Analysis of tempo classes in performances of Mozart sonatas

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This preliminary study investigates the relationship between tempo indications in a score and the tempo performed by musicians. As several 18th century theorists point out, the chosen tempo should depend not only on the tempo indication, but also on other factors such as the time signature and the fastest note values to be played. It is examined whether the four main tempo indications (Adagio, Andante, Allegro, and Presto) imply specific tempo classes which can be found in professional performances or whether other factors influence the choice of performed tempo. In Experiment I, 34 movements of Mozart sonatas performed by one professional pianist are analysed. The mode of the inter-beat interval distribution of a performance is considered to be a representation of the performed tempo. The tempo values depend on what is taken as the beat level; performed tempo did not group according to tempo indications. Event density (score events per second) is found to separate the data into just two clusters, namely slow and fast movements. In experiment II, the tempo values of 12 movements of the first experiment were derived from commercial recordings (Barenboim, Pires, Schiff, Uchida) with the help of an interactive beat tracking system. The pianists' tempos are surprisingly homogenous; they deviate from each other more in slower movements than in the faster ones.

Introduction

Tempo indications should help the performer to know which tempo to choose when interpreting and performing a musical score. Up to the late Baroque period, tempo was self-evident without any special indications, as the texture of the score and the general musical knowledge of the performer were considered sufficient for him to be able to choose a suitable tempo. This changed as the literature became more and more individual. Words such as Adagio (at ease), Andante (walking), Allegro (cheerful), or Presto (quick), specify the particular character of a piece, and thus also the tempo. Daniel Gottlob Türk, a respected piano teacher and theorist, states: *"Ein jedes gutes Tonstück hat irgend einen bestimmten (herrschenden) Charakter, das heißt, der Komponist hat einen gewissen Grad der Freude oder Traurigkeit, des Scherzes oder Ernstes, der Wuth oder Gelassenheit u.s.w. darin ausgedrückt"*[1] (Türk, 1789, p. 114). He continues by saying that the character of a piece and its tempo are linked: *"Da nun zum Ausdrucke der verschiedenen Leidenschaften und Empfindungen, nach allen ihren Modifikationen, unter andern vorzüglich die geschwindere oder langsamere Bewegung viel beyträgt, so hat man auch mehrere Grade derselben angenommen, und zu deren Bestimmung verschiedene größtenteils italiänische Worte gewählt"*[2] (Türk, 1789, p. 114). Not only these Italian words are important for determining the performed tempo, but also factors such as the fastest note values to be played: *"The tempo of a piece, which is usually indicated by a variety of familiar Italian terms, is derived from its general mood together with the fastest notes and passages which it includes. Proper attention to these considerations will prevent an Allegro from being hurried and an Adagio from being dragged"* (Bach, 1949, chapter 3, p. 10).

Several studies have tried to measure the relation between the performed tempo and the subjective perception of the speed. La Motte-Haber (1968) found strong correlations between the impulse density of simple rhythms and slow-fast ratings by subjects. These results were replicated by Kleinen (1968), who introduced the measure of event density (the number of clearly audible notes per time unit). Similar approaches linking performance tempo and the rate of performed notes were used also for ethnological approaches (Christensen, 1960). The relation between expression or *affect* of a performance and performed tempo, as stated above by Türk and Bach, was also confirmed by psychological experiments (Hevner, 1937; Behne, 1972). In recent models for expressive music performance, tempo is one of the basic parameters for conveying emotional information to the listener

[1] *Every good piece has a prevailing character, that is, the composer expressed through it a certain degree of joy or sadness, humour or solemnity, rage or calmness, etc.* (Translation by the authors)

[2] *Because the slower or faster motion is important to express different sentiments and emotions, several steps of motion are used. To specify these, various Italian words were chosen.* (Translation by the authors)

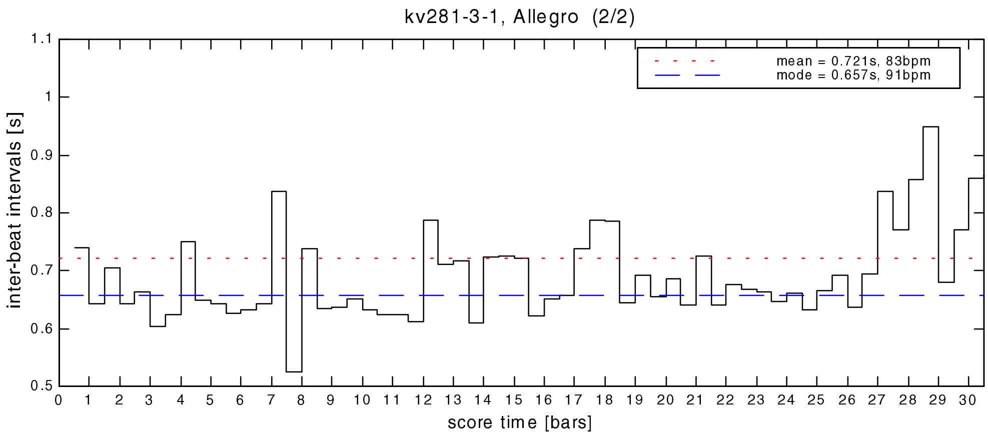

Figure 1. Timing curve at the beat level (half note) of the beginning (bars 1-30) of third movement of Mozart's K.281 piano sonata, performed by one professional pianist. The mean and the mode tempo values are marked by dotted and dashed lines respectively.

(Juslin, 1997; Juslin, Friberg, & Bresin, 1999; Bresin & Friberg, 2000).

In several experiments, Auhagen let subjects adjust the tempo of deadpan MIDI files of baroque music to their own preferred tempo (Auhagen, 1993, 1995a, 1997). He introduced several mathematical measures (such as the quotient of the maximum and the minimum numbers of melodic events per bar), which were found to correlate with the subjects' preferred tempos. Also variations in articulation and phrasing could influence listeners' judgements (Auhagen & Busch, 1998).

As theorists, composers (see Donington, 1980; Fallows, 1980), and contemporary music psychologists (e.g. Behne, 1972) agree that there is not one 'right' tempo for a musical score, it is of considerable interest to investigate what tempos are actually performed by musicians in relation to the indications at the musical score. Problematic were always metronome marks by composers (such as Beethoven) or by their students (like Czerny, Hummel, etc.). A hypothesis that these metronome designations were misunderstood by a factor of two, was rejected by several studies (Auhagen, 1987, 1995b). Another hypothesis by David Epstein that tempo relations within a musical work tend to be performed as small integer ratios (Epstein, 1995), was tested by Bachmann (1999). He analysed over 200 performances of the nine Beethoven symphonies with regard to proportional tempo relations within and between the movements of a symphony. His results confirm Epstein's hypothesis.

Performed tempo is never stable. There are always slowing downs, delayed notes, tempo changes according to phrasing, and some random variation by the player. The huge amount of recent music-psychologist literature on production and perception of expressive timing is sufficiently summarised in Gabrielsson (1999) and Palmer (1997).

What is tempo?

When talking about tempo, it should first be defined what *tempo* actually is. The common definition specifies tempo as the number of equally spaced events (beats) per time unit (minute). The beat is usually defined by the denominator of the time signature of a musical score.

In expressive performances, the inter-beat intervals (IBIs) vary significantly during a performance. Modern performance research deals increasingly with large sets of expressive performance data, derived either from computer-monitored instruments (Widmer, 2001) or by automated analysis of audio recordings (Dixon, 2001). In order to extract a tempo value from expressive performance data which corresponds best to the 'perceived' tempo, several mathematical methods have to be considered. Gabrielsson (1999) distinguishes between the *mean tempo* (average number of beats per minute across the whole piece, disregarding any expressive variations), the *main tempo* (the prevailing tempo of passages, where slow beginnings or final ritardandos or some inter-phrasal caesuras are removed), and *local* or *instant tempo* (which signifies the corresponding M.M. value of a single IBI or the instantaneous percentage deviation from the mean) (Gabrielsson, 1999, p. 540). In a perceptual study on tempo, Repp (1994) found that listeners' adjustments of a metronome to expressive performances correspond quite well to the mean tempo of these performances. However, he points out that large final ritardandos would make an average value too low. In the present study, we develop the modal value of the inter-beat interval distribution as a more accurate representation of the performed main tempo (see below).

The perceptual sensitivity to tempo changes (just noticeable difference, JND) lies around 1-2% of the inter-beat interval,

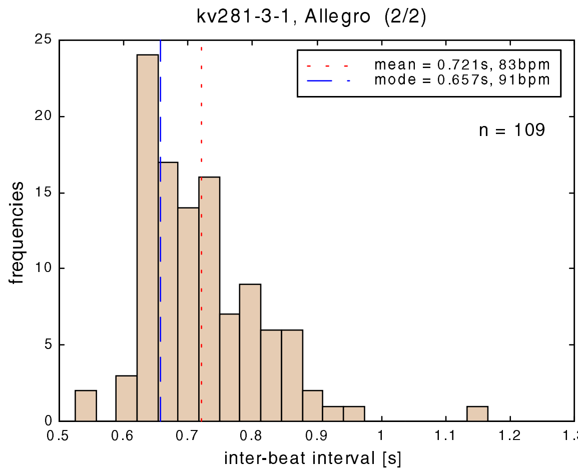

Figure 2. Inter-beat interval distribution of the first section of Mozart's K.281 3rd movement, played by one professional pianist.

depending strongly on the stimuli. Best discrimination is reported at IBIs around 200 ms (below 1%, see Michon, 1964; Nordmark, 1968), whereas at IBIs over 1000 ms the discrimination becomes less precise (Friberg & Sundberg, 1994; Friberg, 1995). The length of the stimulus changed the JND; the discrimination was better for 6 interval stimuli than for 2 interval stimuli (Drake & Botte, 1993). They reported thresholds between 2% and 7% of the IBIs. Nonmusicians' long-term memory of tempo of familiar pop tunes was found to be comparatively precise (+/- 8%, Levitin & Cook, 1996).

Aims

In this study, we examine whether the four main tempo indications (Adagio, Andante, Allegro, and Presto) imply specific tempo ranges which can be found in professional performances, or whether other factors influence the choice of performed tempo. We determine the performed tempo ranges for each tempo indication and discuss what beat level should be chosen for tempo analyses. The influence of other parameters, such as the fastest notes to be played, is evaluated. Finally, the measure of event density (cf Kleinen, 1968) is introduced which takes into account properties of the score (number of events) and the performed tempo (time).

In the first experiment, the performance data of 12 Mozart sonatas performed by one professional pianist are investigated. In the second experiment, commercially available audio recordings by four renowned pianists were compared to the data of the first experiment.

Experiment I

In our first experiment, we chose a large data set of twelve complete Mozart sonatas (K. 279-284, K. 330-333, K. 457, K. 533), performed by a well-known Viennese pianist on a Bösendorfer computer-monitored grand piano. The whole data set consists of about 100.000 notes, all of which were matched to symbolic scores of the sonatas (see Widmer, 2000). The sonatas were cut into *sections* which correspond to repetition markings in the scores. For each of these sections, the inter-beat intervals (IBIs) were computed at the beat level defined by the denominator of the time signatures in the score. Score events which are nominally simultaneous are not played precisely together by pianists (Goebl, 2001). By definition, the highest note of a score event was taken to be the reference point of onset. If a beat event had no played note in the score, it was interpolated by taking the average distance between the adjacent beat events. All grace notes, trill notes, and appoggiaturas were excluded from calculation. From these IBIs, the mean and the mode[3] values were calculated.

Results

The 12 Mozart sonatas contain 214 sections. In 81.5% of these sections the mode value of the IBI distribution was smaller than the mean, in 8.6% they were equal, in 9.9% the mode was greater than the mean. This means that in the majority of the cases, our pianist played more tempo reductions (ritardandos) than tempo increases (accelerandos).

Figure 1 shows the expressive timing curve (at the half note level) of our pianist playing the 3rd movement of Mozart's K.281 (in Bb major). The calculated mode and mean value show a considerable difference. Listening to this excerpt, the mean seems too slow, whereas the mode represents the perceived tempo well. Figure 2 shows the inter-beat distribution of the same section. It is clearly asymmetric towards the slower side.

Each movement consists of 3 to 24 sections (usually less than 10). The tempo values within a movement are very similar, except for the two variation movements (K.284, 3rd movt & K.331, 1st movt), where different tempo indications and time signatures within one movement denote different performance tempos. These variation movements were excluded from calculation in this experiment.

To compare tempos of different movements, the IBI distributions of the whole movements were generated, and mode and mean values, as well as the speed of the fastest notes, and a value for event density were computed.

Tempo classes

The 34 movements showed the following tempo indications: *Adagio* (4), *Andante* (7), *Allegretto* (4), *Allegro* (15), and *Presto* (2); the other two movements were labelled *Menuetto*. The character of the *Andante* movements were specified by *amoroso* (1) and *cantabile* (2), and one *Allegretto* was called *grazioso*. The indication *Allegro* was once slowed down by *moderato*, four times accelerated by *molto* or *assai*. In the following analysis, the four fast *Allegros* were analysed in a separate group. The data were grouped therefore into seven 'tempo classes'.

In Table I, the results for all 34 movements are displayed (grouped by tempo indication, sorted ascending by tempo within tempo groups). In the fourth column, the modal tempo according to the score denominator is printed in beats per minute, in column 5 the modal IBI. The tempo ranges overlap a lot: Adagio: 31-95 bpm, Andante: 46-87 bpm, Allegretto: 64-133 bpm, Allegro: 69-164 bpm, Allegro assai/molto: 130-300 bpm, and Presto: 272-287 bpm.

To compare these tempo values with each other, the beat level (tactus) was adapted as follows: At 2/2 meters the quarter note was chosen to be the beat, at 3/8 and 6/8 the dotted quarter (see column tactus factor). These modified tempo and IBI values are printed in the next two columns.

The fastest note values were extracted automatically from the symbolic score by taking the two most frequent inter-event intervals (in score time) and choosing the faster one. This method avoids some very fast note values which occur only seldom in the score (notated grace notes, turning notes after a trill, etc.). The nominal tempo of the fastest notes was computed by multiplying the tempo (col. 4) corresponding to time signature and the fastest note value. The played fastest tempo was derived by taking the mode of the inter-beat intervals at that fastest notes level.

It is surprising that the fastest notes are played in most of the cases even faster than the basic tempo of the piece. However, this result is consistent with the duration contrast rule of the Stockholm rule system for expressive performance that faster notes are to be played even faster (Friberg, 1995).

[3] The mode was defined by shifting a window – sized 10% of the mean IBI – over the sorted distribution. The centre of the window with the maximum number of values was taken as the mode.

Table I. Tempo analysis of 34 Mozart movements performed by one professional pianist.

names	time sig	tempo indication	mode (bpm)	mode (s)	tactus factor	mf mode (bpm)	mf mode (s)	fastest note values	nominal (bpm)	played (bpm)	event dns (epm)
kv457_2	4/4	*Adagio*	31	1.935	1.00	31	1.935	1/32	252	272	172.8
kv332_2	4/4	*Adagio*	33	1.818	1.00	33	1.818	1/32	263	281	151.7
kv282_1	4/4	*Adagio*	40	1.500	1.00	40	1.500	1/32	319	306	162.5
kv280_2	6/8	*Adagio*	95	0.632	0.33	32	1.895	1/16	191	191	134.7
kv283_2	4/4	*Andante*	40	1.500	1.00	40	1.500	1/16	161	163	159.5
kv330_2	3/4	*Andante cantabile*	46	1.304	1.00	46	1.304	1/16	184	185	110.4
kv333_2	3/4	*Andante cantabile*	46	1.304	1.00	46	1.304	1/32	371	397	157.1
kv279_2	3/4	*Andante*	47	1.277	1.00	47	1.277	1/12	141	145	152.5
kv533_2	3/4	*Andante*	56	1.071	1.00	56	1.071	1/24	338	331	159
kv284_2	3/4	*Andante*	59	1.017	1.00	59	1.017	1/16	236	245	194
kv281_2	3/8	*Andante amoroso*	87	0.690	0.33	29	2.069	1/24	262	259	190.5
kv282_2	3/4	*Menuetto*	125	0.480	1.00	125	0.480	1/16	500	517	238.2
kv331_2	3/4	*Menuetto*	133	0.451	1.00	133	0.451	1/16	531	276	273.5
kv533_3	2/2	*Allegretto*	64	0.938	2.00	128	0.469	1/16	514	546	265.9
kv333_3	2/2	*Allegretto grazioso*	76	0.789	2.00	152	0.395	1/16	609	594	308.2
kv330_3	2/4	*Allegretto*	85	0.706	1.00	85	0.706	1/24	507	551	371.3
kv331_3	2/4	*Allegretto*	133	0.451	1.00	133	0.451	1/16	534	562	392.7
kv330_1	2/4	*Allegro moderato*	69	0.870	2.00	138	0.435	1/32	552	585	359.4
kv281_1	2/4	*Allegro*	70	0.857	2.00	140	0.429	1/32	556	578	432
kv281_3	2/2	*Allegro*	83	0.721	2.00	166	0.361	1/12	500	543	367.2
kv533_1	2/2	*Allegro*	83	0.723	2.00	166	0.361	1/12	498	522	366.7
kv279_1	4/4	*Allegro*	117	0.513	1.00	117	0.513	1/16	470	482	423.3
kv333_1	4/4	*Allegro*	139	0.432	1.00	139	0.432	1/16	554	573	396.2
kv284_1	4/4	*Allegro*	140	0.429	1.00	140	0.429	1/16	561	572	435.6
kv283_1	3/4	*Allegro*	140	0.429	1.00	140	0.429	1/16	560	572	376.2
kv279_3	2/4	*Allegro*	142	0.423	1.00	142	0.423	1/16	569	593	404.7
kv282_3	2/4	*Allegro*	143	0.420	1.00	143	0.420	1/16	572	604	434.8
kv332_1	3/4	*Allegro*	164	0.366	1.00	164	0.366	1/16	655	618	318.5
kv280_1	3/4	*Allegro assai*	130	0.462	1.00	130	0.462	1/16	520	543	375.5
kv457_1	4/4	*Allegro molto*	172	0.349	1.00	172	0.349	1/12	517	543	332.7
kv457_3	3/4	*Allegro assai*	227	0.264	1.00	227	0.264	1/8	455	457	294.8
kv332_3	6/8	*Allegro assai*	300	0.200	0.33	100	0.600	1/16	600	608	396.4
kv280_3	3/8	*Presto*	272	0.221	0.33	91	0.662	1/16	545	560	367.6
kv283_3	3/8	*Presto*	287	0.209	0.33	96	0.627	1/16	574	577	396.5

Two movements are still surprising: the first movements of K.281 and K.330. They both have a 2/4 meter, but their tempo is about the half of the others. However, the tempo of their fastest notes (1/32) is similar to the other Allegro movements. The whole movements are notated at double speed, thus the tactus should be the quaver. Two of the fastest Allegro movements (K.281 3rd, K.533 1st) show relatively high tempo values (166), but their fastest notes (eighth note triplets) have a similar speed to the fastest notes of the other Allegro movements.

The event density is the number of nominally simultaneous events in the score per minute (cf. Kleinen, 1968, p. 73): Event density = number of events * 60 / performed time [s].

In Figure 3 the tempo indications of the 34 movements are plotted with the modified mode tempo on the y axis and the event density on the x axis. At the first glimpse, Figure 3 provides two clusters of movements which are separated clearly: the slow movements (Adagio, Andante) and the faster ones. The threshold of the event density lies between 200 and 230 events per minute, the threshold for the tempo between 60 and 80 beats per minute which corresponds to an IBI of 0.75 to 1 second. Of course, if the beat levels are not corrected with regard to the fastest played notes (column 4), the tempo ranges of slow and fast movements overlap.

Discussion

Analysing a large set of expressive performance data (34 movements) with regard to the performed tempo shows that tempo indications alone do not separate the different tempo classes sufficiently. Only when the beat level was adjusted by the speed of the fastest notes to be played and the time signature, the movements group into slower and faster pieces (threshold 60 to 80 beats per minute). However, the *event density* more clearly separates the data: *Adagio* and *Andante* movements remain always below a threshold of 200 to 230 events per minute whereas *Allegro* or *Presto* movements exceed this threshold clearly.

It was not possible to predict differences in tempo or event density from the tempo indications within slow movements (*Adagio-Andante*) or fast ones (e.g. *Allegro-Presto*). It seems

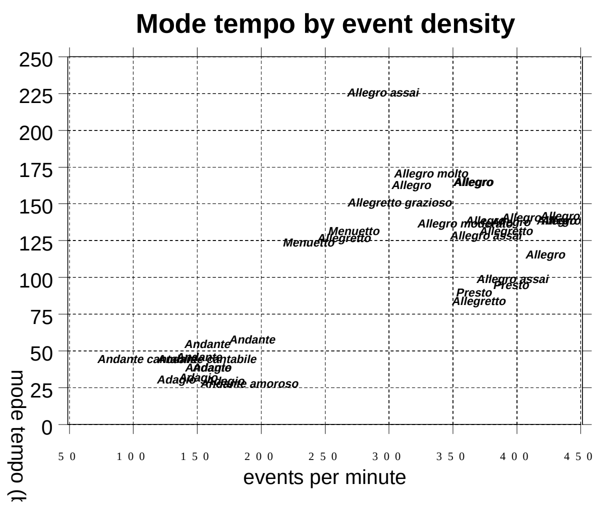

Figure 3. Modified mode tempo by event density of the 34 Mozart movements played by one professional pianist.

that there is no consistent distinction made, at least by our pianist, which can be found in the investigated measures.

Experiment II

The tempo behaviour studied in Experiment I used a large data set, but only performed by one person. The question now is, whether the trends found there can be replicated with data from the 'real world', that is from commercially available audio recordings.

In this experiment, 12 movements were chosen (K.279 1st–3rd; K.280 1st–3rd; K.281 1st; K.282 1st–3rd; K.330 3rd; K.332 2nd). They contained 3 Adagio movements, 5 Allegro (one of which Allegro assai), one Andante, Menuetto, Allegretto, and Presto. The time signatures were 4/4 (3 times), 2/4 (4 times), 3/4 (3 times), 3/8 (once) and 6/8 (once).

Four well-known concert pianists were selected, each of whom produced a recording of the complete Mozart piano sonatas within the last 20 years:

Maria João Pires (1989-1990).
Hamburg: Deutsche Grammophon
András Schiff (1980).
London: ADD (Decca)
Mitsuko Uchida (1983-1984).
Philips Classics.
Daniel Barenboim (1984-1985).
Middlesex: EMI Classics.

Method

The beat tracking system

In order to extract tempo data from audio recordings, an interactive beat tracking program was used (Dixon, 2000; Dixon & Cambouropoulos, 2000; Dixon, 2001). The software analyses audio data, finding the onsets of as many of the musical notes as possible, and examines the time intervals between onsets in order to generate hypotheses of the tempo and the times of musical beats. For each tempo and timing hypothesis, a software agent is created, which attempts to match the hypothesis to the data. The agent with the best match is considered to be correct, and its hypothesised beat sequence is shown in a graphical display. The display consists of a plot of the amplitude envelope of the audio signal with the detected tone/note onsets marked on the plot. The beat times are shown as vertical lines on the plot, which can be adjusted (moved, added or deleted) using the mouse. The inter-beat intervals are displayed at the top of the graph. The system also provides audio feedback in the form of a percussion track (playing at the beat times) mixed with the original sound. After correcting some of the errors made by the system, the remainder of the piece can be automatically retracked, taking into account the corrections made by the user. When the user considers the beat times to be correct, they can be saved on disk in a text format.

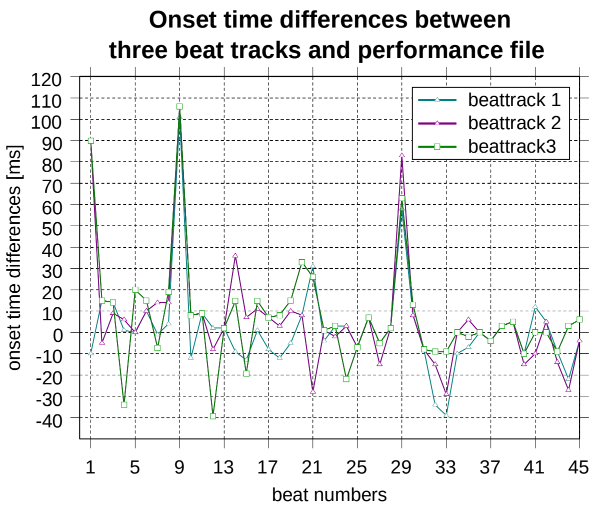

Figure 4. Mozart's K.279, beginning of the 1st movement: Onset time differences between the performance as represented by the Bösendorfer SE290 performance file and three different human beat-tracks of the audio file of the same performance (Pianist of Exp. I).

The Reliability of beat-tracking audio data

The 12 movements were beat-tracked by one musically trained person and then corrected by the authors. This beat extraction method with audio feedback makes use of the hypothesis that the concept of a perceived beat does not necessarily have to coincide with the sounding events, but possibly prefers a beat that is somewhat smoothed against the performed events (as represented in the corresponding MIDI files) (Cambouropoulos et al., 2001). Beat tracking behaviour is also affected by the kind of audio-visual feedback given to the user of the system (Dixon, Goebl, & Cambouropoulos, 2001). Figure 4 shows the variation due to inter-subject differences, relative to the onset times of played notes provided by the Bösendofer SE290 system.

The beat tracks usually deviate +/-20 ms from the corresponding performance file, but differences can extend up to 80-100 ms. These extreme outliers are due to arpeggios, trills or appoggiaturas where the beat-trackers heard different notes as being on the beat other than those literally indicated in the score. The inter-subject differences are smaller, usually between +/-10 ms. For the present study, only the mean and the mode values of the inter-beat intervals were used. These values are very stable over different subjects: they all delivered the same rounded metronome value, only one beat track's mode value resulted in the next smaller number.

Procedure

The 12 movements contained 42–52 sections, depending on which repetitions were played by the pianists. For all sections of one movement the mean and the mode tempo values were calculated, as well as the event density. To compare the variability of the individual tempo values, the standard deviation was calculated, expressed as a percentage of the average tempo of the five pianists.

Results

The mode tempo values for the 12 pieces performed by the five pianists are shown in Table II. The tempo values were calculated according to the modified tempo values in Table I, that is compound meters (3/8, 6/8) were referenced at half bar and bar level, respectively; the first movement of K.281 was

Table II. The mode tempo values in beats per minute for 12 movements performed by five pianists, with the relative standard deviation between pianists.

Movements	Batik	Pires	Schiff	Uchida	Baren-boim	SD in % of tempo
K280-3 Presto 3/8	90	94	97	102	97	4.4
K280-1 Allegro assai 3/4	130	136	140	153	140	6.0
K282-3 Allegro 3/4	143	127	133	130	137	4.6
K279-3 Allegro 2/4	142	121	139	139	139	6.2
K281-1 Allegro 2/4	141	134	140	143	143	2.6
K279-1 Allegro 4/4	117	119	112	119	127	4.7
K282-2 Menuetto 3/4	125	142	119	140	143	8.4
K330-3 Allegretto 2/4	85	92	92	92	89	3.7
K279-2 Andante 3/4	47	52	54	60	52	8.8
K282-1 Adagio 4/4	40	41	45	39	38	6.9
K332-2 Adagio 4/4	33	37	37	35	38	5.6
K280-2 Adagio 6/8	32	31	32	28	29	5.4

counted at the eighth-note level. The last column shows the relative standard deviation between the five performances.

The five pianists disagreed most with respect to their tempo choice for the Menuetto. Since 'Menuetto' is not a tempo indication, but rather a specification of a certain type of dance, this disagreement is comprehensible. Apart from that, it can be seen that slow movements show a larger scattering than fast movements.

Like in Experiment I, the event density separates slow movements from fast ones. The graph for this was not plotted, since this result is a direct consequence of the comparably homogenous tempo values (Table II). A slow movement would have to be played two times as fast to overlap with the fast movements in event density.

Discussion

Pianists produce surprisingly homogenous tempo values for the same scores. To exhaustively investigate differences in tempo between pianists, a much larger number of pianists and movements would be necessary. Then, also comparisions between different performance schools, opinions, and interpretational traditions would be possible. The current method is perhaps too complicated and costly for extracting single tempo values out of an audio recording. Other approaches which deliver sufficiently precise results would be to tap along with the audio recording on a MIDI device several times, as done by Bachmann (1999), or to adjust a metronome to the music (Repp, 1994). On the other hand, the data collected for this study contain much more interesting information on timing that remains to be investigated.

General discussion

In this study, we investigated modal tempo values in performances of Mozart piano sonatas. It was found that tempo classes, as defined by tempo indications in the scores, have a large degree of overlap in tempo, even when information on the time signature and the fastest notes to be played was added to modify the beat level. The modified mode tempo reflected just two very general classes of tempo: fast and slow. In addition to this, the measure of event density was found to separate the slow and fast movements. Differences within the slow (*Adagio-Andante*) or the fast movements (*Allegro-Presto*) could neither be predicted by the performed tempos, nor by the event density. If a general distinction between tempo indications is conceived by performers, it might be reflected in performance parameters other than tempo or event density.

In perceptual studies with deadpan performances, it was found that the rhythmic complexity of a score has a stronger influence on subjects' tempo impression than event density (Auhagen, 1997). However, this work does not take into account expressive timing. In the present study, event density is used to categorise movements in a very general way, without regard to perceptual issues. It still remains to apply Auhagen's perceptual approach on expressive performances.

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