Listeners preferred the no-change condition ( $M = 7.03$ ) significantly more ( $p < .01$  according to the Bonferroni adjustment) than the tempo increases ( $M = 6.38$ ) and tempo decreases ( $M = 6.19$ ). Listeners gave lowest preference ratings to pizzicato articulation in the tempo-decrease condition ( $M = 5.60$ ), and the highest ratings to legato in the no-tempo-change condition ( $M = 7.28$ ). Ratings were similar for all three articulations in the tempo-increase condition.

## Discussion

The present investigation was purposefully designed to ascertain the interactions between and among the changes in articulation and tempo. Results indicated that there were differences between the three articulation styles and, as expected, large differences between the directions of modulation. Importantly, however, these two factors interacted significantly. Further, responses differed to the specific excerpts that varied in rate of rhythmic activity. Although the primary purpose was not to compare differences directly between these two specific selections, listeners' responses to the articulation styles were clearly not the same. As was noted in the literature review, Kuhn (1987) and Duke (1989) found that the speed of the melodic rhythm consequentially influences perception of relative tempo. In this study, the underlying pulse of the excerpts was purposefully structured to be the same (88 bpm), with the difference being in the rate at which individual notes were played. Listeners perceived modulations in the two excerpts differently. This leads to further speculation regarding whether there are unique contextual effects for every different excerpt, regardless of tempo. It seems possible that style variations such as articulation and rhythmic ornamentation have comparable or perhaps, in some contexts, larger effects than tempo itself. It is also possible that articulation style may have an influence that is inextricably linked to the activity level of melodic rhythm.

Although these findings in general support the conclusions of a recent related study (Geringer et al., 2006), specific differences shown for the articulation styles are not consistent with the earlier results. In the present study using solo violin excerpts, legato examples were rated consistently as increasing in tempo more (and decreasing less) than staccato and pizzicato examples. In contrast, the earlier research used two examples of instrumental ensemble excerpts and found that staccato stimuli were judged consistently as increasing more in tempo than legato stimuli, particularly in the tempo-increase examples. Differences in results may be attributed to a number of contextual variables. It is possible that solo performance is perceived differently from ensemble performance. For example, listeners in the present study perceived legato articulation as increasing in tempo more than staccato and pizzicato excerpts, and this perception was more pronounced in the excerpt with less rhythmic activity. In an ensemble performance, the silence between the shorter articulations (staccato and pizzicato) would likely be less obvious because of the connected sonority inherent in an ensemble performance, whereas an unaccompanied solo instrument allows the listener to focus on the sound of only that one instrument, with discernable silences between short notes. It is also possible that timbre as well as texture have an effect on tempo perception. Is tempo perceived the same if excerpts were performed on different instruments? The addition of a third articulation (pizzicato) may also have affected listeners' perception of tempo.

In the previous study with ensemble examples (Geringer et al., 2006), listeners showed a tendency to prefer staccato passages that perceptibly do not rush or slow down, as opposed to legato sections that appear to be preferred with both steady tempo and slight gradual increases in tempo. In the present study, listeners also preferred legato passages with steady tempos, and both legato and pizzicato passages in examples with tempo increases compared to staccato examples. Teachers and conductors may find value in carefully listening to recordings of rehearsals and performances, perhaps using a metronome. Such analyses may reveal further differentiation between actual tempo performance and listener perceptions (Madsen et al., 1986). Wapnick (1987) documented that there is a large discrepancy between metronomic markings and actual tempo of performers.

Additional research is necessary to corroborate these results in a variety of contexts. Present findings appear to have general implications for music performance and teaching. An ensemble performance may elicit a different

listener response than an unaccompanied solo performance. If articulation style does in fact affect listener perception of tempo, it seems prudent to consider the tempo of a given excerpt prior to a performance with the influence of the articulation in mind. Appropriate interpretation of music as well as discrimination in music listening are obviously important ongoing issues for music teachers and others concerned about authentic performance and meaningful listening. Furthermore, although there are many music terms that provide interpretive guidelines, questions still arise concerning the degree of perception that listeners are able to demonstrate when subtle and, in some cases, even large changes are made. Subsequent research is needed to address these and related questions.

## References

- Duke, R. A. (1989). Effect of melodic rhythm on elementary students' and college undergraduates' perception of relative tempo. *Journal of Research in Music Education, 37*, 246–257.
- Duke, R. A. (1994). When tempo changes rhythm: The effect of tempo on musicians' perception of rhythm. *Journal of Research in Music Education, 42*, 27–35.
- Duke, R. A., Geringer, J. M., & Madsen, C. K. (1988). The effect of tempo on pitch perception. *Journal of Research in Music Education, 36*, 108–125.
- Duke, R. A., Geringer, J. M., & Madsen, C. K. (1991). Performance of perceived beat in relation to age and music training. *Journal of Research in Music Education, 39*, 108–125.
- Ellis, M. C. (1992). Tempo perception and performance of elementary students, grades 3–6. *Journal of Research in Music Education, 40*, 329–341.
- Gabrielsson, A. (1999). The performance of music. In D. Deutsch (Ed.), *The psychology of music* (2nd ed.) (pp. 501–602). San Diego, CA: Academic Press.
- Geringer, J. M. (1976). Tuning preferences in recorded orchestral music. *Journal of Research in Music Education, 24*, 169–176.
- Geringer, J. M., & Madsen, C. K. (1984). Pitch and tempo discrimination in recorded orchestral music among musicians and nonmusicians. *Journal of Research in Music Education, 32*, 195–204.
- Geringer, J. M., & Madsen, C. K. (1987). Pitch and tempo discrimination in recorded popular music. In C. K. Madsen and C. A. Prickett (Eds.), *Applications of research in music behavior* (pp. 204–212). Tuscaloosa, AL: University of Alabama Press.
- Geringer, J. M., & Madsen, C. K. (2003). Gradual tempo change and aesthetic responses of music majors. *International Journal of Music Education, 40*(1), 3–15.
- Geringer, J. M., Madsen, C. K., & Duke, R. A. (1993). Perception of beat note change in modulating tempos. *Bulletin for Council of Research in Music Education, 119*, 49–57.
- Geringer, J. M., Madsen, C. K., MacLeod, R. B., & Droeg, K. (2006). The effect of articulation style on perception of modulated tempo. *Journal of Research in Music Education, 54*, 324–336.
- Johnson, C. M. (2003). Effect of rubato magnitude on the perception of musicianship in musical performance. *Journal of Research in Music Education, 51*, 115–123.
- Kuhn, T. L. (1974). Effects of dynamics, halves of exercise, and trial sequences on tempo accuracy. *Journal of Research in Music Education, 22*, 270–277.
- Kuhn, T. L. (1987). The effect of tempo, meter, and melodic complexity on the perception of tempo. In C. K. Madsen and C. A. Prickett (Eds.), *Applications of research in music behavior* (pp. 165–174). Tuscaloosa, AL: University of Alabama Press.
- Kuhn, T. L., & Booth, G. (1988). The effect of melodic activity, tempo change, and audible beat on tempo perception of elementary school students. *Journal of Research in Music Education, 36*(3), 140–155.
- LeBlanc, A. (1981). Effects of style, tempo, and performing medium on children's music preference. *Journal of Research in Music Education, 29*, 143–156.
- LeBlanc, A., & Cote, R. (1983). Effects of tempo and performing medium on children's music preference. *Journal of Research in Music Education, 31*, 57–66.
- LeBlanc, A., Colman, J., McCrary, J., Sherrill, C., & Malin, S. (1988). Tempo preferences of different age music listeners. *Journal of Research in Music Education, 36*, 156–168.
- Madsen, C. K. (1979). Modulated beat discrimination among musicians and nonmusicians. *Journal of Research in Music Education, 27*, 57–67.



- Madsen, C. K., Duke, R. A., & Geringer, J. M. (1986). The effect of speed alterations on tempo note selection. *Journal of Research in Music Education*, 34(2), 101–110.
- Repp, B. H. (1990). Patterns of expressive timing in performances of a Beethoven minuet by nineteen famous pianists. *Journal of the Acoustical Society of America*, 88, 622–641.
- Rose, R. F. (1989). An analysis of timing in jazz rhythm section performance. Unpublished doctoral dissertation, University of Texas at Austin.
- Sims, W. (1987). Effect of tempo on music preference of preschool through fourth-grade children. In C. K. Madsen and C. A. Prickett (Eds.), *Applications of research in music behavior* (pp. 15–25). Tuscaloosa, AL: University of Alabama Press.
- Wang, C. C. (1983). Discrimination of modulated music tempo by music majors. *Journal of Research in Music Education*, 31, 49–55.
- Wang, C. C., & Salzberg, R. S. (1984). Discrimination of modulated music tempo by string students. *Journal of Research in Music Education*, 32, 123–131.
- Wapnick, J. (1987). A comparison of tempo selections by professional editors, pianists, and harpsichordists in Bach's *Well-Tempered Clavier, Book I*. In C. K. Madsen and C. A. Prickett (Eds.), *Applications of research in music behavior* (pp. 190–203). Tuscaloosa, AL: University of Alabama Press.
- Yarbrough, C. (1987). The effect of music excerpts on tempo discriminations and preferences of musicians and non-musicians. In C. K. Madsen and C. A. Prickett (Eds.), *Applications of research in music behavior* (pp. 175–189). Tuscaloosa, AL: University of Alabama Press.