

Studies in the Computer Rendition of Piano Pedalling

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Abstract: The computer rendition of music, and in particular of piano music, is a topic of current interest. The rendition of piano pedalling by that means has, however, not previously been explored very far. Thus my purpose is to survey the possibilities of the computer rendition of piano pedalling, with examples in sound and graphics. Whereas much other research in the computer rendition of music has aimed for the automated rendition of a variety of scores, I have instead treated each case according to its own perceived requirements. The comparison between human and computer resources naturally arises here. The computer's possibilities are in a number of ways greater than those of a human playing on a real acoustic instrument, although I have found one case of a method available to the human but not to the computer: the partial release of a key while changing the pedal. Two fields are combined in this work: piano pedalling and computer methods; although it is not my purpose to provide a tutorial in either field, some instructional value might nevertheless be found in both.

Note on playing the audio examples: minimizing your player will allow you to listen while still viewing the page. To prevent YouTube's following items from playing, turn off autoplay with YouTube's button above the "Up next" panel at the right, or with tools (the gear icon) in the lower right corner of the audio box. This version of the article is authorised; a false version had been published at Min-Ad in September 2016.

Introduction

Aim and scope

The computer rendition of music, and in particular of piano music, is currently being developed in the academic and musical worlds. In that development piano pedalling has not so far been looked into very closely, as far as I am aware, and it is sometimes not considered at all. My aim here is to respond to that limitation by means of a critical survey of the possibilities. Another feature of previous work is that it has often been directed towards the automatic or semi-automatic derivation of a rendition from a given score (e.g. Kirke and Miranda 2013, 1). Here, on the contrary, I will adopt an individualized approach, tailored to each particular situation independently of theories of performance or of composition.

The limited attention paid to pedalling is often noticed, or the limited success with it, for instance when we read that "synthesis of piano with pedalling effects is still an unsolved problem" (Kim et al. 2013, 149). It is well known that appropriate pedal use depends upon the properties of the piano being used – the quantity and quality of sound produced and the regulation of the pedal mechanism – and on the room acoustics. It is clear that it should take into account the *absolute* loudness of the notes played. Less well known is the dependence of effective pedalling on the *relative*, or differential, loudness of all the notes of a chord, especially in conjunction with their harmonic relationships. The ways in which these factors operate in association with the momentary artistic purpose vary widely. Thus the use of the pedals is generally not capable of being successfully automated, with the exception of some limited areas.

The studies in the present work are drawn from the standard classical repertoire; they are limited to a few bars in each instance, as is appropriate near the beginning of a new field, for renditions of complete pieces or movements that are fully worked out and refined belong to the future. I will try to find out to what extent, and exactly how, computer resources can handle some of the subtleties of piano pedalling. Some instructional value in pedalling itself may result incidentally to this aim. I have chosen a number of examples from Schnabel (1950), hereafter referred to simply as K. Schnabel, not with any claim that its author (the son of the famous pianist Artur Schnabel) carried particular weight in the field of piano performance or that the pedallings he indicates in his examples could not in some cases be debated,¹ but because he is one of very few who have specified pedalling in a precise manner, while also exploring a wide range of the piano's possibilities. Thus I will attempt to render some of his examples by computer means.

Computer resources

In deciding on a computer resource for rendering piano music, a three-way choice is to be made between a computer-controlled piano (e.g. Disklavier 2014), sampled sounds (e.g. Garritan 2014) and programmed sounds (e.g. Pianoteq 2014). The Disklavier type has the advantage of being a real piano producing authentic sound quality, together with the attendant disadvantages that perfect regulation is needed and that no two such pianos can respond in exactly the same way; those disadvantages would make controlled experimentation harder. The Garritan type has the advantage of very convincing sound quality, together with the attendant disadvantages that interpolation is needed between the samples that can be taken under only a limited number of fixed conditions, that the sampled piano should have no imperfections that could come to attention after repeated listening, and that the effect of the pedal can only be rendered approximately in view of its dependence upon which notes are sounding at a given time, and at which strength.

The Pianoteq type is instead based on a mathematical and physical model of piano sound, and might therefore have slightly less convincing sound quality; however, no physical regulation is required for repeated experimentation, a very wide range of parameters can be changed and the results heard immediately, and the challenging problem of rendering the effect of pedalling in any given case has been solved quite satisfactorily for the present purpose.² I chose Pianoteq (2014) (hereafter cited simply as Pianoteq) v5.0.1. Pianoteq provides a wide choice of piano models and specifications, as well as of room acoustics and microphone placements. I chose a piano based on the Steinway Model D concert grand, making just two changes to the default specifications: softer dampers for forte sounds, and a small modification in Pianoteq's special kind of equalizer to make lower pitches a little more incisive. The room choice for emulation was a small hall with microphones placed close to the piano. To prepare the raw score data and the nuances desired for each rendition and send them as input to Pianoteq, I wrote a custom computer program in the Matlab programming language, using midi as an essential resource; the program also produces a graphical representation of the rendition, which functions much like the pencilled annotation of a conventional paper score, and which is in practice needed in this work.

¹ "'Modern Technique of the Pedal' is exclusively my father's work. Artur Schnabel didn't teach technique" (Schnabel-Mottier 2014).

² A reviewer has rightly drawn attention to a lesser degree of richness of Pianoteq's pedal sound heard in the present examples as well as fewer sympathetic vibrations than with a real acoustic piano. The richness can be varied by the choice of many Pianoteq parameters including room size, tuning and soundboard impedance; in this article just one choice has been illustrated. The number of sympathetic vibrations is restricted by the real-time implementation allowing only a limited amount of computation, rather than by the physical modelling.

Preliminaries on pedal implementation

The present article does not take on the role of a pedal tutor. Some familiarity with the artistic use of the pedals is therefore assumed of the reader; that can best be acquired in practice, and may be assisted by reference to one or more of the many writings on the subject (e.g. the references in Banowetz 1985). Thus only a few preliminary remarks on that subject will be made here.

The *sustain* pedal, often called just the pedal, on a real piano does not bring about an effect throughout the whole range of the foot movement, because free play takes place before and after the dampers are (on a grand piano) raised above the strings and again lowered onto them. Pianoteq provides the default values of 20% and 25% respectively for free play, represented as dashed horizontal lines in the pedal levels shown near the bottom of the graphs for the examples to follow. Thus a pedal depression of 20% or less gives the effect of no pedal and one of 75% already gives the effect of full pedal. It is the motion of the dampers, rather than of the pedals, that is ultimately relevant and that is represented by the solid lines in the graphs.

Degrees of partial pedal are available, that is, partial raising of the dampers leaving them in some contact with the strings, but not full contact; three intermediate degrees are defined by K. Schnabel. The definitions cannot be given in terms of the proportions either of depression of the physical pedal or of raising of the dampers, for the required proportions will depend upon the particular piano and the acoustic conditions; instead, the definitions are given according to the effect produced. Even within each functional category, a range of proportions of depression is available, to be chosen according to the particular shading desired at the time.

The definitions are: ‘Quarter pedal’ causes no blurring in scales or in changes of harmony, its only effect being to brighten the sound (ibid., 15). ‘Half pedal’ would cause blurring in scales or changes of harmony, “but it will not give the impression that a note is being held after the key is released” (ibid., 18). ‘Three-quarter pedal’ differs from full pedal only by its “transparency of sound” (ibid., 24). Thus the fractions appearing in the names are adopted only to indicate the several categories of function. The functions will be illustrated in Example 1, given shortly.

It will be helpful to have an idea of the minimum duration of a pedal change (up and down motion) for a human. This depends on the pedal mechanism’s resistance, the capability of the pianist’s ankle, and the partial degree of the change being made, so there is no one answer. I have taken 200 ms as a rough guide for a full pedal change (Repp 1997, 168). The minimum duration will be relevant in Examples 4 and 10.

The *left* pedal, or soft pedal, affects the quality of sound, and requires little special study. It is generally not used in short bursts, but instead over longer sections of fairly homogeneous texture. The soft pedal will be used in Example 11.³

The *sostenuto* pedal, also called the middle pedal, is sometimes available on a real piano. It is an on/off device with no partial levels, sustaining only those notes whose dampers are raised at the time it is depressed. The *sostenuto* pedal will be used in Example 10.

The present article does not take on the role of a Pianoteq tutor, any more than that of a pedal tutor. Pianoteq details will be mentioned occasionally, in order to convey some of the available resources. That will suffice for reading the present article, although the interested reader may wish to explore this further online (Pianoteq 2014).

³ On a real piano the soft pedal operates as fully on or fully off, but in Pianoteq the strength of its effect can be changed at any time, even from note to note; the resulting ‘partial soft pedal’ will, however, not be used in this article.

Method of nuancing

Examples 3 to 11 have been prepared with nuances intended to produce renditions that sound musically satisfactory or better, thus proceeding a considerable way beyond the use of just the raw notes of the score (raw notes will be illustrated only in Example 7a). The nuances supplied, in addition to pedalling, are the timing, articulation and loudness of each note. Expressive nuances may be separated into those applying broadly and those applying narrowly, that is, (a) those reflecting the given composer, nationality and historical time period (Becking 1928/2011) and (b) those depending on local context, reflecting phrasing, motives and other compositional and expressive factors. The broad factors operate throughout an excerpt, and indeed throughout a movement, piece and oeuvre (Nettheim 2007), while local modifications take place according to the narrow factors. The exact effect wanted in an excerpt from a movement is likely to depend upon the manner held in mind for the rendering of the movement as a whole, but the present examples may nevertheless have some instructive value independently of a larger conception.

In supplying the nuances, I have not copied from or imitated recorded performances, so I have taken the opposite approach from that in Nettheim (2013). I have attempted to justify every nuance by an artistic or logical reason applying to each case as it arises, never by an automated or theoretical approach. Innumerable satisfactory results are always possible, as well as innumerable unsatisfactory ones, and all people will have their personal predilections. For the present purpose, a satisfactory version will be one that is not considered eccentric and that is sufficient for judging the pedalling. The nuancing is merely auxiliary to the present work and not its main focus; its detailed treatment is reserved for future publication, when it has been refined following studies of other musical features required for a rendition, and only occasional remarks will be made here on the nuances applied.

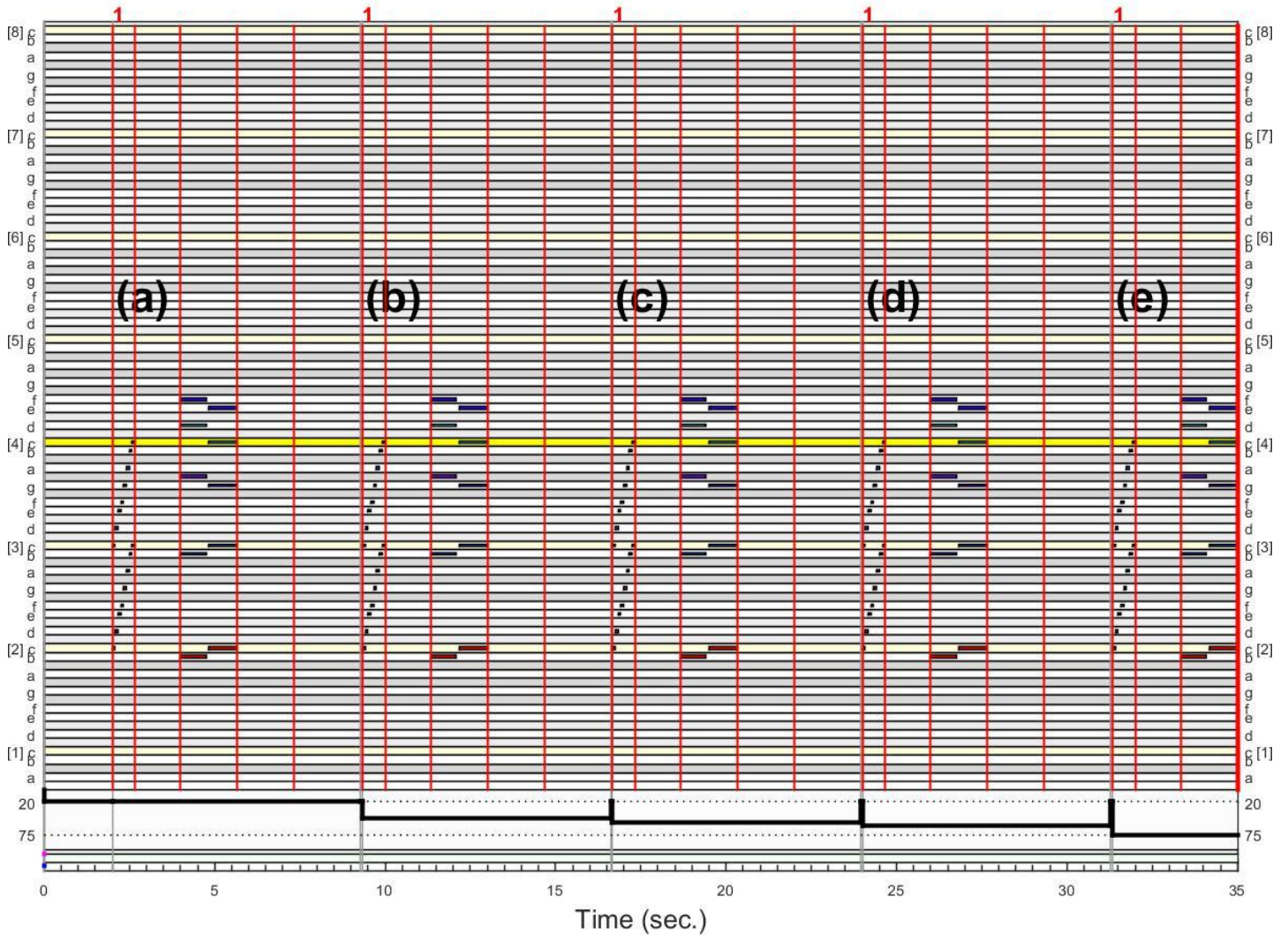
An important set of specifications required for nuancing is that of the loudness of each note; the effect of a given pedalling is often strongly dependent on the individual loudness levels, but K. Schnabel did not mention these. The differential loudness of the notes within a chord has in fact rather seldom been discussed, and I therefore provide a translation from the original German of some of Walter Giesecking's writings which refer in detail to that matter and which, as far as I know, have not previously been translated (Appendices I and II).

Examples

The first example illustrates the degrees of partial pedal, defined above. Ten examples from K. Schnabel follow (Examples 2 to 11), which I have implemented in sound using the resources mentioned earlier. As in that book, the examples are arranged here in approximately increasing order of sophistication of pedal use. Each Example is presented with three components: a conventional Score (except for Examples 1 and 2), a Graph produced by my custom computer program, and Audio produced by Pianoteq. The Pianoteq program provides a video representation of the keys as they are played and the pedals as they rise and fall – that is not seen in the examples to be presented here, but the graphs produced by my custom program indicate the exact timing and depth of the pedal motions, or rather of the resulting damper motions, in relation to the timing of the notes played.

Example 1. Degrees of partial pedal.

This example consists of a scale and two chords with pedal levels 0, 1/4, 1/2, 3/4, 1. Readers may wish to calibrate their audio system, especially the volume level, by making sure that the stated effects are heard; different calibration is likely to be needed depending on the use or non-use of headphones.

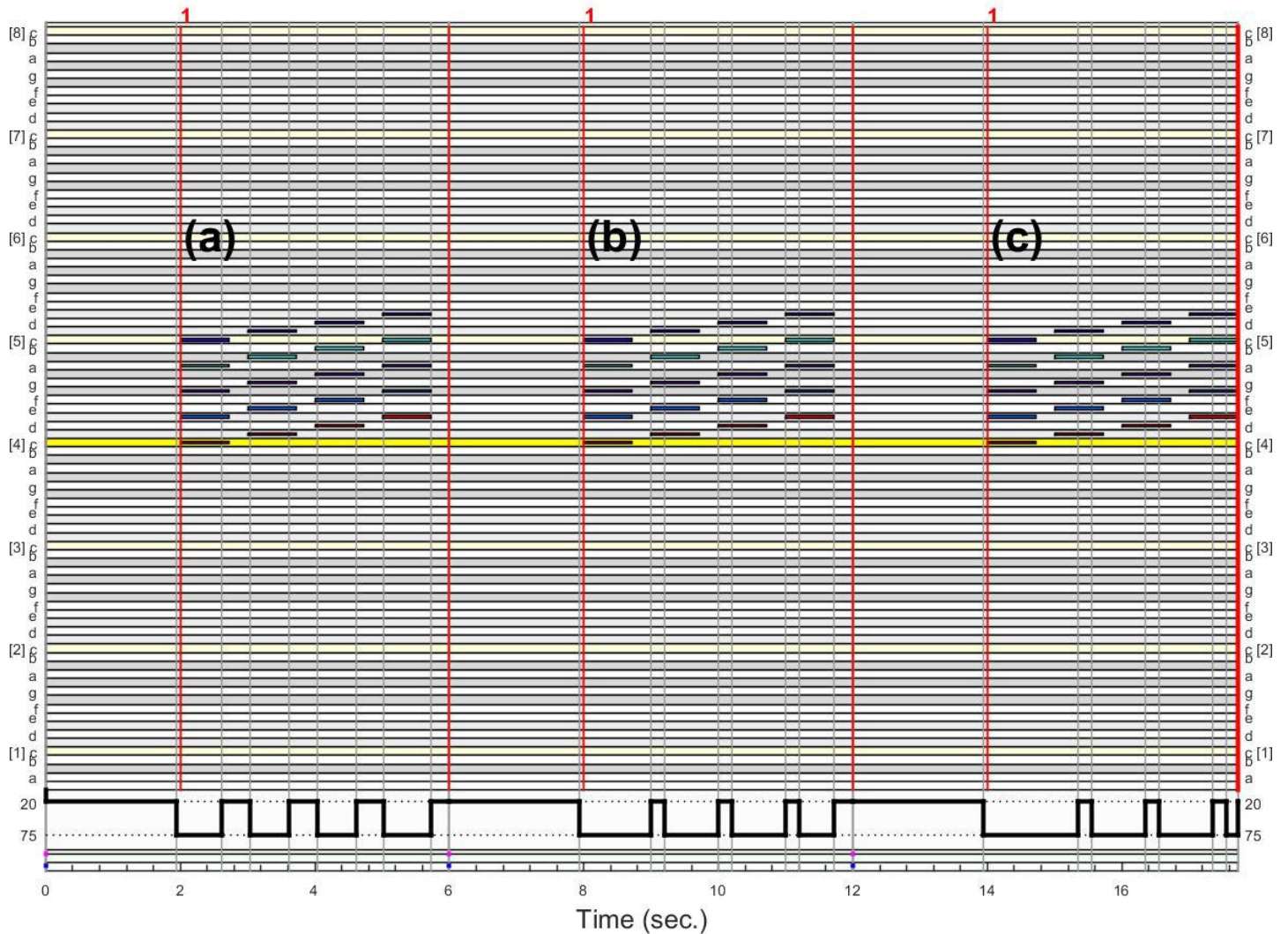


Graph 1. Scale and chords shown in piano-roll format. Pedalling indicated by letters on the graph: (a) none (b) quarter (c) half (d) three-quarter (e) full. Differently-coloured notes indicate different voices. Pedal motions are represented at the bottom of the graph. The sustain pedal has a range of 0% to 100% depression; it is graphed between the horizontal dashed lines which indicate the limits excluding free play (20% and 75%), thus corresponding to damper motion rather than foot motion. Red vertical lines indicate bar lines.

[AUDIO 1](#)

Example 2. Degrees of separation in chord progressions

K. Schnabel begins with chord progressions, comparing separation, legato and legatissimo, which latter he calls “intense legato” (ibid., 4). This example allows a simple demonstration of



the effect of different acoustic conditions on the results of a given pedalling. The first part of Audio 2, illustrated in Graph 2, represents the effect of a Steinway concert grand piano in a small hall, the two microphones being placed close to the piano. For the second part of Audio 2 the same piano has been moved to a large hall, leaving the pedalling and microphone placement unchanged; the extra reverberation will be noticed in all degrees of separation. Finally, the third part of Audio 2 represents the same piano in a church, where the greatly increased reverberation is obvious.⁴

Graph 2. Chord progression with (a) separation, (b) legato, (c) legatissimo. Faint vertical guidelines indicate the timing of pedal motions in relation to the notes played.

[AUDIO 2](#)

⁴ Pianoteq provides a choice of other room acoustics including, as an extreme case, the Taj Mahal, where there enormous reverberation is heard even without pedal. Different resistance of the pedal mechanism can be represented in Pianoteq via its ‘pedal velocity curve’, but that will not be needed here.

This apparently simple example already raises an interesting question: in a computer rendition, should the limitations of human performers be respected and, if so, to what extent? Legato or *legatissimo* in any number of voices is readily achievable with a computer in cases where it would be impossible for a human performer, as here if the chords are to be played with one hand only (computer-legato will be seen in Example 4a). Similarly, should the limitations of physical pianos be respected? One example among many is the option in Pianoteq to voice the piano's hammers differently depending on the loudness of each note as it is played – harder hammers for louder notes, softer hammers for softer notes. A reasonable preliminary answer seems to be that to a certain fairly limited extent the overcoming of human and physical limitations is warranted and will not detract from the appreciation of the rendition, but beyond that point the rendition would seem unnatural because of listeners' long familiarity with human renditions on real pianos, for which, after all, the composers wrote the music.⁵ That attitude will be adopted here: to respect human limitations on the whole though not entirely. In any case, it would be impossible in many instances to calculate the limits of human capability.⁶

Example 3. Legato and staccato in different voices

Schubert's Sonata in B-flat, D960, fourth movement, provides a good example of pedalling for different articulations in different simultaneous voices (Score 3). The lowest line may be taken to represent a *pizzicato* cello part, the middle line a smooth viola part, and the top line a violin melody. A human can play the middle part legato or slightly *legatissimo* by the fingers alone, but cannot also conveniently play the melody legato by the fingers alone, so the result without pedal would be unacceptable. A computer could, of course, render this melody legato, but here we take the point of view of a human; further, even if the fingers could manage this task, some pedal-haze might still be sought. It is therefore desired to use the sustaining pedal for the sake of a legato melody, while at the same time making sure that the pedal does not interfere with the *pizzicato* cello effect in the bass.

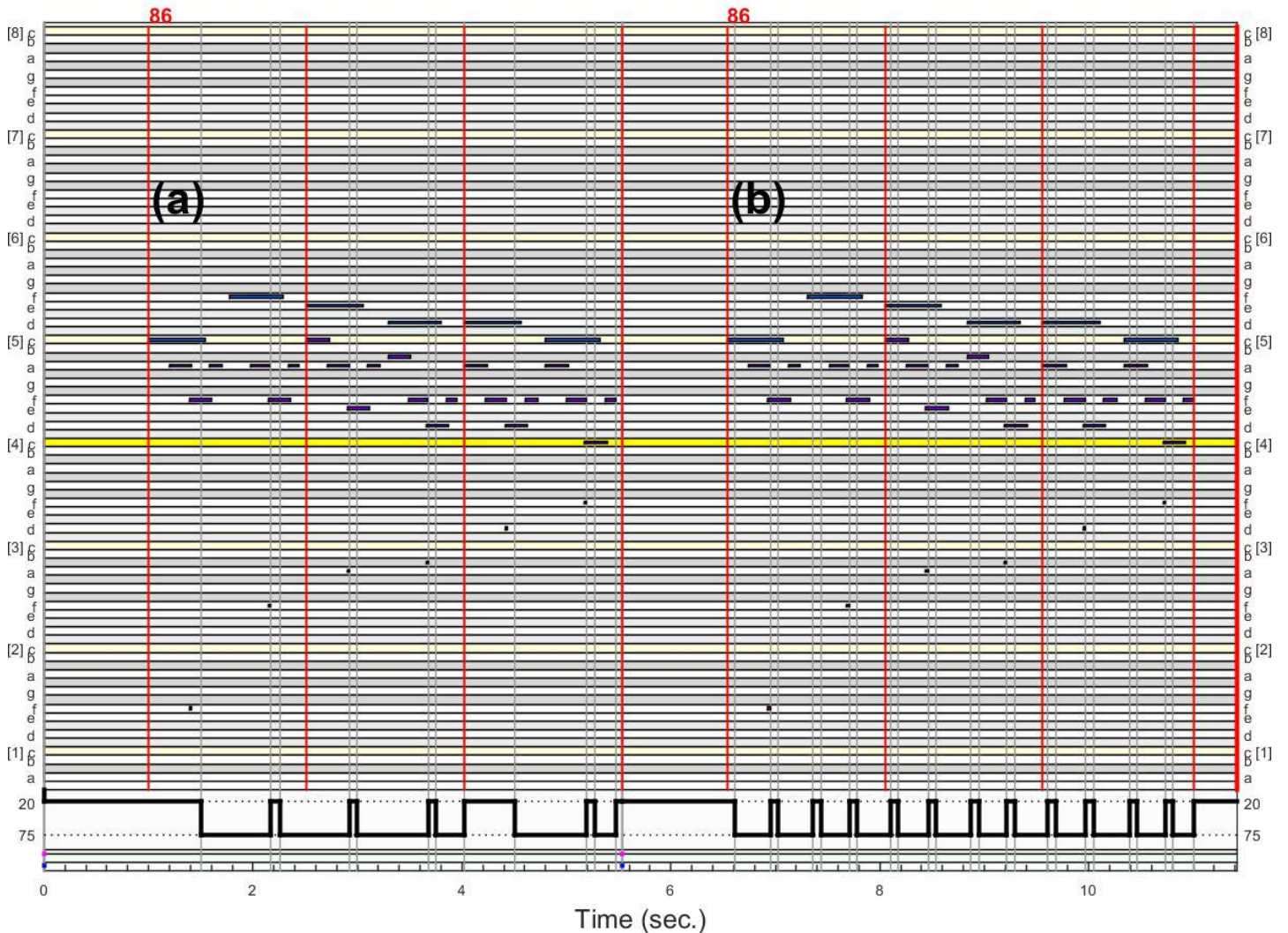
Schubert broke the slur at the point of a repeated note in the melody (d5, at the start of the third bar of the excerpt), and I suggest he did that just so as to avoid giving any possible visual impression of tied notes, or of a repeated note with legato (which would be something of a contradiction). K. Schnabel responded to the break in the slur by lifting the pedal on that melody note for its first 8th-note, producing a change in the texture in that region which might be considered not optimal (Example 3a). I suggest instead changing the pedal uniformly on each eighth-note; this avoids the change of texture just mentioned, and it also reduces the effect, repeated several times, of a build-up of pedal-haze over a half-bar duration before the reduction caused by a pedal-change; thus it promotes uniformity of texture throughout the passage (Example 3b). The latter example produces less pedal-haze than the former, and the choice would depend on the personal preference of the interpreter.

⁵ Conlon Nancarrow was an exception, having written for mechanical rather than human performance.

⁶ On the other hand, the human limitations are taken into account fully when the task is the computer reconstitution of a human performance from a recording, as in Nettheim 2013.



Score 3. Schubert, Sonata in B-flat, D960, fourth movement, bars 86-88 (K. Schnabel, 5).



Graph 3. Schubert passage with pedalling (a) according to K. Schnabel, (b) according to the present author's suggestion (see text).

[AUDIO 3](#)

In respect of the nuancing carried out for Sound 3, notice the reduced loudness in the viola voice for the adjacent notes a4 and b4-flat in the second bar of the excerpt, avoiding an intrusive effect caused by the application of pedal to that dissonance; this illustrates the dependence of pedal effects on the loudness of individual notes.

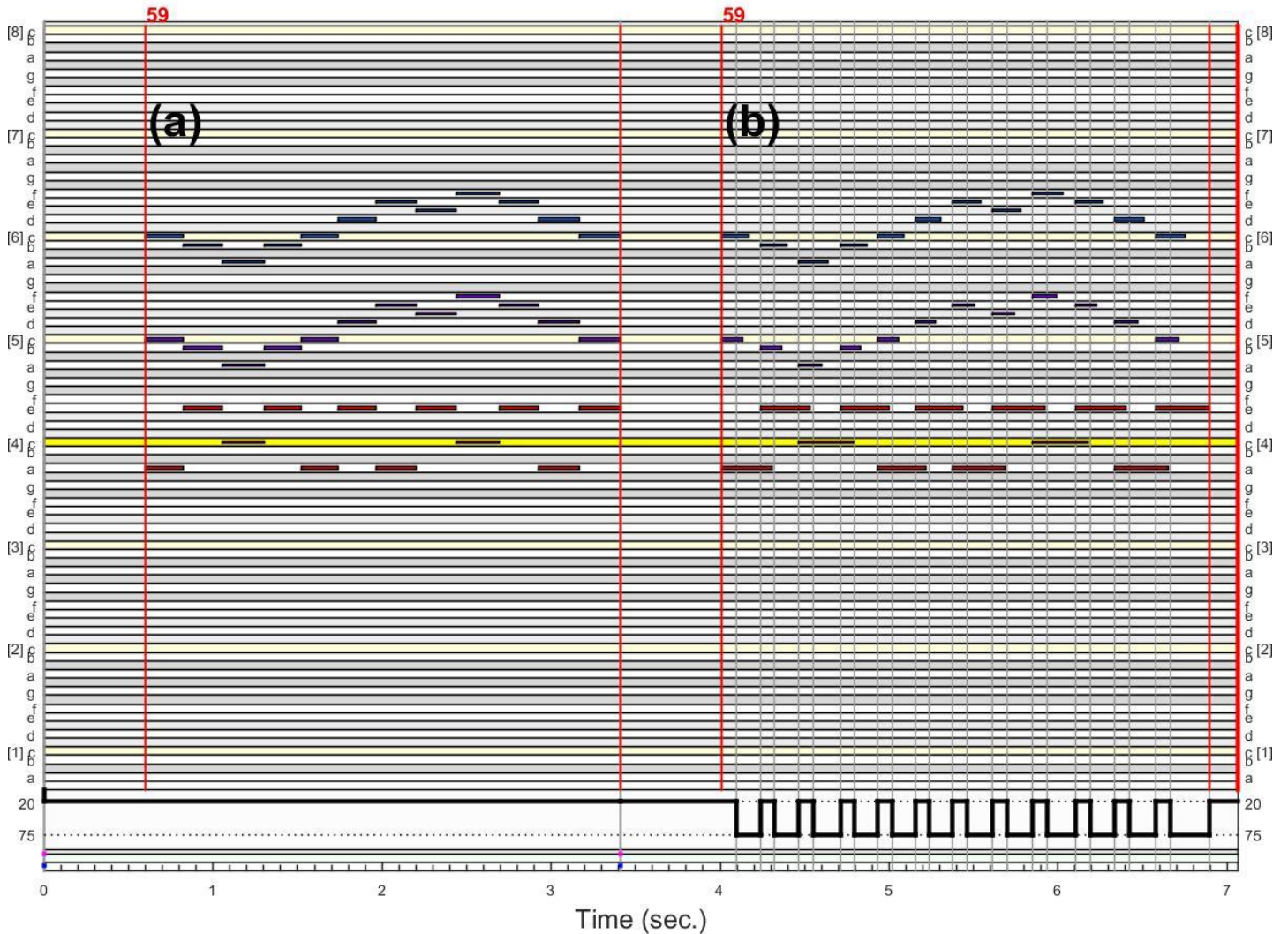
Example 4. Legato octaves

In Mozart's Sonata in A, K331, first movement, bar 59 (Score 4), the octaves could be rendered by a computer with legato in both voices without pedal (Example 4a), but again I take the point of view of a human player, who of course could not do that. I have therefore aimed here for a fair approach to legato together with a minimum of pedal-haze, on the assumption that most of this movement would be played with rather little pedal-haze.⁷ The human will need to control the finger and foot timing carefully (Example 4b). K. Schnabel has specified full pedal here, although 3/4 pedal could be considered.



Score 4. Mozart, Sonata in A, K331, first movement, bar 59 (K. Schnabel, 6).

⁷ Whether legato is quite necessary here could be debated. This bar and the following three are clearly intended to contrast in texture and loudness with the preceding four bars, and the addition of octaves assists with that contrast, but the right-hand slur in bar 59 is not reproduced in the following three bars, nor in the corresponding later bars 71-72. Taking the slur literally as indicating legato might therefore be debatable but, for the present purpose, I have followed K. Schnabel and convention in aiming for legato.



Graph 4. Octave passage, with legato (a) by computer, (b) by pedal.

[AUDIO 4](#)

Example 5 Flutter pedalling

‘Flutter pedalling’ means changing the sustaining pedal rapidly without control of the relation between the change-points and the notes played (K. Schnabel called this ‘vibrating pedal’). This is, at the same time, a kind of partial pedalling, for the full extent of the raising and lowering of the dampers is unlikely to be utilized.

This pedalling technique is illustrated in Chopin’s Scherzo in c#-minor, op. 39, bars 621-629 (Score 5). K. Schnabel (*ibid.*, 6-7) writes that it “will sound too thin and dry if played without pedal”, with which one may readily agree. To change the pedal on each note would be a fair conception, as mentioned by K. Schnabel, but it cannot be carried out by a human player because the pedal motions required are too fast. Such rapid changes can, however, be achieved in a computer rendition (Example 5a). A human player will need to use flutter pedalling proper, as defined above (Example 5b). In this rendition the pedal changes are made at random times. The random times can be specified in two ways: either they can be fixed in advance to be used whenever the excerpt is rendered, or they can be generated afresh giving new results on each running of the program. Here I have used the second method, the random numbers being

generated in such a way that, although the pedalling of each rendition is different in detail, the general effect is always similar.

(Presto con fuoco)

(ff)

cre

scen

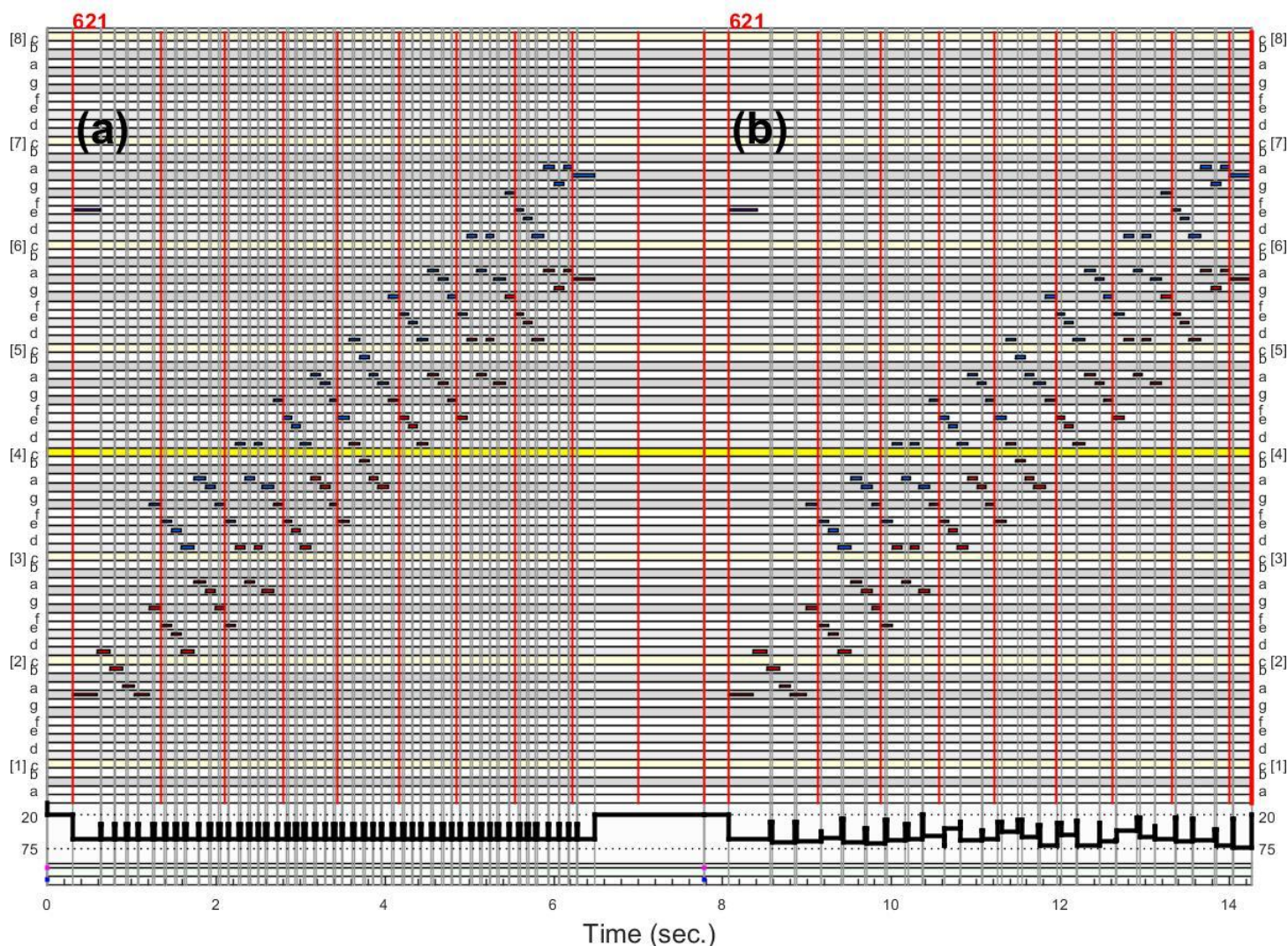
do

sem

pre

ff

Score 5. Chopin, Scherzo in c#-minor, op. 39, bars 621-629 (K. Schnabel, 6). (Differences in Paderewski et al. (1951) compared with K. Schnabel's printed example are: *crescendo sempre* is absent; *ff* in bar 629 is absent; no pedal is marked for the present bars 621-629, but instead pedal is marked for the preceding and following bars 617-620 and 629-632.)



Graph 5. Passage with pedal: (a) rapid and uniform (possible for computer), (b) less rapid, randomized ‘flutter pedalling’ (possible for human).

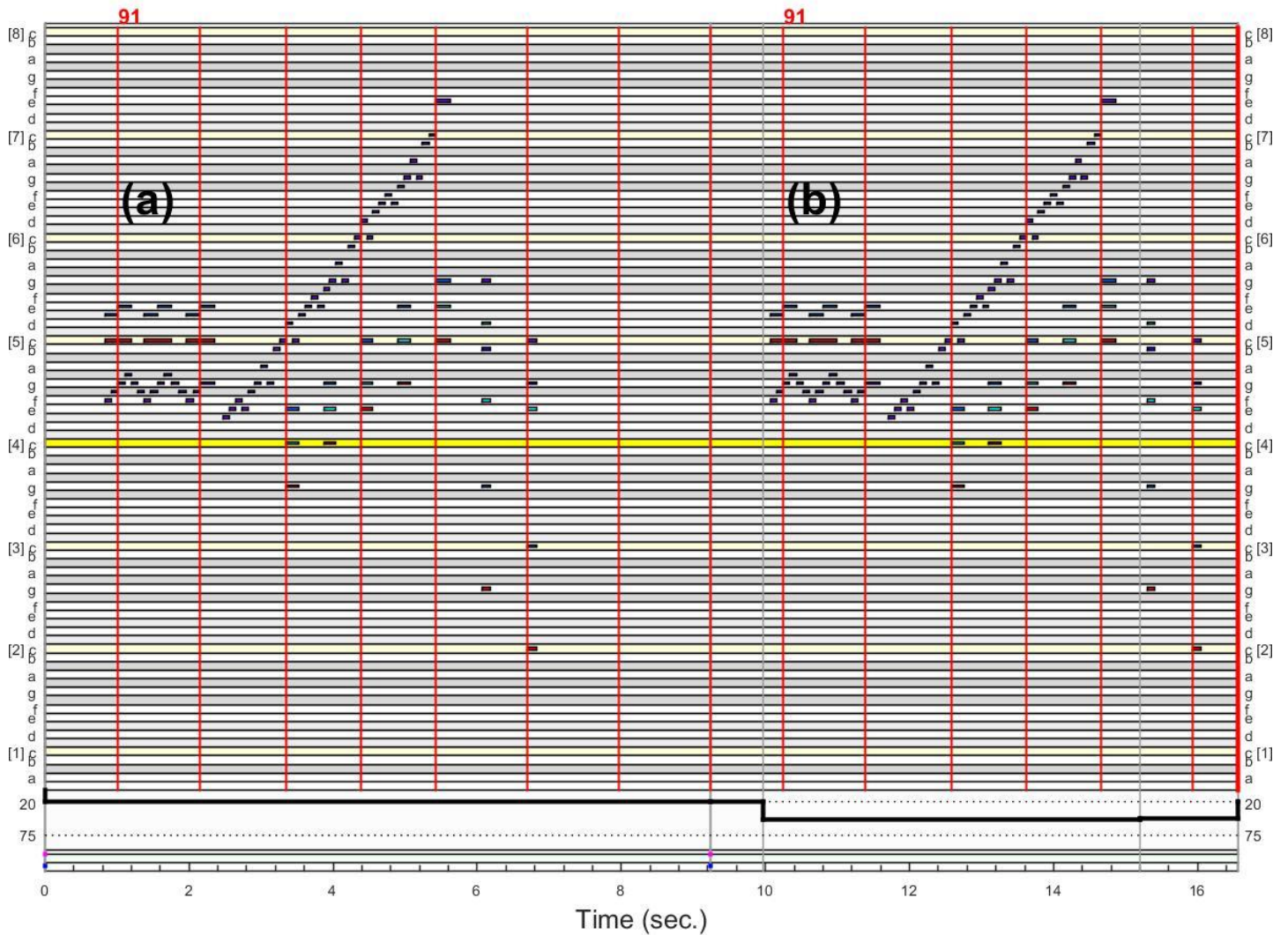
[AUDIO 5](#)

Example 6. Brightening the sound without blurring (quarter pedal)

A good example for quarter pedalling, defined above, is Mendelssohn’s “Song Without Words”, op. 67 no. 4 (“Spinning Song” or “Bee’s Wedding”), bars 91-96. I have held the final pedal a little longer than in K. Schnabel’s version, so that the quality of the last two chords may more nearly match, using slightly less pedal depth for those two chords. With so many notes subject to pedal, it is not surprising that the result is very sensitive to the exact depth of pedal used. Example 6a has no pedal, while Example 6b has quarter pedal, which adds some brightness without causing a problem by blurring.



Score 6. Mendelssohn, “Song Without Words”, op. 67 no. 4 (“Spinning Song” or “Bee’s Wedding”), bars 91-96 (K. Schnabel, 16). (An accent mark was omitted by K. Schnabel on the d5 at the beginning of the 4th bar of the excerpt.)



Graph 6. Passage from Mendelssohn with (a) no pedal, (b) quarter pedal.

[AUDIO 6](#)

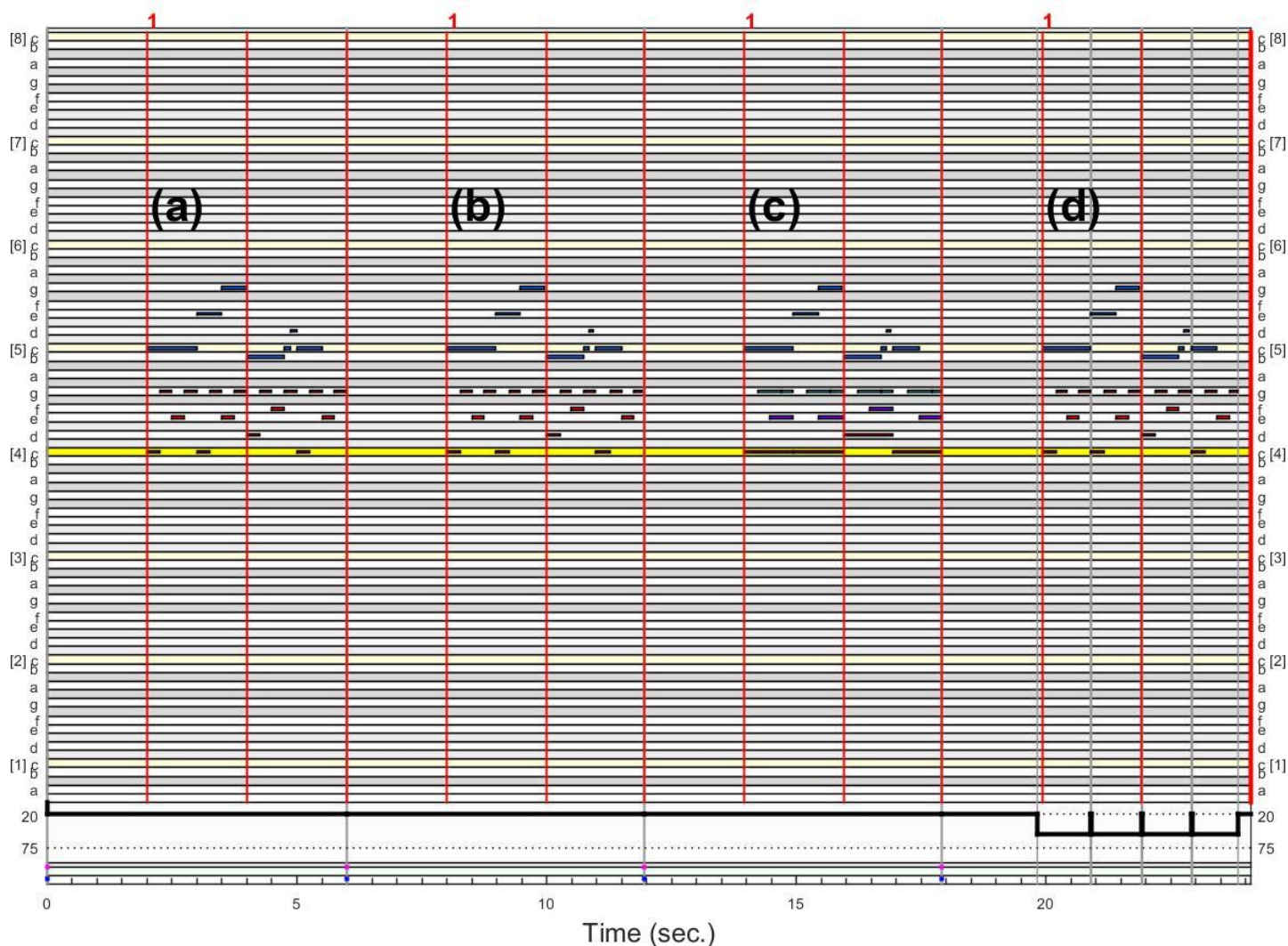
Example 7. Single-voice accompaniment (half pedal)

Mozart's Sonata in C ("facile"), K545, first movement, is very well known (Score 7). The opportunity is taken to show a rendition without nuances (Example 7a), its unacceptably mechanistic character reminding us of the need for nuancing such as is used elsewhere in this article. The problems for pedalling are, first, whether to use the pedal at all, and second, if the pedal is to be used, exactly how to use it. A pupil who is not far advanced might use no pedal and no finger-legatissimo (Example 7b). Giesecking (Appendix I) pointed out that it is quite possible to play this music without pedal if the fingers provide legatissimo in the accompanying part (Example 7c).⁸ Finally, instead of finger-legatissimo, half-pedal may be used throughout the excerpt, as suggested by K. Schnabel (*ibid.*, 22) (Example 7d). Both renditions 7c and 7d seem acceptable, the choice between them being a matter of personal preference.



Score 7. Mozart, Sonata in C ("facile"), K545, first movement, bars 1-2 (K. Schnabel, 22).

⁸ A small technical point in Giesecking's example 7c is that each sounded note should be rendered in one voice only, for otherwise the loudness levels of unisons would be combined as if the voices were played on more than one piano simultaneously.



Graph 7. Mozart passage with (a) no nuances, (b) no pedal and no finger-legatissimo, (c) no pedal but finger-legatissimo, (d) half pedal but no finger-legatissimo.

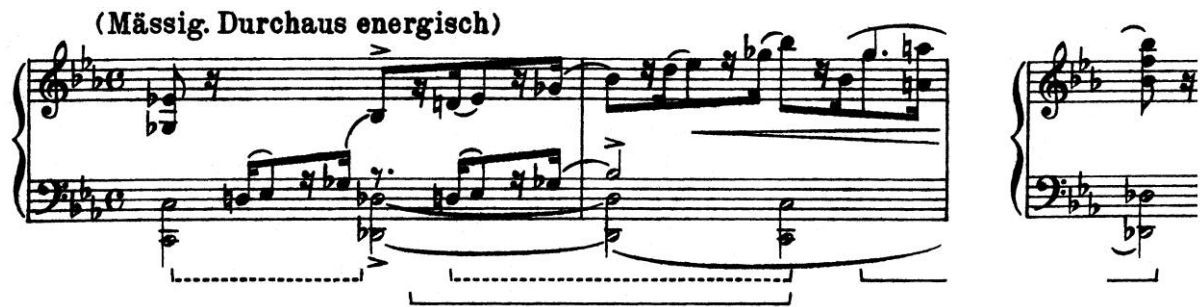
[AUDIO 7](#)

Example 8. Rests to show through (three-quarter pedal, sostenuto pedal)

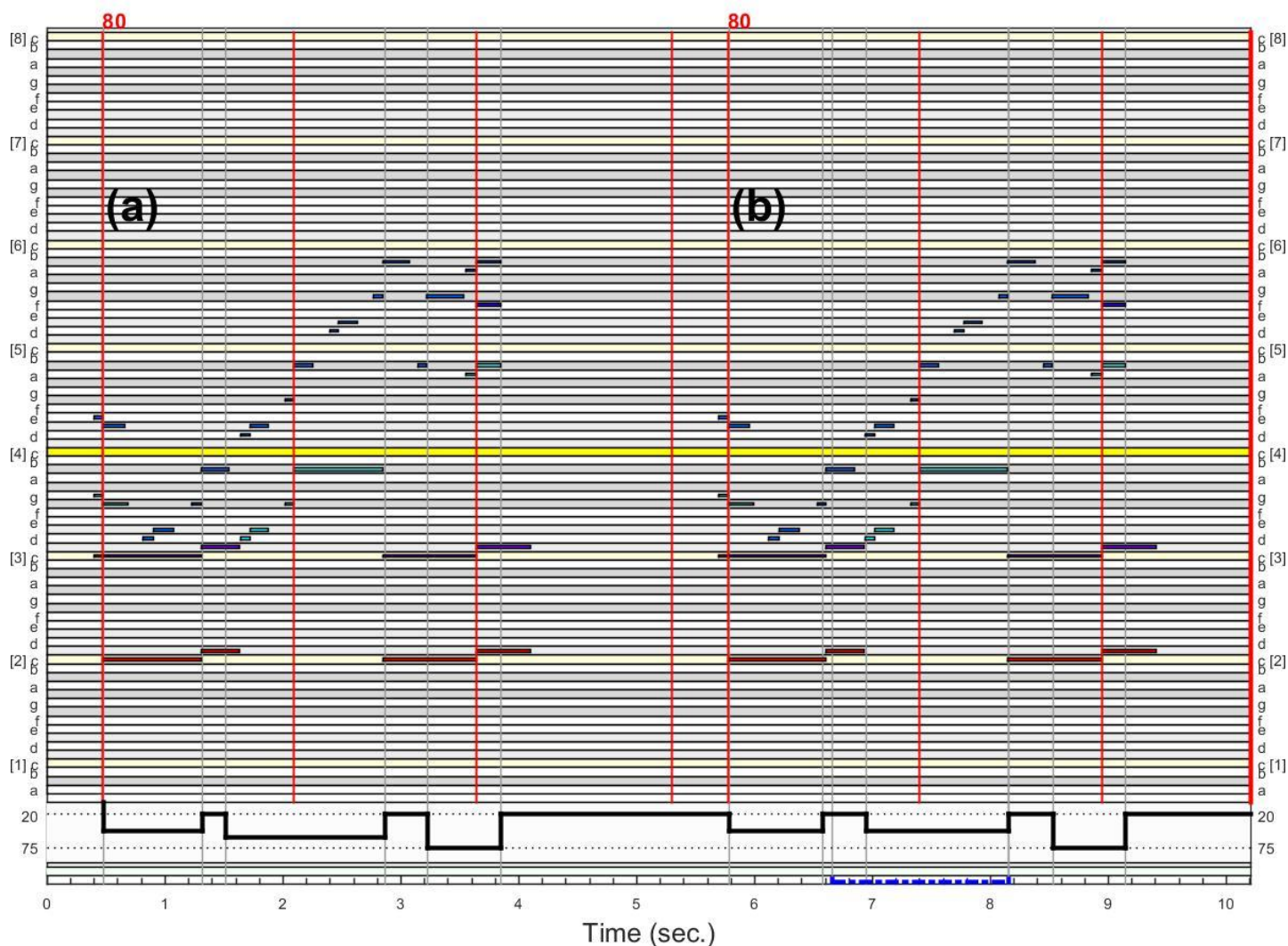
In Schumann's *Fantasia in C*, op.17, bars 80-82 (Score 8a), it may be desired to let the short rests show through the texture to some extent, giving perhaps a skittish effect. One method involves beginning with half pedal and then changing to three-quarter pedal and finally full pedal (K. Schnabel, 27) (Example 8a). A somewhat more elaborate method involves using half pedal and sostenuto pedal simultaneously (Example 8b). The top voice sounds similarly in either case; but with the former method, as here implemented, the bass d-flat octave does not sound for its full length, whereas with the latter method it does.



Score 8a. Schumann, Fantasie in C, op. 17, bars 80-82 (K. Schnabel, 27). (K. Schnabel has not indicated the initial dynamic level, *mf*, here or in Score 8b.)



Score 8b. Schumann, *ibid.* (K. Schnabel, 27-28). The lowest pedal mark indicates *sostenuto*.



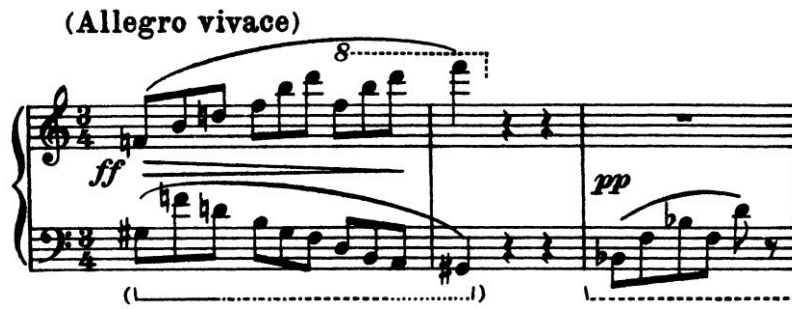
Graph 8. Schumann passage with (a) three degrees of partial pedal, (b) two degrees of partial pedal, together with sostenuto pedal as indicated at the bottom of the graph with a blue dash-dot line.

[AUDIO 8](#)

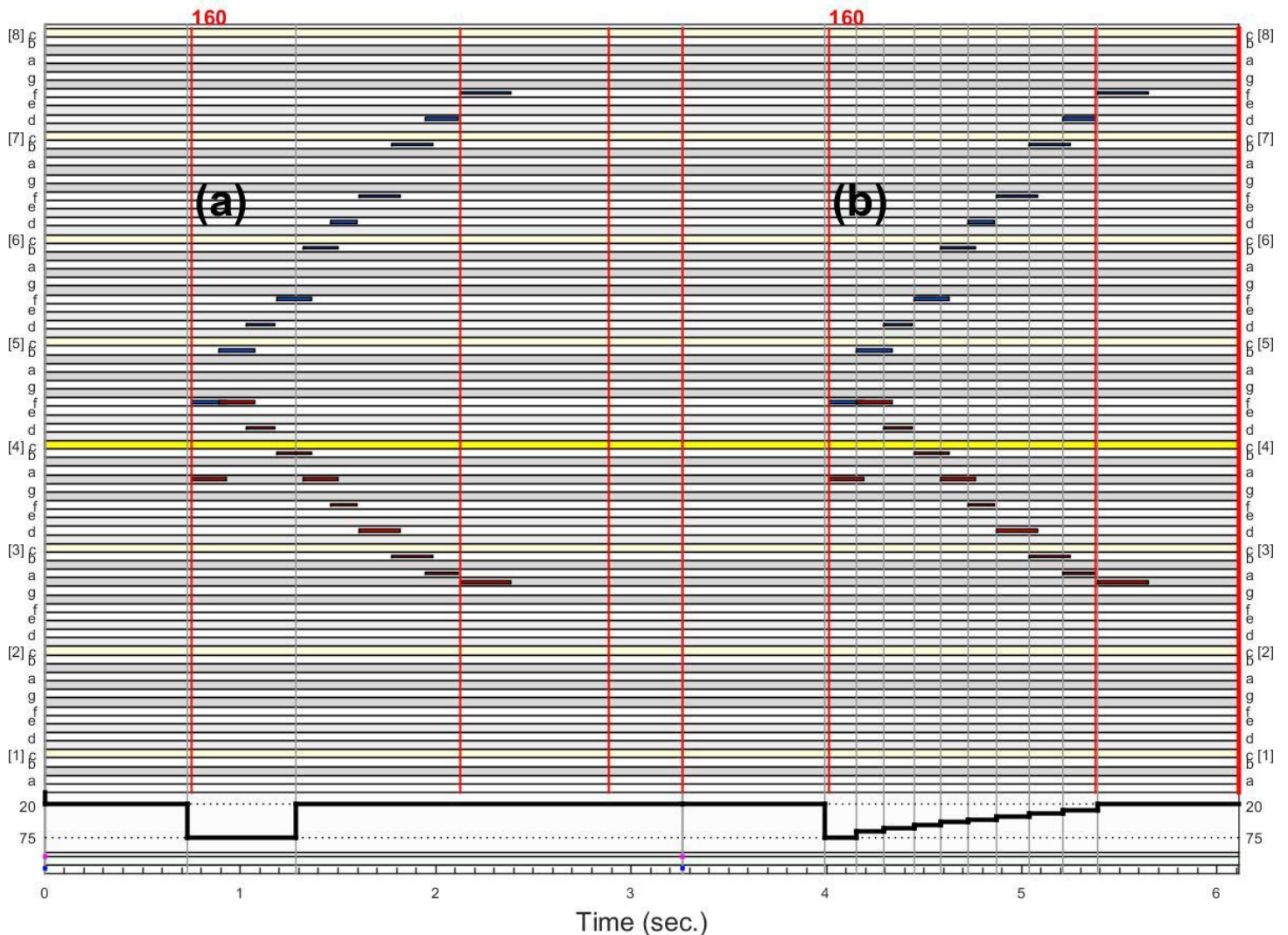
Example 9. Rapid diminuendo in a passage (partial pedal at a gradually changing level)

Schubert’s ‘wedge’ signs are sometimes hard to interpret, for they may signify either an accent or a diminuendo. In his Sonata D784, op. 143, third movement, bars 160-161 (Score 9), either interpretation is possible, some pianists (e.g. Alfred Brendel) having favoured the former and others (e.g. Sviatoslav Richter) the latter. K. Schnabel (*ibid.*, 30) has assumed that a rapid diminuendo is called for and, whatever one’s own opinion might be, that will be assumed here, for the sake of the exercise. In that case, one can simply play successive notes more softly, with a touch of pedal at the beginning (Example 9a). Presumably the diminuendo assumed here is to reach no further than a *pp* level; it could of course be taken to a lower level still, if an extreme effect were desired. K. Schnabel recommended gradually raising the pedal through all degrees of partial pedal (Example 9b). The comparison in sound shows that a more uniform or smoothly

changing texture is achieved by the second method, whether or not that uniformity is considered desirable.⁹



Score 9. Schubert, Sonata D784 op. 143/III, bars 160-161. (K. Schnabel, 30).



Graph 9. Schubert passage with rapid diminuendo by means of (a) softer playing, (b) gradually reduced level of partial pedalling.

[AUDIO 9](#)

⁹ An additional resource would be a gradual increase of the note-off velocity for successive notes; this method, although theoretically feasible, would be very hard for a human to control reliably, and my investigation of a computer implementation of it has found no worthwhile effect from it here.

Example 10. Rapid diminuendo on a chord (several methods)

In the previous example a rapid diminuendo was implemented in a *passage*, whereas in Chopin's Scherzo in b minor, Op. 20, bars 1-8, an enhanced diminuendo might be desired on each of the two *chords* (Score 10). As a baseline or control, a normal diminuendo is first heard, the pedal on each chord being unchanged (Example 10a).¹⁰ I have introduced, as a nuance, a brief silence before the second chord is played, in order to increase the initial impact of the second chord.

K. Schnabel's first suggested method, for a slight diminuendo, is to change the pedal on each chord while the keys are held down (Example 10b). The following points may be noticed: (1) The duration of the pedal change in the second chord is greater than in the first chord, because the bass strings require longer damping than do the treble strings. (2) The top two notes, e6 and b6, might not have dampers on a real piano, but those dampers can be provided in Pianoteq, as they have been in the present rendition. (3) The time during which the keys are depressed, beyond the introduction of the second pedal on each chord, is immaterial because the pedal is fully depressed at that stage. (4) With this method, the low note a-sharp-1 would survive the pedal change to a greater extent than do the other notes of the second chord, so its loudness when struck has been reduced a little from the maximum possible; a stronger-sounding attack could be made in striking the chord if that bass note were played more loudly, but a compromise is needed here.

K. Schnabel's second suggested method, for a greater diminuendo, is to change the pedal while the keys are partially released. That method is feasible for a human on a real piano, although it is perhaps not easily controlled and might be considered an over-refinement; but it is not possible with the Pianoteq program. This is the only case I have so far found in which a resource available to a human could not be rendered by the computer program.¹¹

K. Schnabel's third suggested method, for a more pronounced diminuendo still, is to release the keys while the pedal is fully depressed and then apply a pedal change via a partial pedal release (Example 10c).

K. Schnabel's fourth suggested method combines his second and third ones: a change on each chord via partial pedal release with the keys partially released; since the second method cannot be rendered on the computer, the fourth one cannot either.

Presto con fuoco

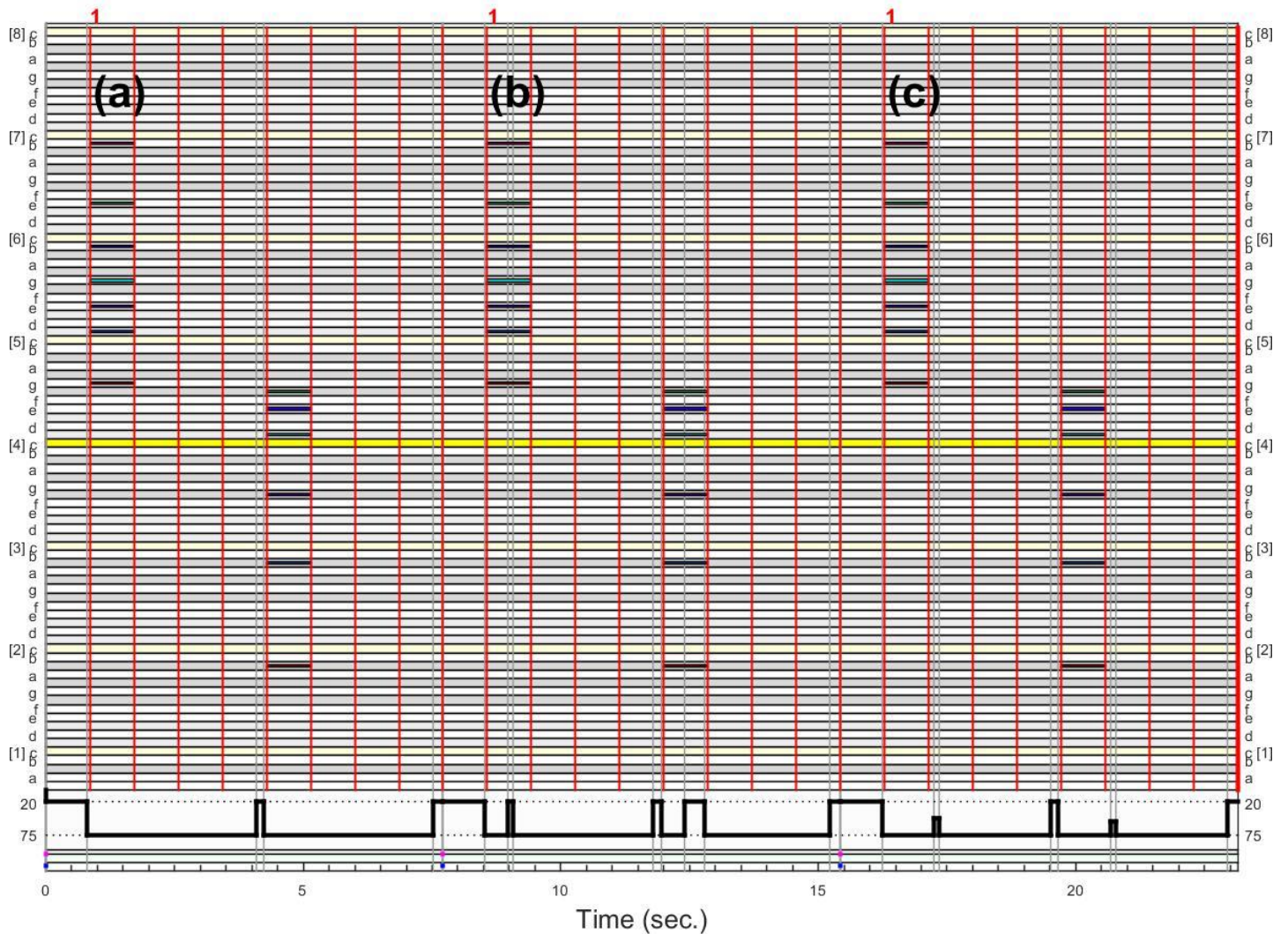
The image shows a musical score for two chords. The first chord is a triad (D, F#, A) and the second is a triad (D, F#, A) with a bass note (A). The score includes dynamics like *ff* and *f*, and a 'Presto con fuoco' tempo marking. A dashed line above the first chord indicates a rapid diminuendo effect.

10

There will always be a change of tone, of course, when a note or chord is held – by finger or pedal – even without using any special technique. But the listener is accustomed to this decrease of tone which he hears with every note played on a piano and therefore it does not give him the impression of being a diminuendo. Only a more rapid decrease of tone, as it can be obtained by the method[s] described above, will give that impression. (K. Schnabel, 32)

¹¹ If partial levels were available for Pianoteq's sostenuto pedal, a similar effect could perhaps be brought about; in fact partial sostenuto could easily be programmed, and I have suggested it to the developers as an enhancement. The damping duration is available as a Pianoteq resource which, however, I have not found effective in this case.

Score 10. Chopin, Scherzo in b minor, Op. 20, bars 1-8 (Schnabel, 31).



Graph 10. Chopin chords with pedal (a) unchanged on each chord, (b) changed with keys down, (c) changed via partial level with keys up.

[AUDIO 10](#)

Example 11. Partial pedal change

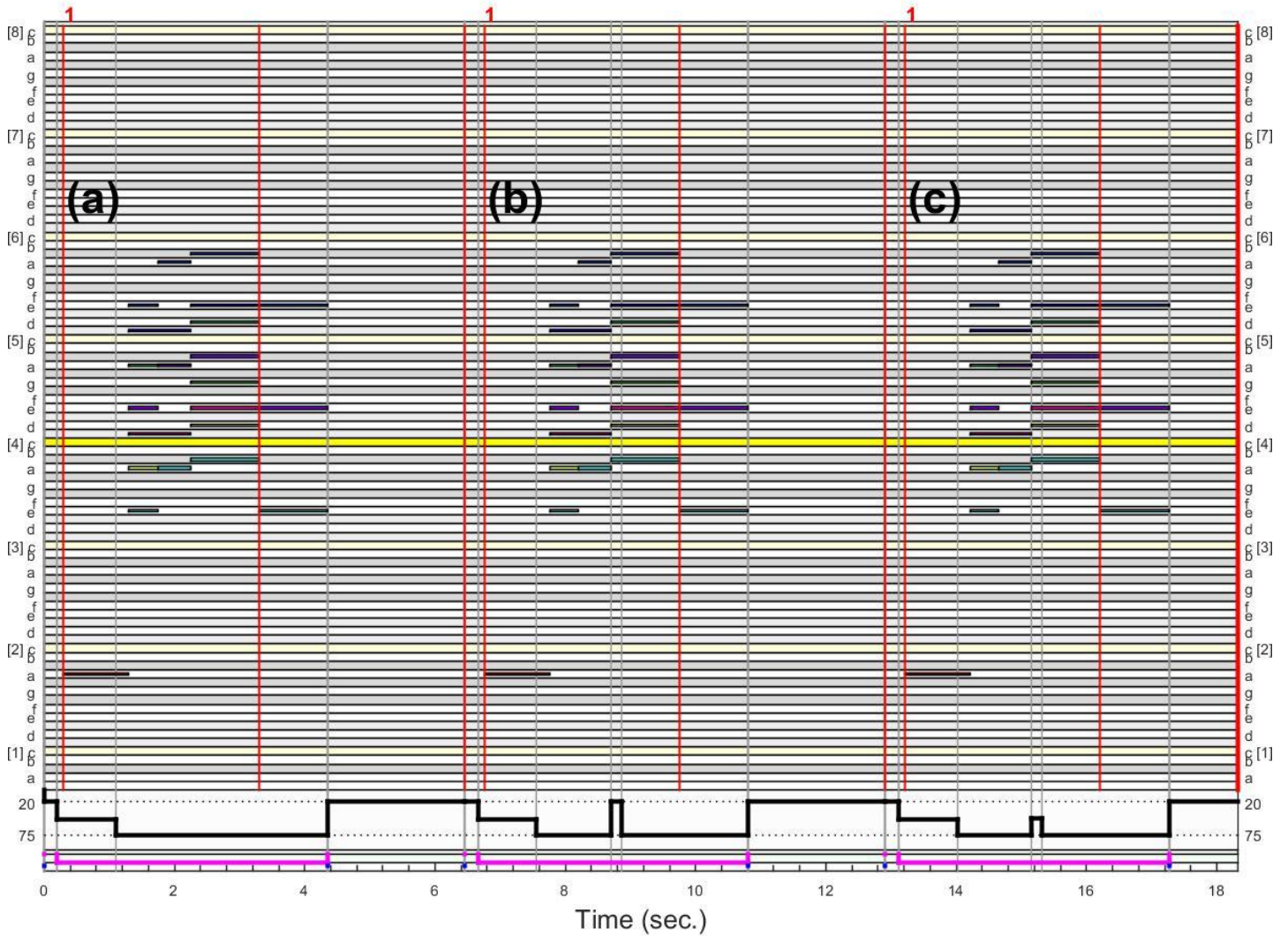
Much of the music of Impressionism requires a certain amount of pedal-haze. Debussy's Prélude, Book I no. 4, *Les sons et les parfums tournent dans l'air du soir*, provides an example (Score 11). I will illustrate the role of partial pedal change in this excerpt by showing, first, no pedal change, which gives too blurred a result (Example 11a), then a complete change, which is too clean a change for this music (Example 11b), and finally a partial change, which seems quite suitable (Example 11c). Giesecking was a great exponent of Impressionist piano music and one who has occasionally written about his approach; as his writings appear to have largely remained untranslated, a translation is provided in Appendix II. Giesecking emphasized the need to control the differential loudness of the notes of a chord; that is an important matter which applies specially in the large tone complexes built up in some of Ravel's music as well as some of Debussy's, although not noticeably in the present example with its more limited scope (K.

Schnabel did not include an example from Ravel). As far as I have noticed, Gieseking never referred to partial pedalling in his writings, although he must undoubtedly have made use of it. Soft pedal is used in all these Examples, shown in pink near the bottom of the graph.¹²



Score 11. Debussy, Prélude, Book I no. 4, *Les sons et les parfums tournent dans l'air du soir*, bars 1-2 (K. Schnabel, 33). (A dot above K. Schnabel's pedal change sign on the third beat is missing – compare *ibid.*, 32, 39.)

¹² All three pedals could, if the need arose, be used at the same time by the computer, but hardly by a human.



Graph 11. Debussy excerpt. Pedal change (a) none, (b) complete, (c) partial. Soft pedal is shown in pink.

[AUDIO 11](#)

Conclusion

To achieve good results in the computer rendition of a given excerpt of piano music with pedal, many experiments would be required with different pedal specifications. The pedal effect is influenced by all the other nuances of a rendition, which also require their own experimentation. All those nuances, together with the pedal use, operate jointly in creating the resulting sound. Only a small number of experiments could be chosen for illustration here. A particular sound source, the Pianoteq program, was chosen, together with a particular choice of virtual instrument, Steinway, within that program. All the desired resources were available from the program, with the exception of partial key release.

Much time and patience is required to choose the many parameters for all the features of a nuanced rendition, in addition to those for the pedals, optimising them to the extent that one can manage. The computer programming to control the procedure is also a considerable task.

Automatic or formulaic methods have not been used here, nor have theories of musical composition or rendition; instead, individualized nuancing and pedalling has been applied in ways that may be considered appropriate to each particular musical situation. The present study of pedal implementation is just one of a number of studies of performance features needed before excellent results could be hoped for in the computer rendition of a wide range of piano music. Nevertheless, the results, even at this early stage, seem quite fair.

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Appendix I

Walter Giesecking. On the pedal. (Undated)

[p.103] The correct use of the pedal is of enormous importance. Poor pedalling can completely ruin the best finger-technique, and a stylistically faultless interpretation depends to a large extent on the correct use or non-use of the pedal.

First, I would like to emphasize that just as the appropriate finger-technique is learned not by the fingers, but by the head, so the pedal is not pressed with the foot, but with the ear. Only in the first years of study is it necessary to think about or write down where and when one will depress and raise the pedal. Later, the pianist must have reached a controlled automatism in the use of the pedal, with which the perceptions of the ear are implemented directly in foot movements, so that the correct use of the pedal occurs as an immediate response to what is heard, and is thus simply a result of the self-control of the player via his trained ear.

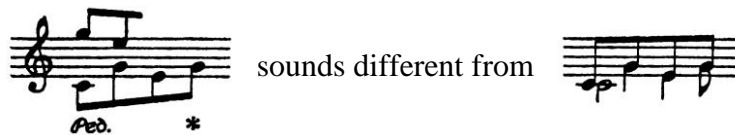
Although it is to some extent possible to determine a precise pedalling for a composition by careful study – with a pianist who is not far advanced this is absolutely necessary –, an accomplished pedal use can be achieved only by instantaneous adaptation to the particular musical situation. By the musical situation I mean the sound with which a rendition of a piece is currently being realised and [p.104] which can never be repeated in exactly the same way. Any differences in the sound quality and the sound volume of the instrument being played and the player's current disposition always result in differences which, although they might seem insignificant to less trained ears, are nevertheless actually present and must be taken into account by the player who aspires to the greatest possible perfection.

To learn the "automatically" correct use of the pedal, a conscious, absolutely exact pedalling must first be used, thus one determined by study. After the player has in this way become accustomed to pedalling with certainty and accuracy, the trained ear will gradually take over direct command of the right foot without the need for prior written instructions, that is, annotations and deliberations. I am speaking only about the right foot, because the – much simpler – use of the left pedal will be set aside here. Only in certain places where special effects have to be achieved – in some newer pieces real trickery is needed to achieve the highest delicacy of interpretation, in which foot and finger technique must complement each other precisely – does the player still have to ask himself: how should I use the pedal here? I hope these considerations will be made easier for him by the following remarks. They are the result of my experiences as a performer and are by no means idle speculations. I will give them in chronological order so as to treat first the simplest and most economical forms of pedal use. I would go so far as to say that the use of the pedal begins only with Beethoven. All previously written music can be played without pedal. Please note "can", not "must"! [p.105] It would be absurd today, when the pedal is available, to refrain from making it easier for the fingers to connect widely separated notes or from beautifying a cantabile passage through the resonance of the overtones. But one should really never hear the use of the pedal in composers such as Bach, Scarlatti, or Mozart, – to my mind a "lustrous" sound does not suit this music. (The lustre of coupled harpsichord arpeggios is something quite different!) As an example showing that I am not putting forward an idea contrived at my desk but am recommending something that I have recognized in practice to be correct, I would like to mention that once in the C Major Concerto (K. 467) of Mozart, when I was accompanied with the utmost delicacy by Furtwängler, I realized at the end of the first movement that I had not yet touched the right pedal. Not by intention, but because the orchestral accompaniment enabled me to bring my part out clearly without any forcing of the tone and my ears had therefore not dictated any use of the pedal at all. – However, this playing without pedal is only possible if certain

accompaniment figures – true to style, as I believe – are played *legatissimo*, and thus with the fingers held down during a harmony. Here is an example:



The often-recommended pedalling on every half-bar at this place "muddies" the melody! [p.106] Do not be under any illusion:



Even if the player does not yet hear it, it sounds different. In this case I have the better trained ears!

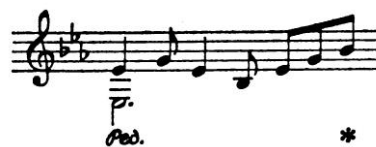


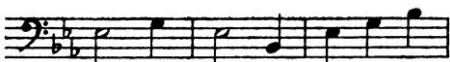
may be allowed [with pedal throughout the bar], because the ascending melody remains fairly clear. Nevertheless, the performance without pedal and with *legatissimo* in the left hand is better. The inverted figure



whereby the melodic line is effaced.

As an example showing that the same succession of notes can have either melodic significance or only harmonic, filling-in significance, I will take the liberty of devising the following variations on the main theme of the *Eroica*:



If  were played on the piano, pedalling would, on the other hand, not be at all appropriate, or at most for strengthening the tones:



Advanced players can pedal:

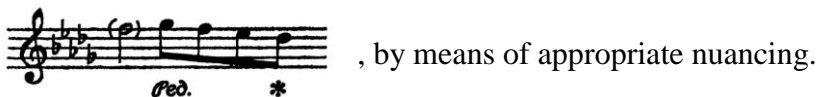
Ped. — Ped. Ped. — Ped. Ped. Ped. Ped.

thus on each note of the melody.

This distinction between melodically significant and only harmonically filling note sequences is very important when considering the correct use of the pedal.

Playing in which the pedal remains inaudible, so to speak, and in any case unobtrusive, has a very different character from a rendition in which the pedal (no matter how clean the technique may be) is used to the extent that is now considered normal by most players. I am firmly of the opinion that early classical music, when it is played in its original version [rather than in a more recent arrangement], must preserve this "pedal-free" character.

Beethoven, Schubert and the Romantics, and in general all piano music written since Beethoven tolerates and calls for the use of the pedal. Passages played without pedal are always the exception here, while the use of the pedal in accordance with the harmony is the rule. However, the conscientious player should, even in this very much pedalled music, always think of the above-mentioned difference between melodically important phrases and simple broken chords, even though most melodies of the Romantics are much more tolerant of swimming somewhat in the pedal-haze, and often even require it. Here the player must often counteract a lack of clarity, which can easily arise in a phrase such as



does not sound unclear because each melody note overcomes the previous ones.

Ascending melodic lines are considerably easier to keep clear in such cases, because the higher sound much more readily overshadows [the previous lower one], and so requires less emphasis and nuancing.

With this shading, this careful nuancing of a melody, we now come to the problems that the stylistically appropriate interpretation of modern, especially so-called impressionist music, poses for us. Here the exact shading of the sounds is necessary not only in the presentation of a melody, but the simultaneously-struck notes of a chord must be struck with different strengths. On this depends the tone quality of a chord, because a triad in extended position sounds different according to whether the third or the fifth [scale degree] dominates, that is, is struck more strongly. The third darkens, the fifth brightens. In "dissonant" harmonies, meaning chords that contain [scale degrees corresponding to] more distant overtones in addition to the third and fifth [scale degrees], it will usually be worth considering that the consonant tones must sound stronger than the inserted dissonant intervals. Sound-effects of that kind are already found in Chopin (the D flat major Nocturne):



[p.109] Once the D-flat major chord in the bass is sonorous enough, no one will hear a

dissonance in this passage in spite of the pedal being held through it. But if the right hand is played too strongly here, the harmony is destroyed and the passage becomes totally unmusical.

To some players it might at first seem impossible to play the simultaneous notes of a chord deliberately with different strengths; and it is not easy, but by complete relaxation of the arm, careful continuous contact with the keys and mental concentration on the notes that are important and to be emphasized, this absolutely necessary perfection of the touch can be achieved. As long as the notes to be emphasized can be struck with the outer fingers of the hand, the difficulty is certainly easy to master. Only when the middle fingers are to give the emphasis is very good hand control required. But with complete relaxation of the arm muscles, making the hand sink down with the keys by its own weight, concentrated thought of the note to be emphasized is enough to cause a contraction of the finger striking this note. As a result of this, more weight is transferred to the contracted finger, and the note in question comes to the fore. Of course, the emphasized note must not sound ahead of time or behind time, but this striking of the notes of a chord simultaneously and nevertheless with different strengths is extremely important to learn.

The reader may wonder why these subtleties of touch are mentioned here, when the pedal is the topic under discussion. The reason is that it is simply impossible to separate the use of the pedal in modern music from these skills of touch. Without these nuances, what results from the too long sustained pedal is an incomprehensible morass of sound, that however [p.110] is a long way from impressionistic music. Even the compositions of Debussy (one must refer to him as exemplary in this case, being by far the most important of all the modern piano composers and being the only master after Liszt who found a really new piano style) must be rendered clearly, even if the pedal sometimes remains held down for pages. ([See for instance] *Voiles* from the second book of *Préludes*.) This long-held pedal requires in the first place that the fingers always strike with the right strength, because a too-strongly accented note can destroy the whole sound-effect of a phrase. The player can generally orient his use of the pedal according to the bass notes that must be sustained, and indeed sustained sonorously enough, for otherwise the dissonances lying above them are no longer remote overtones, but become unrelated figures.

Appendix II

Walter Giesecking: How does one play Ravel's piano music? (1947)

[p.122] The piano compositions of Maurice Ravel rank, for me, among the most interesting works of the piano literature. No other composer, not even Debussy, "orchestrated" better for the pianist's two hands and pedals. If Debussy's work is more versatile and perhaps more expressive, Ravel has reached such unprecedented brilliance of writing style that there is no point arguing over which of the two great French masters, who so far [1947] stand unrivalled in the piano music of the 20th century, has created the most valuable works. For me, Debussy and Ravel signify the ultimate exploitation of the possibilities of the modern piano.

Liszt and several Russian composers draw larger sound masses from the instrument – such a din is prohibited by the French masters' delicacy and "*bon goût*" [good taste] –, and Scriabin and Rachmaninoff have often written admirably beautiful-sounding piano scores; [however,] the perfect unity of idea and instrumental realisation, and the invention derived from the distinctive sound and the specific possibilities of the piano have not been achieved by anyone to the same extent as by Debussy and Ravel.

Consider a piece like "*Alborada del gracioso*" which, presumably because of its difficulty, is unfortunately more often heard as an orchestral piece than in the original version for piano – although Ravel himself orchestrated it masterfully –, [p.123] or study "*Ondine*" or "*Scarbo*", those fairy tales and ghost stories from "*Gaspard de la nuit*": is it not worthy of admiration in the extreme, how a fantastic wealth of ideas of the utmost pianistic brilliance and the most unrestrained delight in sound serves the poetic and musical expression here? The most complete mastery of both the conception and the composition has here created a piano style where the most dazzling virtuosity is not intended to demonstrate the dexterity of the player or to display his more-or-less superficial outbursts of temper – no, every pianistic effect is inseparable from the logical development and connected to the formal structure of the work, and is on that account musically justified.

A good interpretation that combines accuracy and faithfulness to the text with delicacy and sensitivity, bringing out all tonal beauties, gives most marvellous sonic results. Of course, such sophisticated music is not easy to portray, and even the slow movements, which do not place such intimidating demands on the target-striking accuracy of the player, are never easy to play because they require a broad command of the finest nuances of touch.

It is strange how some pianists instinctively adopt these fine differences of touch as well as the correct use of the pedal, while others, who often have much more technical ability, are at such a loss with "impressionist" music that, in their hands, it remains without any sense or tone quality. It is only through these "others" that I have come to realise that there are problems here whose solution is not familiar to every piano player. I have never found it difficult to play such well-composed music harmoniously, [p.124] and my interpretations arose simply from the seemingly obvious need to play the piano in a nice-sounding way.

Without a practical demonstration at the instrument, it is hard to describe a rendering of the sound world of Ravel (and Debussy) in a few sentences – in theory, so to speak. But I will make an attempt to formulate some advice.

The clear portrayal of simple [pre-impressionistic] music is based – roughly speaking – on the apposition of the three components melody, bass, and filling-out harmony (accompaniment) in corresponding sound strengths: melody loudest, bass weaker, and harmony subordinated. In works composed contrapuntally the subject replaces the melody, to which the answer or counter-subject and even more the thematically unimportant voices are to be subordinated in sound. In more richly elaborated works there is an increasing number of

secondary voices that must be emphasized at times, depending on their importance. However, the harmony still remains limited to the chord tones that belong to it.

The "impressionists", who enrich harmony by including more distant, "dissonant" overtones and seek to produce the illusion of tone colour on the piano, make it necessary to use a broad gradation of tonal strengths within a chord, especially when the chord contains considerably more notes than the regular three or four. The right blend of sound usually arises when the consonant notes are sounded more strongly and the dissonant ones more weakly – depending on the degree of their relationship to the root note. Instead of a simple descending scale of tonal strengths: main voice, auxiliary voices, [p.225] bass and harmony, a detailed gradation is needed for all the notes of a chordal union, in which one or more main voices or single important notes must often stand out, but in addition the whole tonal basis must be nuanced according to the harmonic importance of each note.

Particularly important is the right amount of sound for the bass notes, which must be struck with appropriate clarity and (usually) prolonged with the pedal. When a number of fluctuating harmonies are involved, they are understandable to the ear only in relation to the bass notes; their movement and change can be illogical if the foundation of the fundamental tones is missing. Very often, passages or chord sequences must be played so softly that, despite the dampers being raised, they have already faded away when the following notes are played. This is of course feasible only in the treble, or at most in the middle range of the piano, whereas bass progressions are basically connected with a change of pedal.

The right pedal must be used a great deal, and can often be held on for a very long time (in Debussy often for pages!). That all tones must be precisely weighed against each other in their degrees of strength is self-evident.

Playing a sequence of melody notes with raised dampers requires the most careful shading, especially in descending tone sequences. In doing this, each tone must overshadow the previous one, which is achieved by a very gentle, imperceptible crescendo. With an ascending melodic line, this [overshadowing] is of course much easier [to bring about]. These fine gradations of tone must not assume the character of real accents because those have to be saved for the [p.126] places where the composer specifically asked for them. The performance indications in the works of the French masters must be followed exactly; tempo changes and rubato, especially, are to be applied only where they are specified. The indications "*cédez*" (yielding) and "*serrez*" (quicken) are usually no more than the "agogic" fluctuations almost constantly applied in the German romantic style of delivery. Apart from such specially marked places the tempo is, as a matter of principle, uniform.

The execution of all these discreet nuances requires a sophisticated touch technique that must be learned from the foundation of absolutely uniform and exact playing. Anyone who has not yet trained his fingers sufficiently in this evenness of touch will be capable of this "coloured" playing only in those fortunate special cases where a particularly sensitive ear causes the finger to bring about certain modifications of touch intuitively.

The pianist who has mastered his instrument in this way will find in the piano works of Ravel a wonderful opportunity to display his skill. Audiences in all countries will listen to him appreciatively, and there should be no pianist who does not know these masterpieces.