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Mental Representations of Tonal Images in Twentieth-Century Sonoristic Compositions

Concealed in the proposition of reflecting upon 'music as a medium of communication' is the suggestion that music – similarly to language – fulfils one of the basic psychic functions, namely enabling communication, that is, the mutual transmission of information. If 'communication' occurs, this means that there is a sort of transferral of thoughts from one mind to another. In the present article, we will consider the possibility of the 'transferral of the thoughts' of a composer to the mind of a listener (listeners) with the conscious omission in this transfer – so as not to complicate the exposition any further – of the role of the performer (performers). Since we do not have direct access to the thoughts of another person, 'there is a need for an intermediary, in the form of an effective cipher, comprehensible to both sides'.[1] Such an intermediary in communication between a composer and a listener is music, which enables the two sides to communicate (in the case of music without a verbal text) in a paraverbal way.

There is no doubt that conscious listening to music requires its perception, which in psychology is characterised as the set of psychological processes by which people 'recognize, organize, synthesize, and give meaning (in the brain) to the sensations received from environmental stimuli [in the sensory organs]'.[2]

The effect of these psychical processes is the creation of a specific perceptual representation of the heard work of music, which in turn con-

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[1] Edward Nęcka, Jarosław Orzechowski and Błażej Szymura, *Psychologia poznawcza* [Cognitive psychology] (Warsaw, 2006), 590.

[2] Robert Sternberg, *Cognitive Psychology*, 2nd edn (London, 1999).

stitutes a concrete perceptual image of the tonal events derived from the musical structures contained in the composition. It is by means of musical structures that a composer communicates with listeners, wishing to transmit to them his thoughts. Often, however, listeners express the opinion that the perceived music is not understood by them. Communication between the composer and the listeners to his music is absent or incomplete when the composer's auditory representation, being the expression of his thoughts and 'ciphered' in the concrete musical structures of a work, are not identical or close (similar) to the perceptual representations of the heard work of music that are formed in the mind of the listener.

Listeners receive a certain message issuing from the composer effectively when they respect the rules for the interpretation of the semantic units contained in that message.

The essence of music based on sonoristic technique is – as indicated by Józef M. Chomiński – the use of 'the purely sonoric properties of the tonal material for artistic purposes'.[3] Hence the communicational competence between a composer and a listener often boils down to the ability to recognise communicational situations and the composer's selection of appropriate means for the creation of an auditively perceptible sound shape. This auditively perceptible sound shape results from the composer's auditory representations, which in turn reflect his thoughts, and influences the shape of the perceptual representations arising in the mind of the listener while consciously listening to music, of which – as Chomiński claims – the score constitutes the projection of the composer's creative intentions.

In this context, it is not surprising that sonoristic music is rarely made the object of reflection from the perspective of semiotic research and various theories of communication. It would seem more legitimate to employ examples of sonoristic music in reflection from the field of psychoacoustics or the psychology of hearing. And yet sonoristic music is unquestionably a cultural phenomenon, and as such it must subject itself to semiotic-musical reflection.

Michał Bristiger pointed out that sonoristics could constitute 'a whole new area of musical thinking, straddling music theory, compositional practice and the psychology of hearing'.[4] To my mind, this 'new musical

[3] Józef M. Chomiński, 'Podstawy sonologii muzycznej' [Rudiments of musical sonology], typescript, I.1, cit. after Iwona Lindstedt, 'Teoria sonologii muzycznej Józefa Michała Chomińskiego' [Józef Michał Chomiński's theory of musical sonology], *Muzyka* 1–2 (2006), 37.

[4] Michał Bristiger, 'Krytyka muzyczna a poetyka muzyki' [Musical criticism and the poetics of music], in *Współczesne problemy krytyki artystycznej. Materiały z sesji*

thinking' is linked to the fact that in a sonoristic composition the semantic unit refers to the musical sign that is created by autonomous qualities produced by the musical structure and most often not having an object of reference to extra-musical reality. Sonoristic music is characterised by an exceptional wealth – in comparison with all other musics – of musical structures, arising from the huge possibilities for the sonological transformation of pitch material. As Józef M. Chomiński writes:

> Formal structuring assumes the simultaneity of the joint action of all the elements of a work, namely the tonal material, tonal systems, frequency bands, time regulation, states of compression and rarefaction of the sound and its modulation. And different types of structure depend on selection, hierarchy and proportion and the way these elements are treated.[5]

The accentuation in this article of the mental representations of the tonal images of sonoristic music, and not of its musical structures, is due to the fact that it is musical structures that are essentially the source of subceptionally formed auditory sensations, which, determined by the sum of the tonal stimuli received over a particular period of time, create the auditory images or – to put it another way – tonal images of the heard music. The subceptional forming of auditory sensations concerns the reception of music which takes place beyond the threshold of the listener's awareness, and so relates to the preconscious processing of information, during which the listener processes specific stimuli without being aware of doing so.[6]

The auditory image of music (being the foundation of its mental representation) is the result of its conscious perception by the listener and is conditioned by the measurable physical parameters of musical structures, coincidences (masking, summation of loudnesses, beating, etc.) and factors deriving from the listener, resulting from psychical elements of perception (perceptual categorisation and schematisation).

The decoding by the listener of the tonal image generated by auditory experience leads to the creation of a perception which also takes a certain shape. The specific configuration of these shaped perceptions, meanwhile, shapes the mental representation of the heard music.

A sort of communicational trail from auditively experienced music to the listener's thoughts may be schematically presented as follows:

IS PAN [Contemporary problems of artistic criticism. Materials from the conference organised by the Institute of Art of the Polish Academy of Sciences] (Wroclaw, 1973), 109; cit. after Iwona Lindstedt, 'Teoria sonologii muzycznej', 61.

[5] Józef M. Chomiński, 'Podstawy sonologii muzycznej', cit. after Iwona Lindstedt, 54.

[6] Robert Sternberg, *Psychologia poznawcza*, trans. Ewa Czerniawska and Anna Matczak (Warsaw, 2001), 69 [Eng. orig. *Cognitive Psychology*; see above, n. 2].

musical structures (the musical work written in the score)

↓

sound stimuli (the performance)

↓

auditory sensations (the subthreshold reception of music)

↓

auditory images = configurations of auditory sensations

↓

perceptions with a particular shape = configurations of auditory images

↓

mental representation of heard music in the mind of the listener
= configuration of shaped perceptions

The auditory idea (arising in the composer's mind), meanwhile, as Tomasz Łętowski puts it, 'is a psychical state that results from the combining in a new whole of fragments of a person's various past perceptions'.[7] By way of supplementing this definition, it should be added that the perception per se is understood in cognitive psychology as the result of the decoding of nervous impulses; in other words, it is 'the effect of the activeness of the sensory fields of the brain's cortex, which have received information from various senses and brought them all together'.[8] The conclusion is that the vision of the sound of the musical structures that arises during composing – a vision which takes shape in the imagination of the composer – belongs to the category of auditory ideas. Their configuration is the basis for the mental representation of the musical work, which reflects the composer's thoughts about the music he has created. Its foundation is a compilation of auditory ideas, the source of which are the appropriately shaped simultaneous, successive and simultaneous-successive musical structures notated by the composer in the score.

If the composer's mental representations of the configuration of the auditory ideas and the listener's (listeners') mental representations of the

[7] Tomasz Łętowski, *Słuchowa ocena sygnałów i urządzeń* [The auditory assessment of signals and devices] (Warsaw, 1984), cit. after Andrzej Miśkiewicz, *Wysokość, głośność i barwa – badanie wymiarów wrażeniowych dźwięków muzycznych* [Pitch, loudness and timbre – research into the sensory aspects of musical tones] (Warsaw, 2002), 15.

[8] Tomasz Maruszewski, *Psychologia poznania* [The psychology of cognition] (Gdańsk, 2001), 33.

configuration of the tonal images are largely similar, then we can speak of a sort of communication between the emitter of the 'communicational act' and its receiver (receivers). At the same time, the remark concerning the possibility of a large degree of similarity arising between these mental representations of the composer and the listener(s) suggests a genuine lack of the possibility of a relationship of identity existing between these representations. Why does this happen? Why is such a situation particularly commonplace in relation to sonoristic music?

The reason for this is the complexity of the active mechanisms and the processes taking place, which are responsible for the effect of conscious listening to music.

Auditory perception is based on the identification and differentiation – through observation – of the tonal images of heard music. The task of identification essentially involves the listener seeking the mental representation of a given tonal image. Differentiation, meanwhile, concerns the assessment as to whether two tonal images derive from the same configuration of musical structures or from different configurations. Research into perceptual processes in respect to the identification and differentiation of tonal images indicates that these are processes for which different areas of the cortex are responsible. We conclude from this that among potential listeners to a given piece of music there may exist different levels of ability in identifying and differentiating its tonal images. This is conditioned by the cortical properties of their brains, since there may arise certain anatomical differences between the two hemispheres.

We may posit the thesis that the composer knows his music, whereas the listener, each time he listens to it, is only becoming acquainted with it. Auditory perception is, alongside memory and thinking, one of the more important elements in cognitive processing. In order for sensory features to be interpreted by the brain as relating to the same perceived object, the brain 'must employ' information held in the memory. However, 'connecting various sensations together is the result of perceptual learning'.[9]

Sonoristic music is a difficult object of perception, because while listening to it the perceiver experiences the auditory images of highly complex musical structures. These produce highly complex and variable sensations, which for the listener may cause difficulties with perception. During the auditory reception of music, the listener makes a sort of selection of sensations, and extremely important here is the process of learn-

[9] Ibid., 33.

ing. A listener learns to differentiate the distinctive features of sensations. When a given piece of music is 'heard through' many times, the ability to differentiate these features is enhanced, thanks to the process of learning.

The complexity of the problem discussed here is also due to the fact that two kinds of process participate in the perception: bottom-up and top-down. Bottom-up processes begin with the reception of information by the sensory organs, which is then analysed on higher levels of the nervous system, leading to the generation of perceptions and the forming of a tonal image. In top-down processes, a greater role is played in the generation of perceptions by processes of memory, which direct the search for and interpretation of sensations. Due to the diversity of sonoristic music in respect to form and sound, it is chiefly bottom-up processes that are employed in the cognitive processes.

In addition, the retention of simple information obtained as a result of sensory registration takes place in the store of sensory information, which enables this information to be kept in the cognitive system until the phase of emotional assessment and then the phase of the recognition of the content of the stimulus (perceptual categorisation).[10] In perceptual categorisation, the listener seeks in his mind the category to which the incoming information is best suited. The experienced listener also effects a schematisation. Categorisation and schematisation are not mutually exclusive processes; indeed, they are mutually complementary, since the construction of the standard that serves as a model in memory recall is based on the memorisation of an ever greater number of the distinctive features of the heard music, which are employed in their integration into a schema. Cognitive psychology links categorisation with schematisation in the sense that it treats the schema as a part of the perceptual process, a part which – as Ulric Neisser states – 'is internal to the perceiver [listener], modifiable by experience and somehow specific to what is being perceived. The schema accepts information as it becomes available at sensory surfaces and is changed by that information [...].'[11] This reasoning contains the suggestion that there exists a certain set of innate perceptual elements, within which, besides the senses, there also exist schemata that control them. The

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[10] It is worth mentioning here that the primitive emotional assessment of music is a function of specific subcortical structures, to which lead collateral vessels that branch off in the nervous system from the sensory ducts. Ibid., 38–39.

[11] Ulric Neisser, *Cognition and Reality: Principles and Implications of Cognitive Psychology* (San Francisco, 1976), cit. after Tomasz Maruszewski, *Psychologia poznania*, 53.

schema, meanwhile, acts as a prototype for the classification of patterns into well-defined categories.

In the case of sonoristic music, which arose and flourished in the twentieth century, there exists a potential difficulty in the forming of cognitive schemata enabling formal tonal images to be recognised. The cognitive schema is the result of repeated experience of music composed of specific musical structures. In music history, sonoristic compositions have functioned 'too briefly', as yet, for the conditions to arise for the consolidation of the patterns which constitute the roots of the cognitive schemata of this music.

It follows that the listener, in the phase of perceptual categorisation, makes use of a certain store of ready-made innate schemata and of schemata of 'generalisation' employing prototypes which have the character of arithmetic means or modal values (the most frequently occurring images). In each case, the schemata, through their relative constancy and their connections with other parts of the auditory experience, enable the listener to recognise tonal images which on the surface resemble nothing that the listener could have previously perceived.

In the case of the perceptual categorisation of the tonal images of sonoristic music (although not only), the role of invariants shaping a prototype may be played by stable patterns to the pitches of tones, which refer to a relative pitch, recurrent patterns of rhythmic values, expressed in numeric relations referring to rhythmic pulses, and the repetitiveness of a particular configuration of sensory features, which determines the qualitative relationship among tonal images (linked to such parameters of the musical work as performance means, articulation, the pitch range of the musical material employed, dynamics and agogics).

In the process of the cognition of music, the role of memory cannot be overestimated. Passing over the classification of kinds of memory, less important to us here, it is worth remembering that psychology states that each of us (potential perceivers) possesses three kinds of memory, which are outlined in the table below.

The organisation of memory and the limits to our capacities for remembering have a strong influence on the way we perceive, and consequently on the shape of tonal images and their temporal boundaries. Memory affects the listener's decisions as to when given tonal images or their configurations end and others begin, and also as to the way in which tonal images are connected with each other in the mental representation of heard music. The three basic kinds of memory are linked to three temporal levels of auditory experience.

Table. Essential properties of sensory, short-term and permanent memory (from Tomasz Maruszewski, 159).

PROPERTIES	TYPE OF MEMORY		
	Sensory	Short-term	Permanent
capacity	approx. 18 elements; variable, depending on research method	7±2 elements (Miller}, 8o bits (Lehrl, Fischer}	185 billion items of information (Csikszentmihalyi), practically unlimited
storage time	0.5 s, exceptionally slightly longer	15–18 s (Peterson and Peterson}, 5.4 s; can be extended thanks to internal repetition	Practically unlimited
format of recorded information	visual or auditory; other modalities also possible	acoustic, possibly semantic	semantic, also possibly visual, auditory, more rarely in other modalities
forgetting	decay, masking effect also occurs	decay or interference*	lack of access
control exercised by subject over given type of memory	lack	internal repetition	very substantial; various forms concerning both the organisation of remembering and also the use of specific recall strategies

* Interference involves the disturbance of an existing memory trace by information reaching the individual later.

Elements of musical structures occurring 50 milliseconds apart (which corresponds to a frequency of 20 tonal events per second) accumulate, creating a level of blending of the tonal events (often termed their 'fusion'). In the auditory experience, this level is linked to the forming of the sensory features of musical structures, and the boundaries of this level result from limits as to the speed at which the neurons can process incoming information.[12]

[12] Bob Snyder, *Music and Memory* (Cambridge, 2001), 25.

The musical structures responsible for tonal events occurring at intervals greater than 63 milliseconds participate in the second level of auditory experience. They are separately distinguishable, but are not so far apart from one another on the timescale as to cross the time limit of short-term memory (ave. 3–5 seconds per event). In relation to music based on classical norms of construction, linked to tonal organisation as broadly understood, such tonal events create a melodic and rhythmic level of auditory experience. In the case of sonoristic music, these levels can be defined as levels of the forming of pitch and time patterns. Within the range of this level, there ultimately occurs the successive, simultaneous or successive-simultaneous grouping of elementary events endowed with particular sensory features. A proximity of pitch, of time, a similarity among the dominant sensory features, a common type of motion and a continuity to the flow of the music determine the integration of these events, which are subject to the above-mentioned criteria for grouping. The main difference between the level of grouping and the level of blending of events is that on the latter level the listener registers the boundaries between single formed tonal objects with specific sensory features, whereas on the level of grouping he registers temporally expanded patterns comprising numerous events. The difference concerns the timescale. The boundaries between events on the level of blending have an immediate character, not exceeding the length of ultrashort (sensory) memory, but at the level of grouping, the events are sufficiently extended in time that short-term memory is required for their perception. However, these temporal differences are not absolute. Moreover, the duration of the recollections from sensory and short-term memory may coincide.[13] This is also the level of the forming of the listener's tonal images and the composer's auditory ideas.

Configurations of the succession of tonal images extended for a time exceeding the limits of short-term memory create mental representations of music that refer to the formal level of its experience. This level of experience is most often described by the listener metaphorically, the metaphors concerning movement within a physical space. Movement in large physical spaces requires the use of long-term (permanent) memory. The listener says of groupings of tonal events formed in this way that they are 'earlier' or 'later', and describing the auditory experience he indicates that he becomes 'lost' in the music, 'finds himself in a particular place'. The formal level and its articulation are linked to the structure and limitations of permanent memory. In contrast to patterns existing on the level of grouping, in which short-term memory is engaged, segments

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[13] Ibid., 31–45.

or sections on the formal level exist within a timescale that is too great for memory to be able to embrace them all 'in the present'. Additionally, broad sequences of events on this level do not automatically conserve their order in time. This order must be reconstructed – it is not a given characteristic. Thus for the links between the configurations of tonal images on the formal level to be discovered, they must find their way, at least in part, into consciousness (by being summoned or recalled) from the permanent memory.[14]

At this point, it is very important to realise that all the listener's experiences from the above-described levels are temporally interconnected as they occur. In actual fact, the different levels of experience are no more than differences between individual ways of processing information in the memory.

Also important in music cognition are memory processes which enter the realm of non-declarative memory (implicit knowledge, which occurs automatically and exclusively in such a context in which it was assimilated). These are priming, sensitisation and habituation.

With the effect of priming, each stimulus presented sufficiently early contains a trace that modifies the correctness and facility of the recognition of stimuli appearing at a later time. Priming acts bi-directionally, and so the identification of further stimuli can be made easier or more difficult.[15]

Sensitisation increases the attention devoted to stimuli which differ – be it only in some minor detail – from stimuli previously memorised. The memory has the chance to alter the information it contains. Habituation, meanwhile, is the opposite to sensitisation, as it involves the reduction of attention devoted to the analysis of stimuli that are already familiar.[16] Although it does occur that one of these memory processes dominates, barring exceptional situations these processes mostly act together, responsible for the evolution of our memory.

All the above-mentioned phenomena accompanying a listener's cognition of music can be followed through a specific example.

Of course, for the potential listener unfamiliar with the score notation of a perceived composition, the only source of his cognition of the music is auditory experience. However, in order to make it easier for the reader to follow the analysis of the cognitive processes of the given work, it will be helpful to refer to its score. The piece to be analysed is the opening fragment (2'45") of Kazimierz Serocki's composition *Forte e piano*, from 1967.

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[14] Ibid., 69–72.

[15] Tomasz Maruszewski, *Psychologia poznania*, 168–169.

[16] Bob Snyder, *Music and Memory*, 23–25.

The duration of the analysed fragment allows for all the kinds of memory to be involved in the cognitive processes, namely sensory, short-term and permanent memory.

Whilst aware of the fact that the listener may be able to register information concerning the heard music in his permanent memory before the lapse of the storage time of information in the short-term memory (5.4 seconds, according to Siegfried Lehrl and Bernd Fischer[17]), it should be stressed that Serocki's sonoristic composition is characterised by a variability of sound, which hinders the categorisation and schematisation that activate this kind of memory.

Above all, there is a lack here of traditional themes and motivic working, and in place of this the sound flow of the composition is shaped by a succession of clearly dismembered tonal sequences formed by structures of various shapes. The brief duration of the structures favours the involvement in the perception of particular tonal phenomena of bottom-up processes, which enable acoustic information to be received by the auditory system and analysed on higher levels of the nervous system, leading to the creation of specific tonal images. The sensory memory that is activated on this level of the perception of a work enables (in keeping with its specific nature), as part of the auditory experience, tonal structures occurring approx. 0.5 seconds apart to accumulate and to be fused; that is, it enables the sensory features of the musical structures to form. Thus, for example, the opening 30 seconds of *Forte e piano* constitutes in the receiver's auditory image a succession of rhythmic tonal structures, the image of which is complicated 15 seconds into this sequence when the composer adds to the intoned tone of the kettle drum a two-note motif in a low register of the second piano. The duration of this figure (0.375 sec. – a succession of two semiquavers with M. M. minim = 40) and the notes from the contra and sub-contra octaves only enable the forming of an overall sensory feature of this structure, that is, the perception of the fusion of tones of a very dark timbre with a duration that is hard to specify. (See Example 1).

The gradual thickening of the sound of the work – the condensing of the pitch-time space, which results from the introduction of an increasingly substantial modification and complication of the musical structures and from the gradual acceleration, lasting for over two minutes, of the flow of the music (successive tempos are designated by the following metronome markings: minim = 46; 54; 64; 76; exception 66; 80) – cause increasing difficulties in the categorising and schematising of the auditory images that appear.

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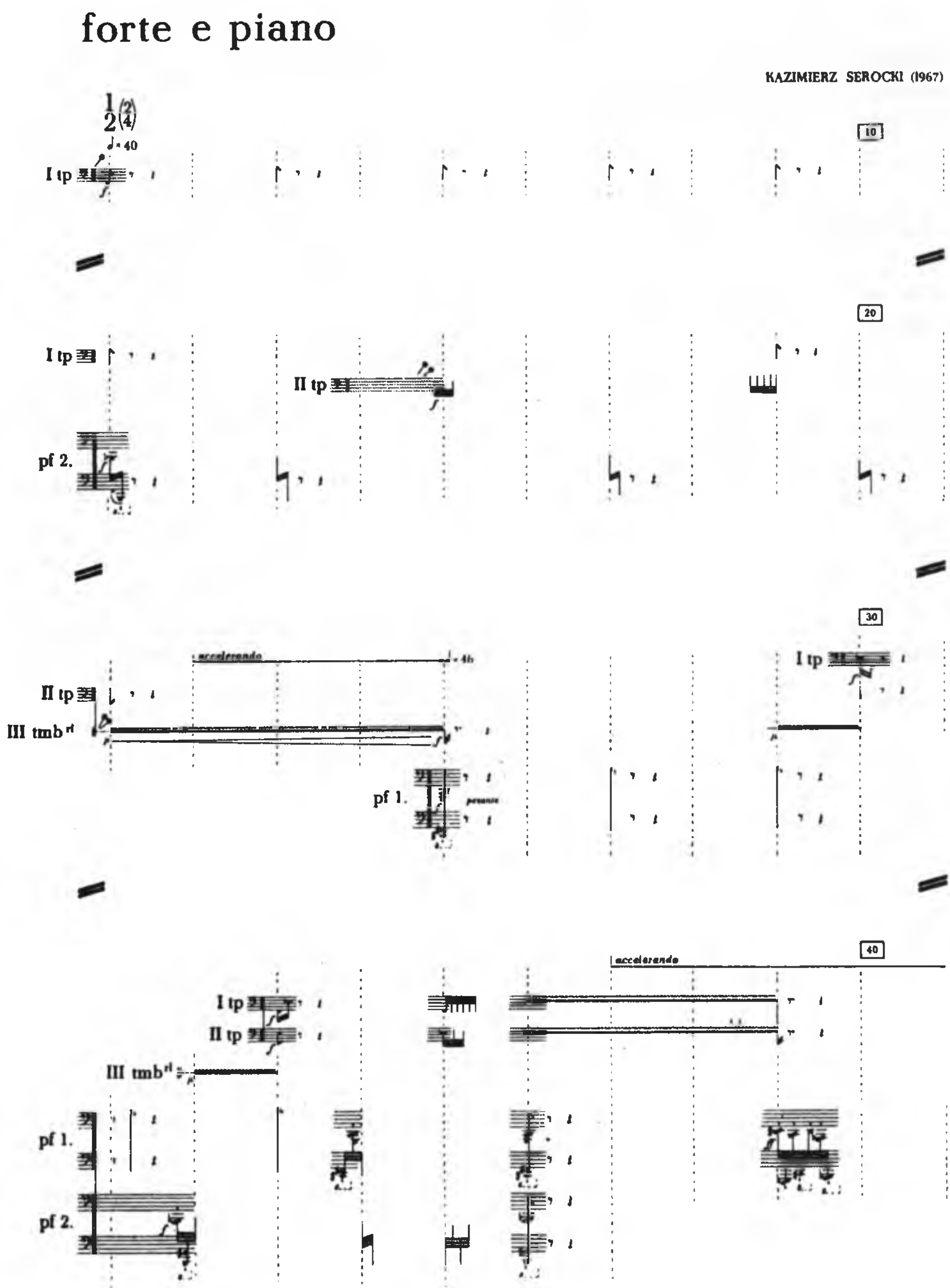
[17] Siegfried Lehrl and Bernd Fischer, 'The Basic Parameters of Human Information Processing: their Role in the Determination of Intelligence', *Personality and Individual Differences* 9 (1988), 883–896.


forte e piano
KAZIMIERZ SEROCKI (1967)
I tp
II tp
III tmb
pf 1.
pf 2.
accelerando
10
20
30
40

Example 1 – p. 1

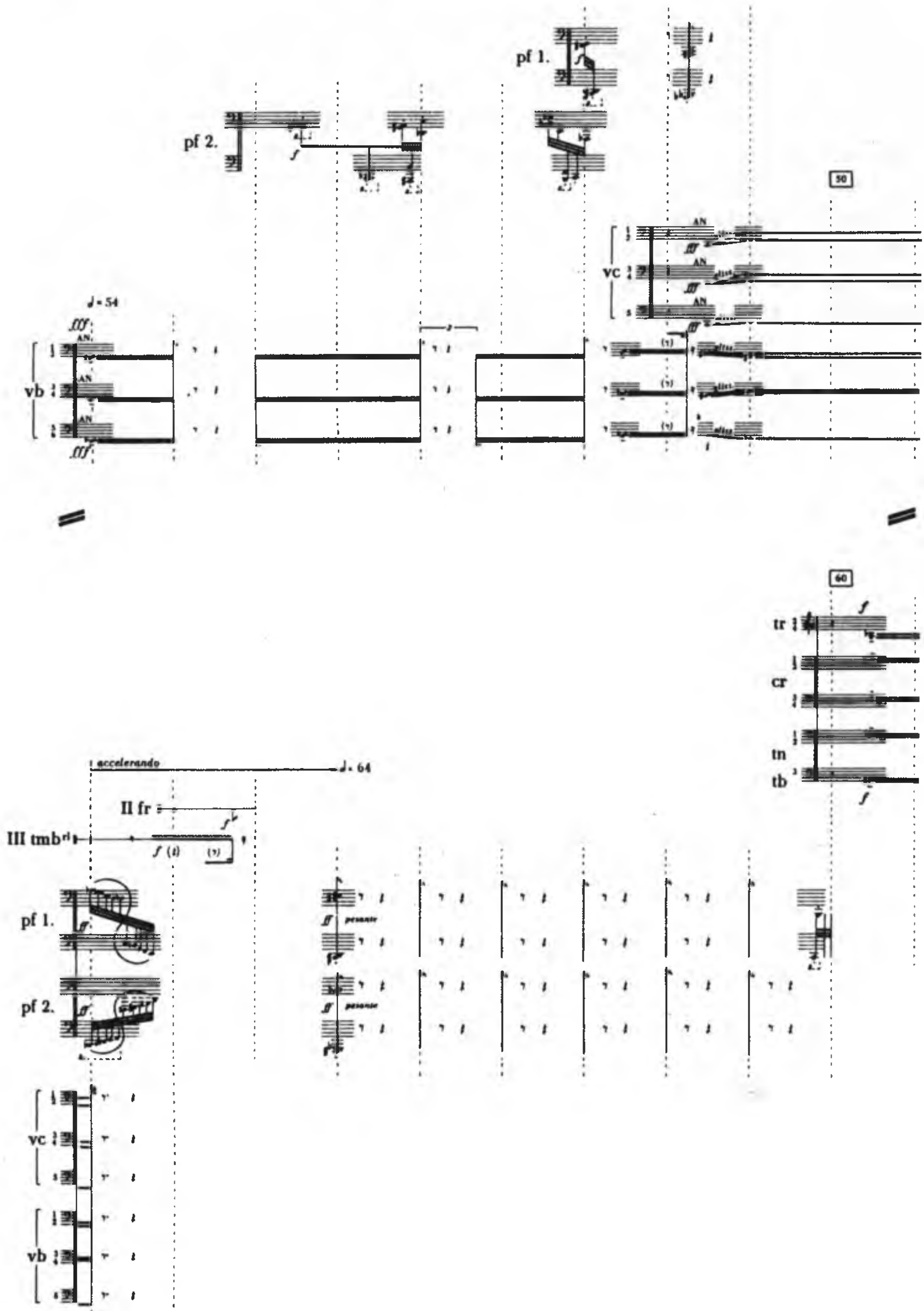
However, the similarity of the tonal structures intoned by the pianos allows the listener to memorise their distinctive features, which refer to a specific harsh timbre and the imparting to them – due to their fusion – of an impulsive character. Their auditory perception refers to the level of the forming of pitch and time patterns, which in turn, due to their specific sensory features, are subject to a successive grouping. The common type of motion to the tonal structures in the parts of the pianos, the similarity of timbre and the temporal proximity integrate them, with the result that the listener registers temporally extended patterns consisting of numerous tonal events, the perception of which engages short-term memory. A similar perceptual situation is created by the fragment of the composition in number 90. (See Example 2 – nos. 50–60 and p. from no. 80).

These fragments of *Forte e piano* are also a good example of the presence during listening of memory processes derived from non-declarative memory. The identification of patterns in the integrated piano structures favours the formation in the listener's mind of a certain schema, which acts like a prototype for their classification into well-defined categories. At this stage of the auditory perception, the listener is subject to the joint action of sensitisation and habituation. The presence of habituation relates to the piano structures, to which – as stimuli already familiar – the listener now devotes less attention in his analysis of the perceptual situation.

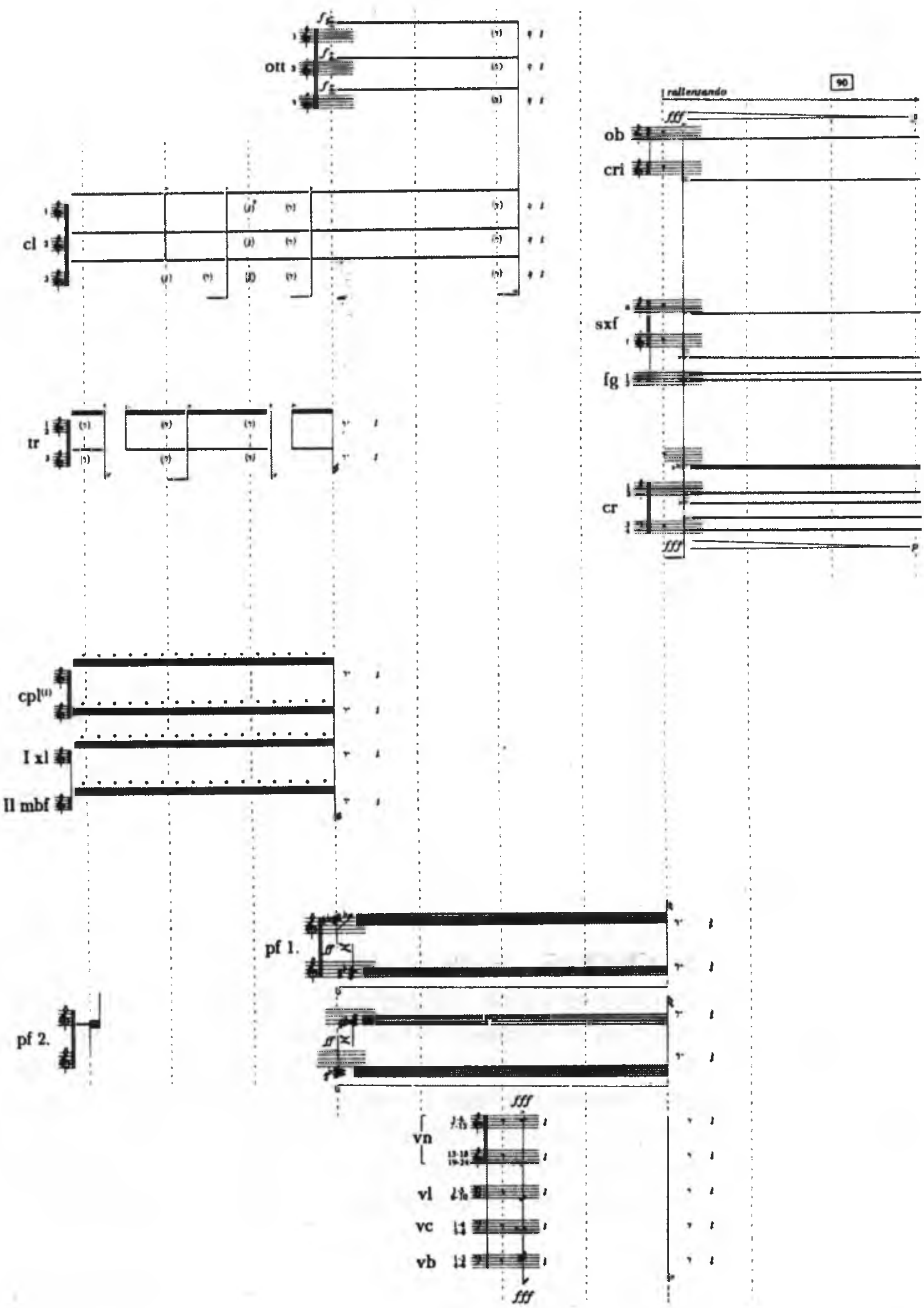
By contrast, in respect to the musical structures which become the source of new sensory features – e.g. those which derive from the cellos and double basses (nos. 40 and 50) or the brass (no. 60) – the listener becomes particularly sensitive. He is aware that in the perceived music there now appear stimuli which he had not previously observed, and he begins to focus on these more intensely. As the auditory image of the music takes shape, there are numerous coincidences present, such as masking[18] or the summation of loudnesses,[19] the sources of which the listener – even on experiencing this music many times – is unable to pinpoint. It is the composer who, in scoring his work, is aware of the number and type of sources forming the particular tonal structures which are necessary

[18] In the fragment under discussion, we observe the phenomenon of partial masking, which leads to a weakening of the audibility of the voices of the double basses and the cellos, due to the presence of piano structures with a greater intensity and a lesser frequency than the masked structures.

[19] The intensity of the pairs of string instruments is summed and gives a generalised loudness of the perceptual stream shaped by them, and also increases the loudness of the whole section, which is generated by the successive and simultaneous-successive musical structures of the pianos, double basses and cellos, and later also by the side drum and the wind instruments.



Example 2 – nos. 50–60



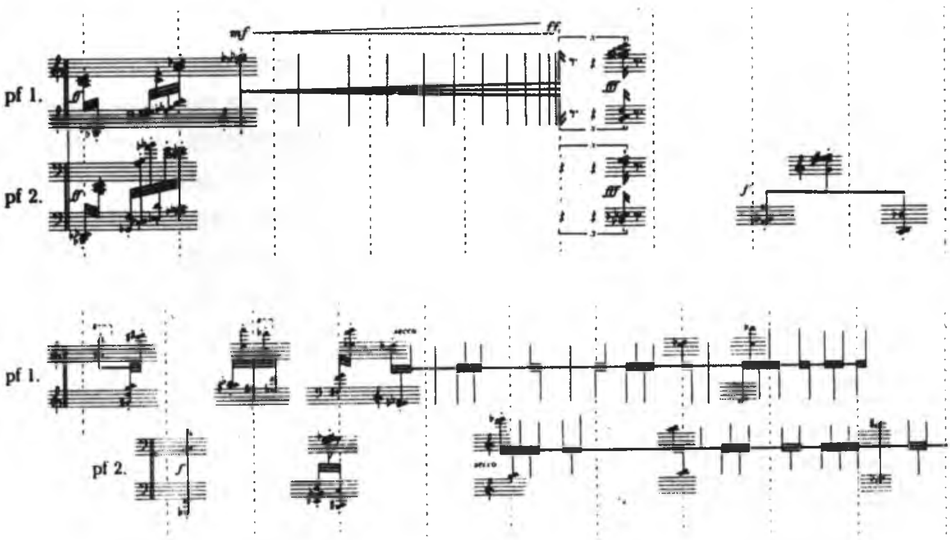
Example 2 – p. from no. 80

to generate the intended auditory ideas. The listener, meanwhile, perceives the configurations of specific sensory features which become for him the basis on which he generates tonal images with specific shapes. The shapes formed by the three pairs of double basses have the character of a perceptual stream, the organisation of which is governed, first and foremost, by a bottom-up mechanism involving the integration of the succession of tones in pitch and time proximity. Within the scope of short-term memory, there occurs a perceptual binding of pairs of tones, the basic frequencies of which are determined by tone pitches differing by no more than two or three semitones; furthermore, these tones succeed one another very rapidly (a semiquaver lasts for approx. 139 milliseconds) and are characterised by a similarity of timbre (pairs of double basses). The perceptual conditions described here favour so-called 'compulsory fusion', which results in the integration of several such pairs of tones into a single perceptual whole.[20]

The tracking of the sequences of the two pianos throughout the whole fragment of *Forte e piano* under analysis confirms the substantial role played by the phenomenon of priming. The intoning of demisemiquaver dyads and chords, the succession of which condenses the pitch space, becomes a source of the generation of impulsive tonal events, harsh in timbre, which, within the scope of sensory memory, undergo fusion. The constancy of the sensory features forms a memory trace, which facilitates the identification of similar tonal images at any moment they appear. On the other hand, the changeable time patterns, shaped by simultaneous-successive structures in the pianos, mean that the listener devotes greater attention to those sequences which modify the trace produced as a result of the perception of the previously heard sequence of the pianos (e.g. the sequence of the pianos in no. 60 and the sequence of the pianos in number 70. See Example 3).

An interesting example of an perception that is difficult to describe is provided by the perception of numbers 70–80 of the composition. The listener perceives numerous tonal structures of different pitch, duration and above all timbre. Perceiving tonal structures with different basic components (different pitches) and a differentiated harmonic composition (tones of definite and indefinite pitch), the listener follows separate auditory images, which are generated by combined perceptual determinants.

[20] Albert S. Bregman, *Auditory Scene Analysis: The Perceptual Organization of Sound* (Cambridge, 1990), 472; based on Leo van Noorden, *Temporal Coherence in the Perception of Tone Sequence* (Eindhoven, 1975); Leo van Noorden, 'Minimum Differences of Level and Frequency for Perceptual Fission of Tone Sequences ABAB', *Journal of Acoustical Society of America* 61 (1977), 1041–1045.



Example 3 – only the sequence of the pianos, no. 60 and no. 70

These are the pitch proximity of successive structures (e.g. the part of the three trumpets or three trombones in no. 70), differentiated durations (a regular and irregular succession of tonal impulses (the part of the pianos or the impulses of the xylophone and marimbaphone in no. 70) or a continuity to the tonal stream (the sequence simultaneously intoned by the flutes, clarinets and saxophones in no. 70 or by the parts of the pianos in no. 80, the sequence simultaneously intoned by the bells, xylophone and marimbaphone in no. 80)), similarity (structures intoned within the same group of instruments, e.g. woodwind or percussion) or a difference in timbre among intoned tonal structures (asynchronous structures generated by instruments from different groups). The listener's attention proceeds from the perceiving of one timbral set to the next.[21] A consequence of the formation of separate auditory images is a difficulty with perceiving the temporal relationships which arise among images, and also with identifying and differentiating the sources of the auditory images that arise. (See Example 4 – nos. 70 and 80).

A similar perceptual situation is created by numbers 100 and 140 of the composition.

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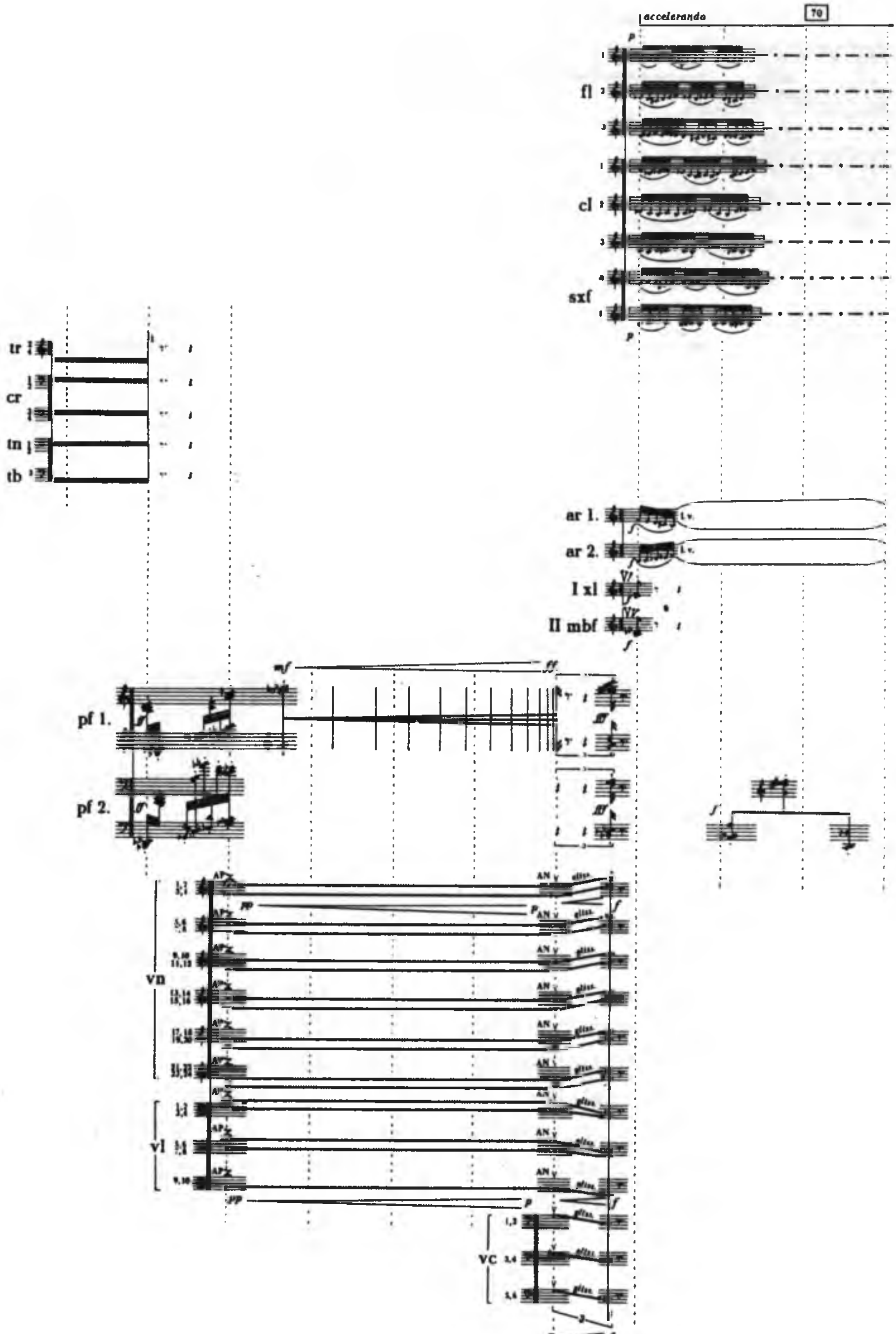
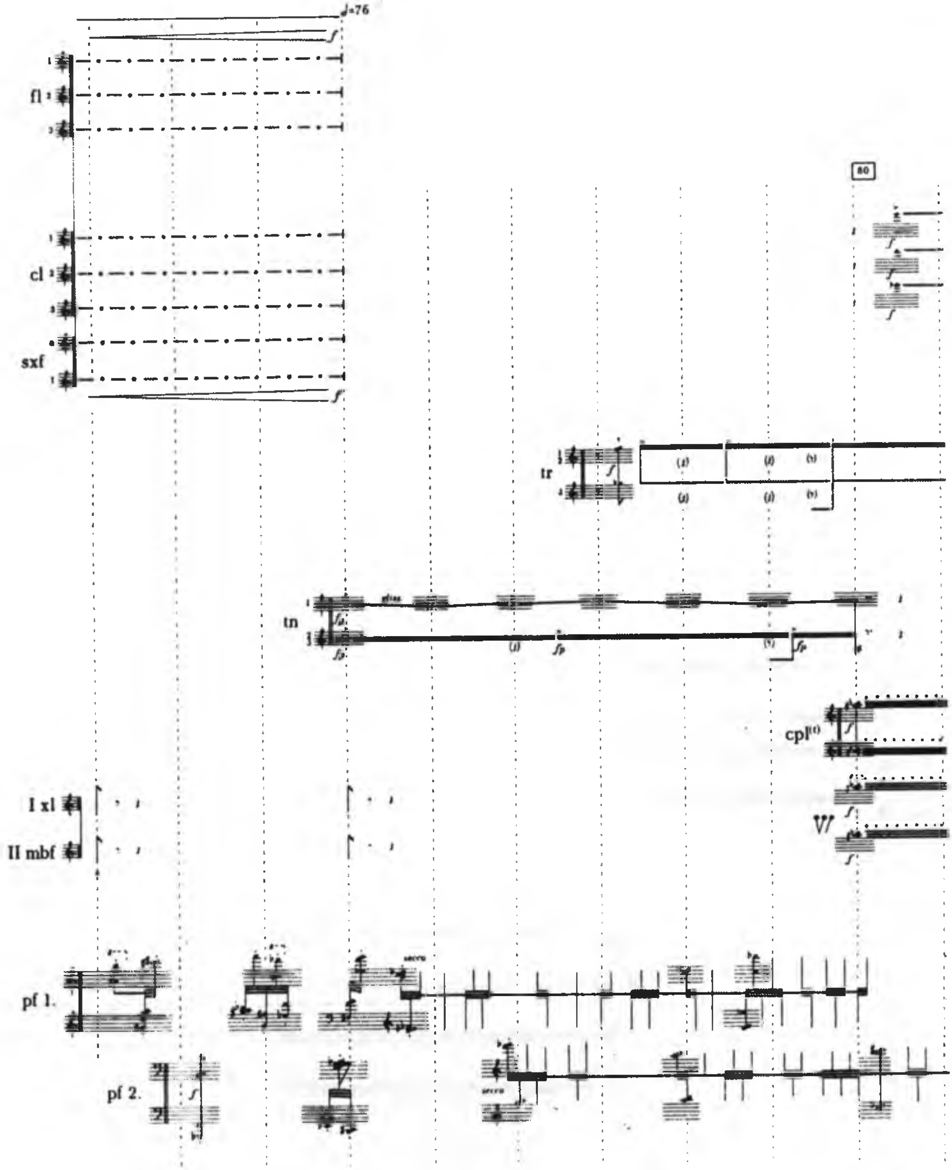
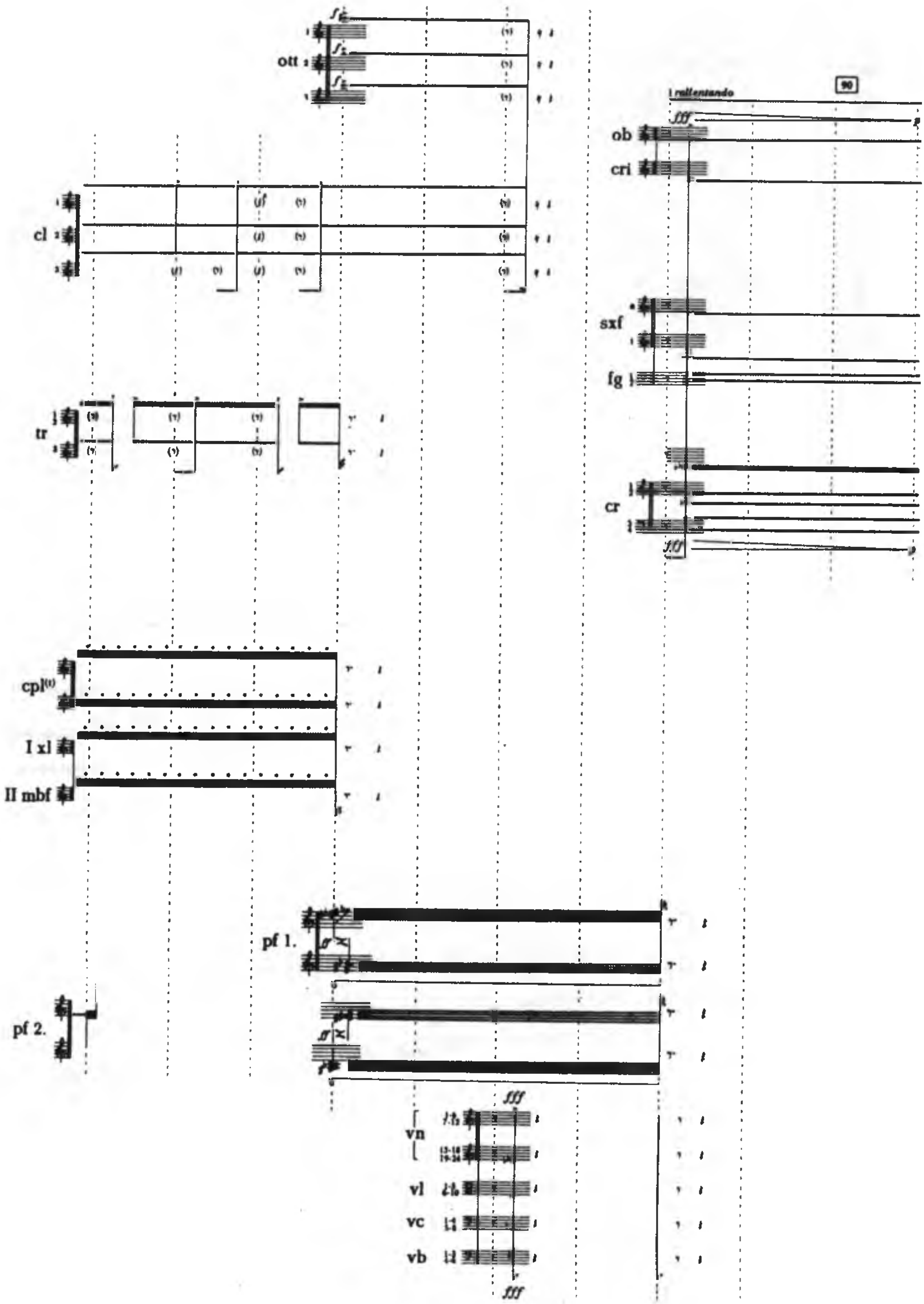
[21] Punita Singh, 'Perceptual Organization of Complex Tone Sequences: A Tradeoff Between Pitch and Timbre?', *Journal of the Acoustical Society of America* 82 (1987), 886–899.



Example 4 – no. 70



Example 4 – nos. 70 and 80



Example 4 – nos. 80 and 90

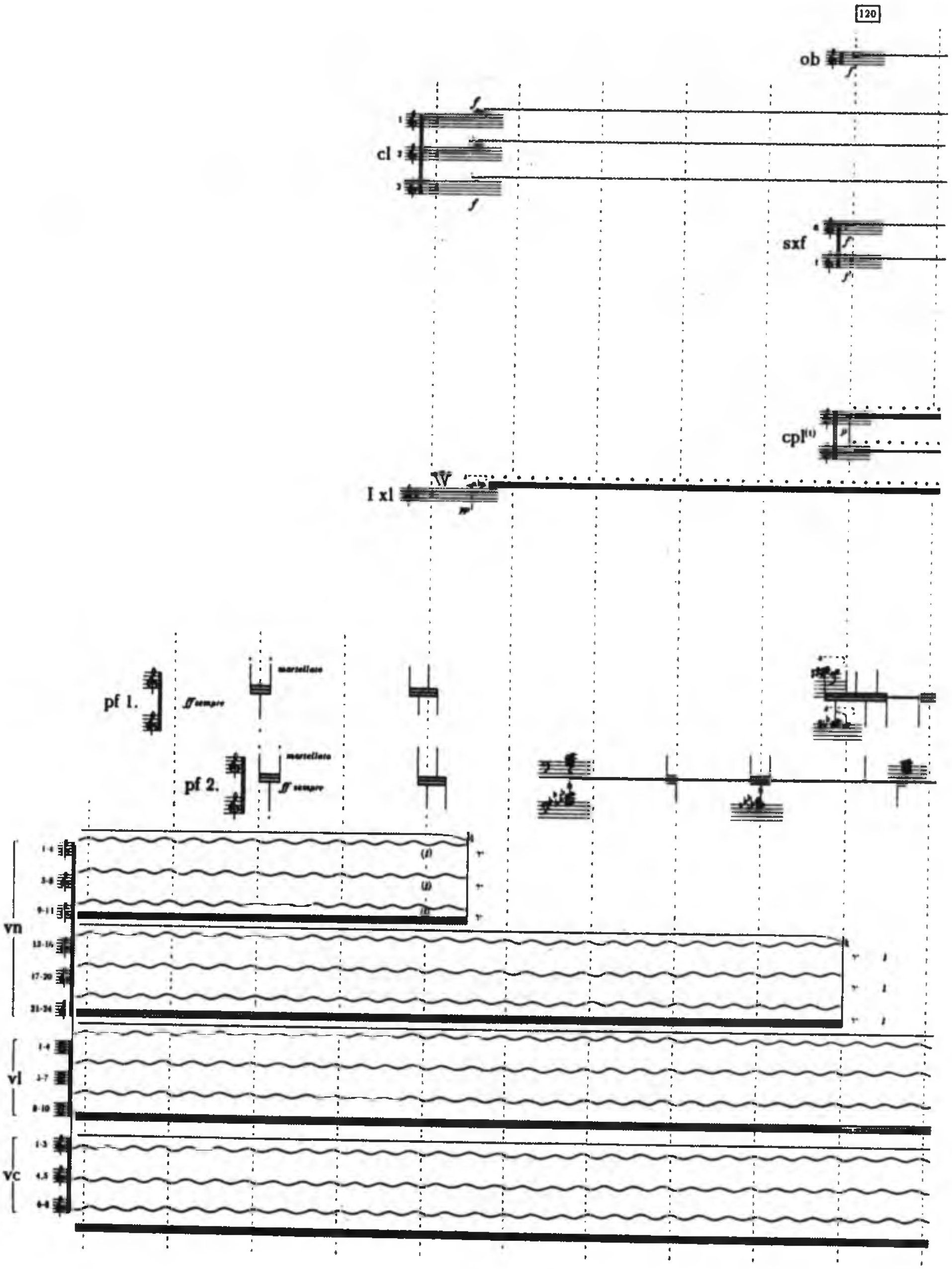
Numbers 110–120 and 150, meanwhile, provide the listener with new perceptions. These are certainly such fragments of the work in which the listener makes a perceptual categorisation based on schemata of 'generalisation'. In constructing these categories, the listener makes use of prototypes, which have the character of 'modal values', that is, they are created from the most frequently occurring auditory images. Their relative constancy enables the listener to activate his permanent memory and to treat them as 'familiar'. In the fragments in question, this type of categorisation concerns the sequences intoned by the two pianos and also the tonal structures generated simultaneously by the clarinets and xylophone (in no. 110), the oboes, saxophones and bells (no. 120), the bassoons, French horns, trombones, tuba, kettle drum, tom-tom, side drum and bass drum (no. 150) and the cellos and double basses (no. 150). (See Example 5 – nos. 110–120 and 150).

The duration of the section of *Forte e piano* covering numbers 110 and 120 (approx. 15 seconds) enables the listener to activate all three kinds of memory; as a consequence, there ensues during listening both a perceptual organisation, which effects a fusion of tonal structures, their grouping into a continuous perceptual stream, and also an organisation on the formal level, which assigns to particular auditory images the functions of backgrounds and figures.

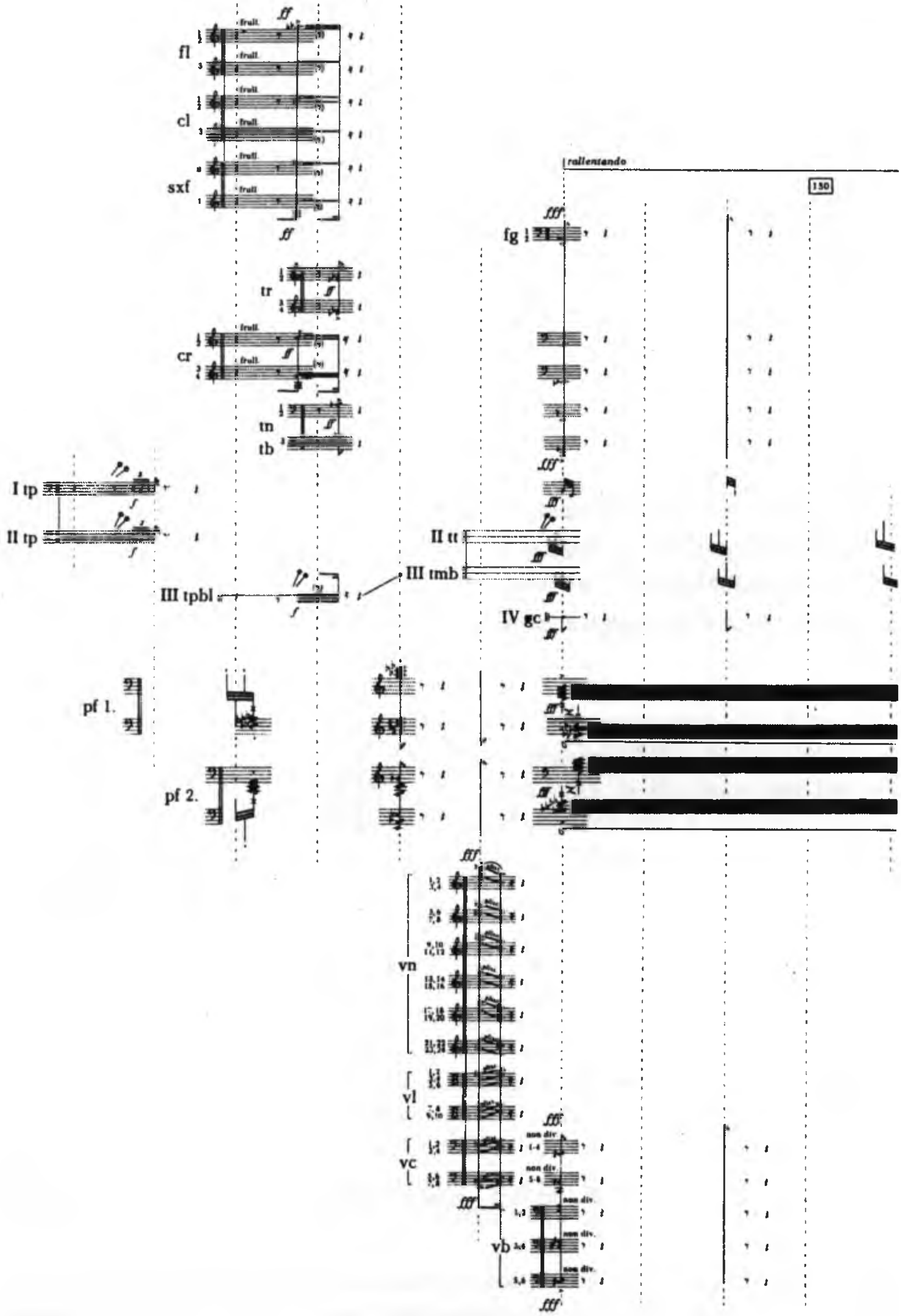
Here, the function of background is discharged by the sequence of tones intoned simultaneously by the strings, which perform a structure that conditions the arising of fusion. The pitch proximity of the tones (a semitone between the subgroups of instruments – in the strings divisi), the similarity of timbre (all the instruments of the string section) and the common type of motion, namely tremolo (the principle of common 'fate'), shapes an auditory image with the form of a hum-like stream. A parallel change of pitch in the strings causes the fusion of the simultaneous tones, since the auditory system employs the coherent modulation as a sign for the integration of the spectral components and their separation from the rest of the tonal material of this fragment of the composition.[22] These same mechanisms are at work in the sequence of the pianos, which is the source of an auditory image with the character of a continual cluster (no. 150).

A similar perceptual mechanism organises the perceptual image derived from the simultaneous structure of, for example, the clarinets and xylophone (no. 110), the oboes, saxophones and bells (no. 120) or the bassoons, French horns, trombones, tubas, kettle drum, tom-tom, side drum

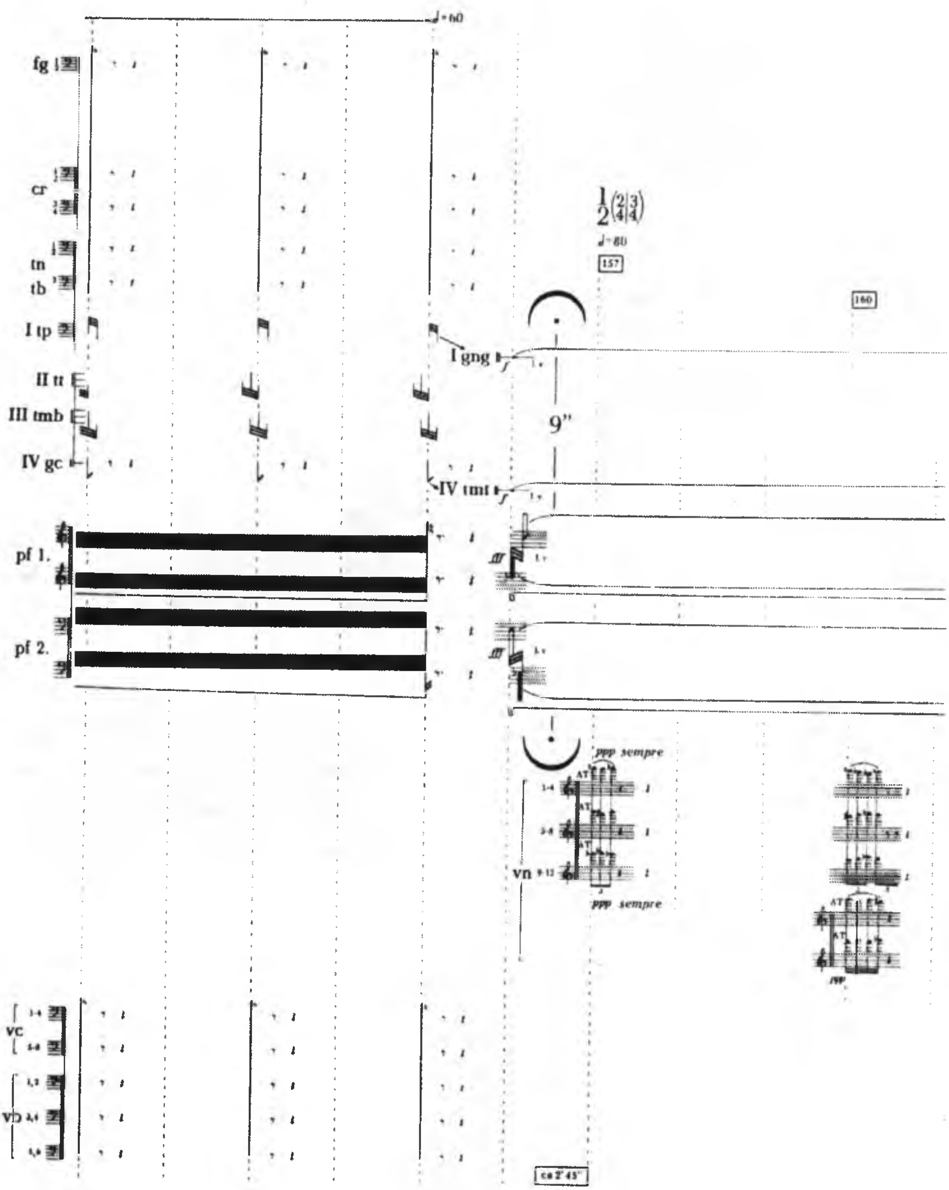
[22] Albert S. Bregman, Jack Abramson, Peter Doehring and Christopher J. Darwin, 'Spectral Integration Based on Common Amplitude Modulation', *Perception and Psychophysics* 37/5 (1985), 483–493.



Example 5 – nos. 110–120



Example 5 – no. 150



Example 5 – nos. 150–160

and bass drum (no. 150). Here, too, on the level of sensory memory there occurs a fusion of the harmonically-related tones. As a result, the individual instruments lose their perceptual identity and a single sound sensation is created. Due to their continuity, structures whose duration is comparable with the storage time of information in the short-term memory group together. They are then integrated into a temporally extended stream, and the listener 'switches' his attention to new qualities generated in other groups of instruments (sensitisation and habituation). Structures whose duration falls within the scope of sensory memory, meanwhile (no. 150 – quaver = 0.214 sec.), shape impulsive auditory images with a specific harsh timbre. The auditory images described here segregate themselves from the background and on the formal level discharge the function of short- or long-lasting figures.

Ultimately, the mental representation of the fragment of the composition under analysis, relating to the formal level of its experiencing, is formed from perceptions of different configurations of auditory images with the character of perceptual streams or simple impulses, or else of a sequence of impulses which, due to their distinctive sensory features, fulfil the function of a hum-like background or of tonal figures. The changeability of the succession of complex auditory images makes it more difficult for the listener to mentally reconstruct the order in which successive perceptions occurred. However, with each subsequent 'hearing through', the listener adds further details to the mental representation, which thus becomes closer or even very similar to the mental representation of the composer.

The sample analysis described above of the perception of a fragment of Serocki's *Forte e piano*, allied to our knowledge of the mechanisms accompanying conscious listening to music, allows us to state that the effectiveness of communication between a composer and a listener (listeners) depends on the degree to which their mental representations of a given work coincide.

In the special case that is sonoristic music (heterogeneity of form and sound), the success of the 'communication' between the composer and the listeners to his music also depends to a large extent on the musical sign created by the autonomous qualities characterising the sensations which derive from the musical structures. The sonological modification of the expanded tonal material in sonoristic music favours the creation of complex auditory images. 'Communication' is hampered by the variability of these images and the consequently hindered categorisation and schematisation, which constitute a problem for the listener alone and do not bear a negative influence on the forming of the mental representation of a given work in the composer's mind.

A huge role is played in the shaping of the auditory ideas of the composer and the tonal images of the listener by the knowledge and experience that ensue from contact with music in general. Where significant differences occur between the mental representations of the same work in the mind of the composer and in the mind of the listener, this is most often caused by individual differences in the process of the cognition of music, which consists of perception, memory processes and thinking. The effectiveness of the process of communication may be improved through learning, as a result of which a potential listener improves the process of identification, differentiation, categorisation and schematisation in music cognition and also increases the part played by memory processes related to non-declarative memory.

Translated by John Comber