Factors Affecting the Choice of Performed Tempo

Erica Bisesi
Department of Physics, University of Udine, Italy

Giovanni Bruno Vicario
Department of Philosophy, University of Udine, Italy

Introduction

The question of whether an optimal tempo exists for performing musical melodies is regarded as a central issue in both the cognitive psychology of music [1,2,3,6,7,24,25,26,27,34] and in music performance practice. This problem arises directly out of broader issues about "correct" performing speeds. Perceptual experiments on moving images show that selected speeds are comprised into a very narrow range: this implies that a "correct" velocity of image rendering does exist [10,20]. By analogy, one could expect that perception of musical stimuli should require a well-defined speed: lower values in interval durations would be excluded by the impossibility of connecting subsequent elements with each other, while faster realizations would prevent a clear distinction of components [17,25]. However, musical practice results in considerably different conclusions, as it is a general belief among professional musicians and performers that a certain melody – and more generally a given piece – may be played at many speeds, as demonstrated by the availability of multiple realizations of a single piece by professional performers, as well as numerous interpretations by the same performer. Not only is this fact self-evident, but musicians just base their own interpretations on the adequacy of the selected tempo, according to their expressive purpose. Reversing the problem, the musical score is never played exactly as written, because musicians in creating their own personal interpretation vary a range of both mutual-dependent acoustic and musical dimensions once the overall tempo has been fixed. The question of how listeners' tempo regulations are guided by specific music cues has been investigated in literature [3,5,6,11,12,14,15,20,29,32]. The general underlying assumption is that musical tempo is perceived as analogous to physical motion [1,3,5,7,8,11,16,20,29,36], and therefore certain musical phenomena may influence the choice of a "correct" speed of melody performance [5,6,7,8,14,25,34]. For example, performers may use *(i) timing* variations (variations in the "inter-onset" interval, i.e. the time interval between the onset of the tone and the onset of the immediately following tone) [12,20,29,32,33,34], *(ii) dynamics* (variations in the intensity of notes or chords) [11], *(iii) articulation* (the degree of *staccato* (separation) or *legato* (overlap) of successive events) [3,5,29] to communicate a musical structure and/or an expressive content [1,15,29]. Furthermore, some efforts in previous studies focused on rhythmic, grouping and structural aspects [13,15,19,21,26,29,30], although neglecting many possible effects related to the topic addressed hereby.

Research Questions

There have been a number of attempts to investigate tempo in music [1,2,3,4,5,6,7,11,12,13,14,16,17,19,20,23,24,25,26,27,28,29,30,32,33,34,35,36]. Recent results show that listeners are capable of making consistent tempo judgments [1,2,4,18,24,25,26] and that the optimal tempo varies across extracts [1,25], while other studies demonstrate that rhythm is important in making temporal judgments [1,5,17,26,27], and/or investigating the effects of rhythmic pattern and tempo on periodic grouping [25,29,30]. Other findings strongly suggest that the style of musical examples influences the degree of tempo consistency across trials [23]. Despite the relevant number of attempts to address the question, we are lacking systematic investigations of the dependence of the rendering (or performing) speed on the character of a piece (fast or slow), the musical style and the instrumental ensemble. Within this framework, our main research questions are:

- Does an optimal tempo exist for rendering musical melodies?
- If yes, is this comprised of a wide range of accepted speeds or not?
- What are the main factors influencing the performer's choice?
- Are these factors related to one another, and – eventually – in which way?

Methods

Two main aspects may be recognised as possibly influencing the suitability of tempo for a given melody: *(a) expressivity* [12,15,29,33,36,37] and *(b) musical structure* and *grouping* [1,12,13,15,29]. The experiment described below deals with the first aspect: the role of expressivity on the rendering speed.

Experimental stimuli consisted of 2 series of 7 differently randomised speeds for each performance of the 4 pieces listed in Table 1: 2 flute baroque-style melodies and 2 string quartets from the classical period. Whereas restricting the investigation to only two musical styles may initially seem like a limitation of the method, our choice was mainly suggested by the lower number of expressive cues involved in baroque and classical-style compositions, allowing a greater flexibility in selecting the rendered tempo.

piece	**character**	**instrument**
J. S. BACH – BWV 1013, *Allemande*	fast	flute
L. van BEETHOVEN – op.18 n.4, *Allegro ma non tanto*	fast	string quartet
J. S. BACH – BWV 1031, *Sicilienne*	slow	flute and harpsichord
F. J. HAYDN – op.76 n.1, *Adagio sostenuto*	slow	string quartet

Table 1. Musical pieces used as trials in experimental setup, listed by intrinsic expressive character (for instance, *Allegro* versus *Adagio*) and instrument(s) involved.

Subjects

We asked 12 trained musicians (6 pianists, 1 flutist, 1 clarinettist, 1 horn player, 1 conductor, 1 singer, 1 guitarist) to rate each stimulus in a grid spanning from "extremely slow" to "extremely fast" boundaries, passing across "a little too slow", "slow but acceptable", "ok", "fast but acceptable" and "a little too fast" (Figure 1). Minimum and maximum metronomic values of the trials were decided in a preliminary test carried out with a few number of subjects, and normalised within each character category (fast and slow pieces). Intermediate speeds were then fixed in a logarithmic scale. The pieces listed above were presented in 9 short extracts (no more than a musical period for each one). The first two stimuli – repeated at the end of each series were used to train the participant and subsequently ruled out.

Piece 1	extremely slow	a little too slow	slow, but acceptable	OK	fast, but acceptable	a little too fast	extremely fast
1							
2							
3							
4							
5							
6							
7							
8							
9							

Figure 1. Example of working card distributed to participants for judging the piece's tempo. The grid spans from "extremely slow" boundary (red panel on the left), to "extremely fast" (red panel on the right), passing across "a little too slow" (orange), "slow but acceptable" (yellow), "ok" (green), "fast but acceptable" (yellow again), and "a little too fast" (orange).

Participants were divided into two groups, differing only in the expressive purpose of the trials they underwent: *(a) nominal,* i.e. inexpressive MIDI realizations of the score played by a computer, and *(b) expressive*, i.e. professional recordings of the same pieces. Data collected on the working cards were then processed by descriptive statistical analysis for repeated measures (mean effects comparison, variance, test F of the effect within subject, Bonferroni correction). Intermediate mean values have been interpreted as the "best" performance speed, while distributions of mean rates around the optimal tempo are indicative of the degree of tolerance in the choice. At the end of his/her evaluation, each participant completed a questionnaire designed to apprehend any possible difficulties they may have encountered, and the cognitive procedure followed in ascribing each rate. The experiment concluded with a lengthy discussion aimed at illustrating our experiment and purpose to the participant, and to gain his/her opinion of it and possible suggestions for future improvements.

Results

Mean cumulative rates for respectively fast and slow character pieces are shown in the left panel of Figure 2. The horizontal axis corresponds to the excerpt's tempo (from the lowest (0) to the highest (8)), while the vertical axis indicates the mean rates ascribed to each stimulus (from -3 – corresponding to extremely slow, to +3 – extremely fast). The righthand panel gives an equivalent representation of the same content.

The effect of expressivity on preferred and accepted speeds is shown in Figure 3. The optimal tempo is simply derived by the interception with the horizontal axis, while the range spreading between “slow but acceptable” and “fast but acceptable” conditions is indicated by coloured boxes.

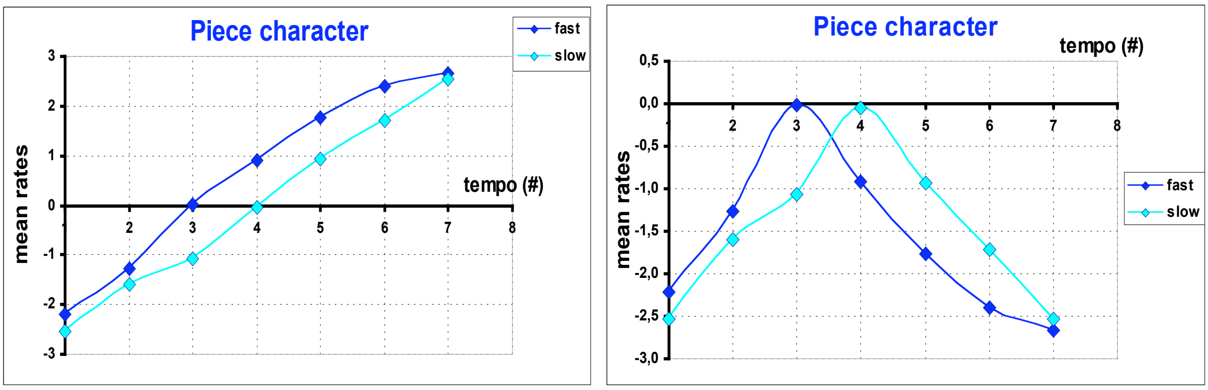
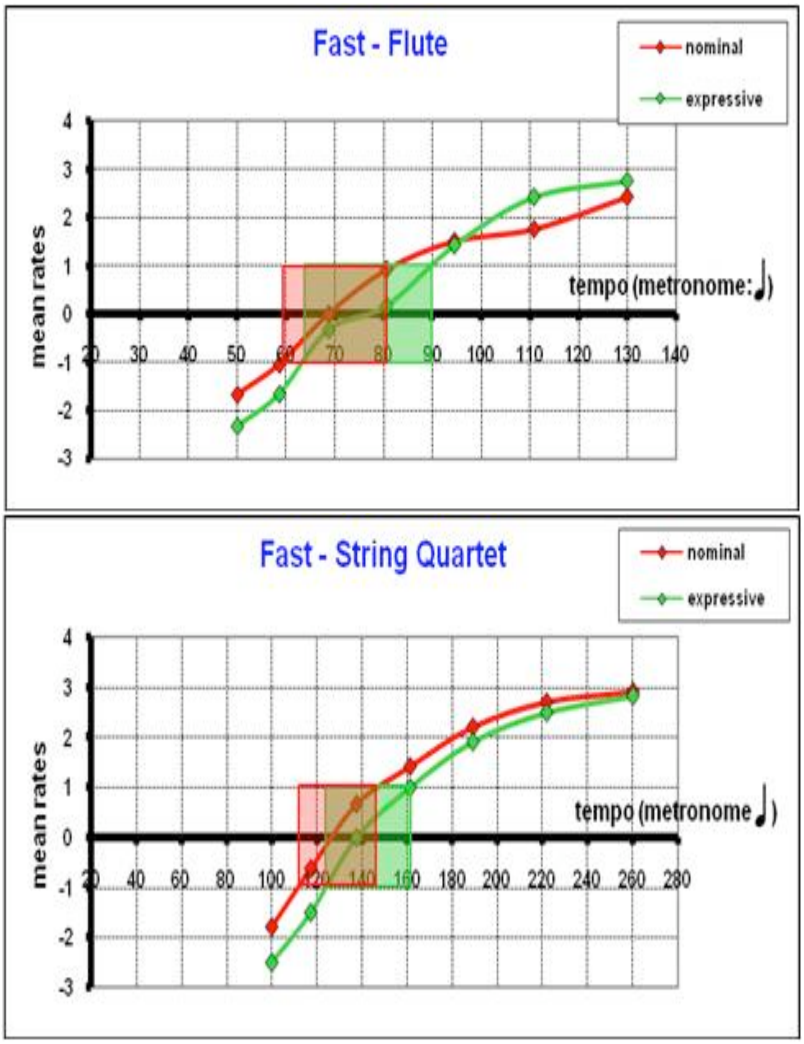


Figure 2. *Lefthand panel:* mean cumulative rates for fast (dark) and slow character pieces (light). Horizontal axis shows the excerpt’s tempo; vertical axis indicates the mean rates ascribed to each stimulus, from -3 (extremely slow) to +3 (extremely fast). *Righthand panel*: symmetrical rates far from the optimal situation are indicated with the same mark.



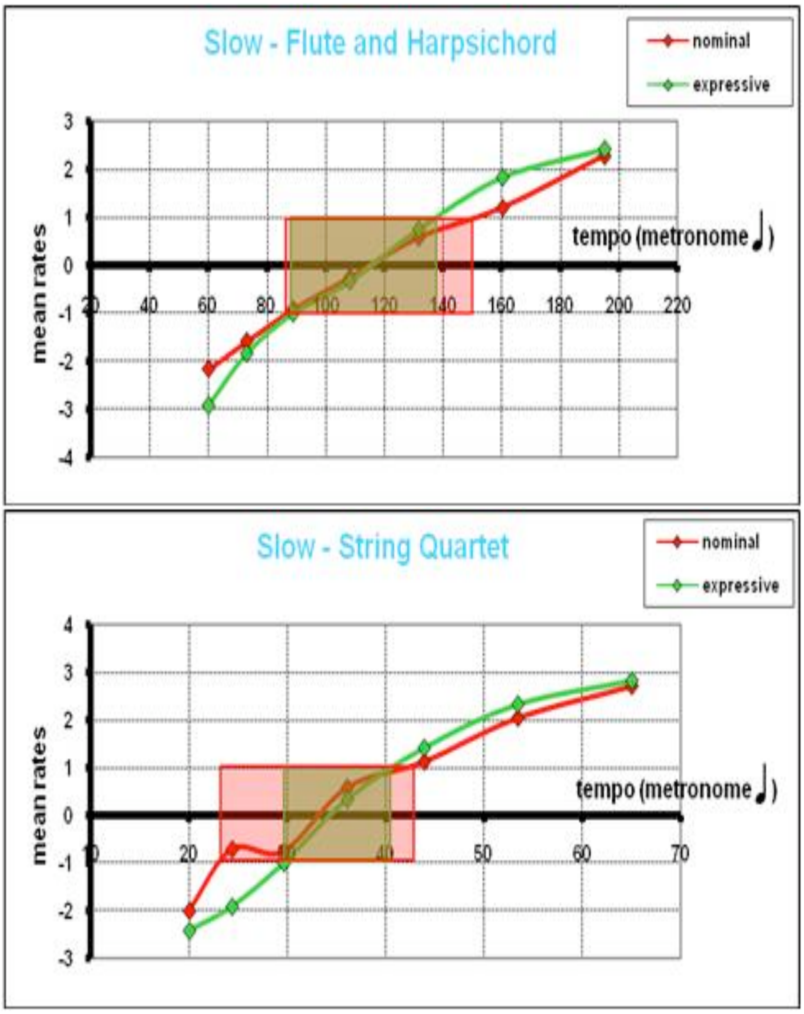


Figure 3. Role of expressivity on selected (preferred and tolerated) speeds. On the horizontal axis are metronomic speeds, while vertical ones indicate the mean rates ascribed to each trial, from -3 (extremely slow) to +3 (extremely fast). Coloured boxed indicate the range spreading between "slow but acceptable" (-1) and "fast but acceptable" conditions (+1). *Upper panel*: J. S. BACH – Partita BWV 1013 for solo flute, *Allemande; middle upper panel:* L. van BEETHOVEN – String Quartet op.18 n.4, *Allegro ma non tanto; middle lower panel:* J. S. BACH – Partita BWV 1031 for flute and harpsichord, *Sicilienne; lower panel:* F. J. HAYDN – String Quartet op.76 n.1, *Adagio sostenuto*. Metronomic velocities for fast and slow pieces are normalised to the elementary musical beat in each piece (respectively, ♩, 𝅗𝅥, ♪ and ♩ from upper to lower plot).

Discussion and Conclusions

As we can easily see from Figures 2 and 3, all the curves describing mean rates ascribed to different tempos are increasing monotonic functions (i.e. always not-decreasing or not-increasing functions, without changes in slope's sign) of the metronomic tempo. As participants were randomly allotted to the different trials, this means that their evaluations are not affected by the stimulus heard immediately before. This sounds surprising, mostly in view of the fact that during debriefing almost all participants stated the opposite. Our findings demonstrate that *there exists one (and only one) "preferred"* *speed in rendering melodies,* and that *its value is altered to compensate for the slower (faster) character of a piece with higher (lower) values* (Figure 2). This finding agrees with the known fact that, in acceleration, the short tempo varies less than the long one, because of its proximity to perception limits [17]. Moreover, participants indicated quite a wide range of "acceptable" tempos, whose standard deviation is smaller for fast character pieces, and larger for slow character ones (Figure 3). When looking at faster character pieces, it seems that the expressivity does not affect tempo distribution. This fact can be interpreted as follows: ideally, the addition of expressive elements to a nominal performance should enlarge the interval of speeds in order to preserve the musical features of the performance (provided that choices are made in a consistent way, i.e. according to the general principle of combining timing and dynamics in a way that is dependent on the chosen global speed). Timing and dynamics may be combined to bring out a given musical event: for instance, in some Romantic repertoire, there is a tendency to reinforce a *crescendo* by initially speeding up the local tempo *(accelerando),* and subsequently slowing down *(rallentando)* before the climax. This approach – known as the *"congruence hypothesis"* [14] – seems to emphasise the effect of the climax in terms of both salience and emotional intensity, and is reflected by a characteristic counterclockwise movement of the *performance worm* (i.e. a representation based on an offline tempo-loudness animation developed by musicologist Jorg Langner [22]) in a smoothed intensity-tempo space [37]. On the opposite side, another paradigm interprets local tempo regulations as *"perceptual compensations"* [3,5,6,14,28,29], suggesting that the level of a given cue in a specific direction would influence another parameter in the opposite way (e.g. faster tempo would require a softer dynamic), so that the overall stimulus content would remain constant. This tendency also finds a correspondence in exchanges of heterogeneous properties of visual phenomena: an object moving at a physically defined velocity is perceived to move more slowly, if its size is bigger [9]. Nevertheless, our expressive trials do not reproduce this ideal situation, because they were produced by simply varying the rendering speed in real recordings; as original expressive features have been maintained, this implies that associations with different tempos were inconsistent. In this perspective, participants' tuning within the same range of judgements given to nominal performance can be regarded as a confirmation of the statement that *global tempo variations are well tolerated only if they correspond to adequate expressive features*. This effect is more evident in slow character expressive performances, whose range of tolerated speeds is also narrower as in the previous examples. Moreover, the expressive rendering mode influences the preferred speed by shifting it to higher values when the piece has a fast character; this is an irrelevant effect for the slow character melodies (Figure 3). This result may be ascribed to counterbalancing variations in local tempo.

In conclusion, our findings agree with the psychological statement of the existence of a "correct" speed for melody performance, when a musical piece is played without any expressive aim; at the same time, we can say that speeding melodies up and down without adequately changing their expressive content does not enlarge the range of possible optimal tempos. In order to shed light on the dependence of the preferred tempo on expressive elements, we plan to improve on this study by repeating the same experiment whilst controlling expressive features synthetically (i.e. by manipulating acoustical and musical cues one by one). By adapting the expressive content of each trial to its own speed, we will be able to investigate the laws connecting the global tempo to each expressive event in the multidimensional cue-space.

Scientific and Pedagogical Implications

One advantage of the experiment presented here is its ability to highlight the link between the speed of melody performance and psychoacoustic and musicological aspects (i.e. any acoustic cue relevant for expressive performance). Our findings – and scientific research on music performance in general – also provide indications for a possible alternative way of teaching musical topics in Further Education. By stimulating analytical reasoning with presentation of results like these into academic curricular paths, teachers can lead students to build logical and scientific categories useful to consciously discipline their artistic activity. A scientific or analytical approach to music performance is often absent from post-secondary music curricula, because much of the research is quite recent and because content of this kind tends to be associated more with intuitive rather than logical thinking. When piano teachers discuss interpretation in lessons and masterclasses, they may use high-level imagery that includes little or no specific detail about the role of different expressive cues in rendering musical works [31]. Pedagogical approaches of this kind may be combined with the existing discourses of performers and teachers, especially in the area of timing, dynamics, articulation and tempo.

Acknowledgments:
The authors are very grateful to Profs. Giulio Vidotto and Lucia Ronconi (University of Padova), for very useful discussions and suggestions.

References:

1. Auhagen, W. (1996). In G. W. Gruber, Review of the 3rd Congress for Music Theory, Vienna, Austria, 1996, *Music Theory Online*, Vol. 2, n. 7.
2. Auhagen, W. (2003). Preferred tempi of imagined compositions. In R. Kopiez, A. C. Lehmann, I. Wolther, & C. Wolf (Eds.), *Proceedings of the 5th Triennial ESCOM Conference*, Hanover, Germany: Hanover University of Music and Drama, 2003 (pp. 639–642).
3. Auhagen, W., & Busch, V. (1998). The influence of articulation on listeners' regulation of performed tempo. In R. Kopiez & W. Auhagen (Eds.), *Controlling creative processes in music*. Frankfurt am Main and New York: Peter Lang.
4. Behne, K. E. (1972). *Der Einfluß des Tempos auf die Beurteilung von Musik*. Köln: Volk.
5. Busch, V. (2004). Musical cues for listeners' tempo perception. In S. D. Lipscomb, & al. (Eds.), *Proceedings of the 8th International Conference on Music Perception and Cognition*, Evanston (IL), 2004 (pp. 456–457). Adelaide, Australia: Causal Productions.
6. Bisesi, E., & Vicario, G. B. (2009a, in press). Psychoacoustical aspects on the speed of melody performance. In M. M. Marin, M. Knoche, & R. Parncutt (Eds.), *Proceedings of the first International Conference of Students of Systematic Musicology (SysMus08),* Graz, Austria, 2008.
7. Bisesi, E., & Vicario, G. B. (2009b). The "right" speed of movements and preferred musical tempo. Accepted for publication in A. Galmonte, & R. Actis-Grosso (Eds.), *Different psychological perspectives on cognitive processes: current research trends in Alps-Adria region*. Cambridge: Cambridge Scholars Publishing.
8. Bozzi, P. (1990). *Fisica ingenua*. Milano: Garzanti Libri.
9. Brown, J. F. (1931). The visual perception of velocity. *Psychologische Forschung,* 14*,* 199–232.
10. Caprin, C. (1995). La natura delle alterazioni del tempo nella schizofrenia: una analisi sperimentale. *BcL Thesis,* Università degli Studi di Padova.
11. Dalla Bella, S., & Palmer, C. (2004). Tempo and dynamics in piano performance. In S. D. Lipscomb, & al. (Eds.), *Proceedings of the 8th International Conference on Music Perception and Cognition*, Evanston (IL), 2004 (pp. 256–257). Adelaide, Australia: Causal Productions.
12. Desain, P., & Honing, H. (1994). Does expressive timing in music performance scale proportionally with tempo? *Psychological Research*, 56, 285–292.
13. Deutsch, D. (1999). *The psychology of music*. 2nd Edition. San Diego: Academic Press.

14. Eitan, Z. (in press). Intensity contours and cross-dimensional interactions in music: Recent research and its implications for performance studies. *Orbis Musicae*, 14.
15. Friberg, A., & Battel, G. U. (2002). Structural communication. In R. Parncutt & G. E. McPherson, (Eds.), *The science and psychology of music performance: Creative strategies for teaching and learning* (pp. 199–218). New York: Oxford University Press.
16. Friberg, A., & Sundberg, J. (1999). Does music performance allude to locomotion? A model of final *ritardandi* derived from measurements of stopping runners. *Journal of Acoustical Society of America,* 105(3): 1469–1483.
17. Fraisse, P. (1974). *Psychologie du ritme*. Paris: Presses Universitaires de France.
18. Grepmair, L. J. (1990). Beethovens Metronomisierungsproblem. In *Musikpsychologie. Jahrbuch der Deutschen Gesellschaft für Musikpsychologie, 7* (pp. 157-172). Wilhemshaven: Noetzel.
19. Honing, H. (2005). Is there a perception-based alternative to kinematic models of tempo *rubato*? *Music Perception,* 23: 79–85.
20. Honing, H. (2005). Timing is tempo-specific. *Proceedings of the International Computer Music Conference,* Barcelona, Spain, 2005 (pp. 359–362). Barcelona: UPF.
21. Honing, H. (2006). Computational modelling of music cognition: A case study on model selection. *Music Perception*, 23: 365–376.
22. Langner, J., & Goebl, W. (2003). Representing expressive performance in tempo-loudness space. *Computer Music Journal,* 27(4): 69–83.
23. Lapidaki, E. (2000). Stability of tempo perception in music listening. *Music Education Research,* 2(1): 25–44.
24. LeBlanc, A., & al. (1988). Tempo preferences of different age music listeners. *Journal of Research in Music Education*, 36(3), 156–168.
25. Moelants, D., & McKinney, M. F. (2004). Tempo perception and musical content: What makes a piece fast, slow or temporally ambiguous?. In S. D. Lipscomb, & al. (Eds.), *Proceedings of the 8th International Conference on Music Perception and Cognition*, Evanston (IL), 2004 (pp. 558–562). Adelaide, Australia: Causal Productions.
26. Quinn S. C. M., & Watt R. J. (2004). Tempo judgements for music. In S. Lipscomb, & al. (Eds.), *Proceedings of the 8th International Conference on Music Perception and Cognition (ICMPC)*, Evanston (IL), 2004 (pp. 458–461), Adelaide, Australia: Causal Productions.
27. Quinn S., & Watt R. (2006). The perception of tempo in music. *Perception,* 35(2): 267–280.
28. Palmer, C. (1997). Music performance. *Annual Review of Psychology,* 48: 115–138.
29. Penel, A., & Drake, C. (1994). Timing variations in music performance: Musical communication, perceptual compensation, and/or motor control? *Attention, Perception & Psychophysics,* 66(4), 545–562.
30. Parncutt, R. (1994). Perceptual model of pulse salience and metrical accents. *Music Perception,* 11: 409–464.
31. Parncutt, R. (2007). Can researchers help artists? Music performance research for music students. *Music Performance Research,* 1: 13–50.
32. Repp, B. H. (1992). Diversity and commonality in music performance: An analysis of timing microstructure in Schumann's "Träumerei". *Journal of the Acoustical Society of America,* 92, 2546–2568.
33. Repp, B. H. (1994). Relational invariance of expressive microstructure across global tempo changes in music performance: An exploratory study. *Psychological Research/Psychologische Forschung,* 56, 269–284.
34. Repp, B. H. (1994). On determining the global tempo of a temporally modulated musical performance. *Psychology of Music,* 22, 157–167.
35. Sloboda, J. A. (1985). *The musical mind. The cognitive psychology of music.* Oxford: Oxford University Press.
36. Todd, N. P. (1995). The kinematics of musical expression. *Journal of the Acoustical Society of America,* 97: 1940–1949.
37. Widmer, G., & Goebl, W. (2004). Computational models of expressive music performance: The state of the art. *Journal of New Music Research,* 33(3): 203–216.