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Understanding musical structure and form: papers in honour of Irène Deliège

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Auditive analysis of the Quartetto per Archi in due tempi (1955) by Bruno Maderna

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People very often ask me questions about form. They expect me to talk about mathematical formulae, a bit like I do with spectrum; it's easy with spectrum, but not with time. I find it impossible to use the same form for different pieces: every musical work is a new experience of time. It's for this reason that I can't explain it beforehand... because for me, explaining the form of a piece is the same as listening to it. Talking about form when we are dealing with listening, is simply a pleonasm.... it doesn't add anything else. (Tristan Murail 2002)

• ABSTRACT

The present study on Maderna's quartet aims to compare the "macroform" (the large-scale structure of a musical piece) perceived by subjects while listening to the piece in real time, and the "macroform" as perceived by professional analysts. The study also examines the correlation between "macroform" and perception of tension/relaxation. Two groups of subjects took part in the experiment: 25 non-musicians and 32 musicians. The experiment was carried out both in Bologna and in Edinburgh. We made use of a special computer program, which allows each subject to listen to a piece through head-phones and indicate the points of division and the tension/relaxation perceived while listening in real time. The experiment lasted approximately 60 minutes and involved various steps and tasks. After an initial listening which served to become familiar with the piece and with the computer program, the subjects had to listen to the piece again and identify its main sections. They then had to indicate the criteria they used in formulating their solutions. In the next listening they had to indicate the largest zones of tension and relaxation they perceived. The macroforms perceived by the subjects were compared with 4 macroforms indicated by professional analysts based on listening rather than on analytical theories. The data showed higher correlation between macroforms perceived by the subjects and only 2 macroforms indicated by the analysts, and correlation between the macroforms and tension/relaxation perceived by subjects. The differences between musicians and non musicians and Italian and Edinburgh groups were not significant.

INTRODUCTION

In this article, an exploratory study on Maderna's quartet is introduced which aims at investigating the relationships between the macroform perceived by subjects while listening to a piece of post-tonal music and the macroforms of the same piece indicated by professional analysts based on listening rather than on analytical theories. This investigation is part of a project carried out at the University of Bologna, which deals with the analysis and perception of "macroform" in post-tonal music, that is, the problem of the overall form of a piece. The project has concentrated mainly on 20th Century string quartets and has taken into consideration both score and auditive analyses (Addessi & Caterina 2000, 2005, Baroni 2003).¹ The study presented in this article aims at investigating whether the perception of "cues" (Deliège 2001), and tension/relaxation (Imberty 2005) could affect the auditive analysis of the macroform of a piece of post-tonal music and whether this could be used as "explicit" criteria for the analysis of post-tonal music (Cross 1998). First of all, an overview of macroform, segmentation and tension/relaxation will be introduced in order to identify the basic concepts underlying this study. We will then look briefly at the Maderna quartet. The method and the results will then be shown and discussed.

1. MACROFORM AND SEGMENTATION

The term 'macroform' and the concept we wish to identify by this term need to be carefully defined, since they are not always used in the same way. By the term "macroform" we refer to the global form of a piece, that is, the division of the piece into its largest parts with reference to its overall structure. In musicological literature various terms are used which would appear to have a similar sense but which actually have meanings that are sometimes quite different: *e.g.* "large dimensions" (La Rue 1970), "large scale form" (Levinson 1997), or large-scale structure (Lerdhal & Jackendof 1983, Lalitte *et Al.* 2009). Imberty (1993) uses the term "macrostructure", which originates from the field of linguistics, but is here considered from a perceptual point of view: a "scheme for structuring time, where sound events are arranged *a priori* according to rules drawn from the perceptual mechanisms involved in the detection of changes within the continuum of sound" (1981, p. 90). Our use of the word basically derives from this concept of macrostructure, but we have felt the need to distinguish between the concept of "division into parts", which only identifies the macroform, and that of the perception of change and local discontinuities, which we have defined with the term "segmentation". Although the term segmentation is invariably used as a synonym for the division into parts, segmentation is not a

1 The project was funded by the University of Bologna. It was developed inside the post-tonal research team of GATM-Gruppo di Analisi e Teoria Musicale, coordinated by Mario Baroni, from 1998 to 2003. The data illustrated in this paper were collected in 2001. The first results of this experiment were presented in Adessi & Caterina 2002.

sufficient criterion to identify the main parts of a piece (*i.e.* its macroform) since the perception of a strong local discontinuity does not necessarily produce a division in terms of the piece as a whole. A very long pause, for example, may give rise to the perception of a segmentation, but this does not necessarily constitute a separate self-contained section. The reasons behind the choices used for segmentation vary considerably, but generally speaking they include: repetition (Ruwet, 1966), change or discontinuity (Imberty, 1981), rhythmic grouping (in metrically organized music, Lerdahl and Jackendoff, 1983) and the principles of difference and similarity (Deliège 2001a, 2001b, 2007). The analysis of macroform poses different problems to that of segmentation, especially where memory is concerned. The question is: when we reach the end of the composition, have we already mentally elaborated a possible division of the piece in parts? And are we able to say the exact number of parts and identify them? Do we identify the parts as a result of their qualities and homogeneity or on the basis of local discontinuities? For the purposes of this article, therefore, the term segmentation will be used only to indicate the exact point where two sections are separated, a local phenomenon brought about by the presence of a contrast or discontinuity that involves one or more parameters of the musical material (duration, dynamics, timbre, density, register, *etc.*). The term macroform, on the other hand, is used to indicate the result of a process of memorisation involving the division of a piece of music into its largest parts, where each part has structural coherence and homogeneity. In this sense, the concept of macroform used in this study does not necessarily coincide with either the tonal or rhythmic hierarchies (as for example in the Lerdahl and Jackendoff model), or with segmentations based on the perception of musical ideas (see for example the concept of large-scale structure in Lalitte *et al.* 2009). From a perceptive point of view, the macroform is closer to the concept of “imprinting” proposed by Deliège: “the cognitive processes at work when there is an insistence upon using the same cue by a composer through literal repetitions or more or less varied elaboration” (2001, p. 238). Given that the main aim of this study was to investigate the memorization of macroform, that is the division of a piece into its largest parts, the participants of our experiment were not asked to indicate the segmentation points, but rather the points of division of the parts. The subjects were asked to listen to the same piece a number of times, to mentally divide it into its main parts and to mark these parts on a line, indicating the points of division between one part and another. For tonal music, Deliège (1998) proposed this particular experimental procedure, that is a “mental line” that tests the ability to memorize the quality and the order of succession of the parts identified in a piece while listening. In our experiment, the subjects were also asked to respect the proportion between the parts: longer sections of lines had to correspond to longer parts. In order to keep to the principle parts, we imposed a limit of 4 to 8 parts. The direct task of dividing the piece into its principle parts, assured us that the procedure of segmentation was not reflected as the attention of the listener was guided towards memorization of the parts of the piece and not to

micro discontinuities of the local segmentations. In order to draw some conclusions on the criteria which induced the listener to divide the parts, we introduced some questions which aimed to investigate how the listeners perceived the “quality” of these parts: they were asked to describe the quality of each part determined, both through adjectives and through sounds parameters.

2. THE PERCEPTION OF MACROFORM IN POST-TONAL MUSIC

One last remark should also be made about the difference between the criteria used in the division into parts of a post-tonal piece and a tonal piece. Studies carried out by Deliège (2001, 2007) show how the listener, when faced with music that is not ruled by tonal structures, tends to identify certain qualities of sameness and difference which can easily be perceived and memorized, allowing the listener to abstract ‘cues’ (or prominent features) which distinguish one part of the piece from another. These cues, which in tonal music are provided by the hierarchical harmonic, melodic and rhythmic structures, can also appear in non-tonal music, above all as elements linked to dynamics, duration, speed and timbre. Lerdhal (1989) suggests that in atonal music the criteria which constitute the hierarchy are based on timbre parameters. The division into parts of a tonal piece largely depends, however, on formal (and cultural) rules (exposition, development, conclusion, coda, recapitulation, bridge, repetition, symmetry, *etc.*). Traces of these cultural rules may, in fact, persist in post-tonal music (Baroni 2003, Addressi and Caterina 2005, Imberty 2005, Lalitte *et al.* 2009).

3. MACROFORM ANALYSED AND MACROFORM PERCEIVED

The links between formal structure and psychological processes in music has already been widely discussed in the sphere of the cognitive sciences. Although belonging to two different domains (the psychology of perception and theory of music), the two analyses (score analysis and auditive analysis), have several activities in common: the segmentation into small, medium or large pieces; the grouping formation; the organizations of hierarchies, and so on.

In a past article, Cross (1998) posed the crucial problem of another aspect of the relationship between perceptual analysis and musical analysis, that is the difference between the psychology of perception, which studies perceptual phenomena from the cognitive point of view, and perception as considered by musical analysts, orientated fundamentally towards the confirmation of musical theories (defined by Cross as “folk psychology”). The function of the psychology of perception could be to render explicit the perceptual supposition present in a piece of musical analysis, and in so doing make them debatable and verifiable. In our research, we aimed to investigate the auditive analysis of the macroform in order to distinguish “rules” which could be used for analysis of the score. In our experimental studies we investigated the perception of macroform in several quartets from the 20th century. By working on such a homogeneous repertoire, the number of variables is limited

and it is therefore easier to formulate plausible and general hypotheses about the problems of listening to post-tonal music. In Addessi & Caterina (2005) a comparison was made between the macroformal analyses of the fifth movement of the *String Quartet Op. 1* by G. Kurtág, carried out by several professional music analysts from different Italian universities, and those perceived by two groups of subjects (musicians and not musicians) while listening to the piece in real time. The macroform analyses were largely based on Deliège's theory of "cue abstraction" and on the theory of "domains" proposed by Christopher Hasty (1981). The results showed that the difference between the analytical and listening procedures was not particularly significant in the case of score analysis which was based on explicit criteria taken from theories dealing with perceptual aspects of sound (notably the cues abstraction model). The experiment which we are going to introduce below, is based on the second movement of Maderna's *Quartetto per archi in due tempi* and aims to investigate the relationships between macroform indicated by the analysts and macroform perceived by subjects while listening to the piece in real time. In this experiment the analysts were asked to use explicitly perceptual models of large-form memorization in order to archive their score analyses.

4. THE CORRELATION BETWEEN MACROFORM AND TENSION/RELAXATION

According to the hypotheses of several scholars, the large-scale form of a piece is assimilated by the listener through tension and relaxation schemes (see, e.g. Imberty 1993, Bigand, Parncut, Lerdhal 1996). The tension concept in music has been difficult to define, both due to the problem of describing the experience itself and the musical structures generating tension. In tonal music these schemes would be activated above all by tonal syntax (see, e.g. Meyer 1956; Nielsen 1989; Lerdahl 1987, 1996; Bigand 1993; Krumhansl 1996, 1997). According to Imberty (2005) a dual function exists in musical memory which creates a double possibility of processing the perceived data mentally. On the one hand there is an "informative memory" that organises the sound information into syntactic systems whether they be tonal or atonal; on the other hand there is a "dynamic memory" linked to dividing up the sound material over time. It is in this second type of memory that concepts such as tension and relaxation are situated. In atonal music, such as in the quartet by Maderna, the schemes of tension and relaxation could play a determinant role because they would allow the listener to assimilate the total form of the musical piece even if there is a lack of tonal reference points. More recently, Lalitte *et Al.* (2009) showed that tension and relaxation affect the perception of the large-scale structure of a piece of atonal music (obtained artificially by modifying the pitch of a tonal piece) during listening in real time. In this study, the thematic and rhetorical structure of the tonal style of the original piece, which had not been modified, seems to continue to have a determining role in the perception of form and also in the perception of tension/relaxation. In our previous experiment (Addessi & Caterina, 2000) we investigated the correlation between memorization of the macroform and

perception of tension/relaxation in relation to the presence of tonal/atonal structures. We used 3 pieces of music with a gradual distance from the tonal system, from Milhaud, to Maderna and finally to Webern. The data on tension and relaxation only partially sustained our prediction that in the most tonal piece (Milhaud) the causal link between point of divisions, tension and relaxation, would be stronger than in the piece where tonality is less present (Maderna) or totally absent (Webern). In reality we found that also in Webern's piece the macroform also seems to have been influenced by the perception of tension and relaxation more than in Maderna. The exploratory study presented in this article makes use of the same experimental paradigm in order to once again investigate whether memorisation of the macroform of a post-tonal piece can be influenced by the alternation between tension and relaxation experienced by the subject while listening to the piece. We have tried to formulate a definition of the tension arising from the necessity to explain to the listeners what they had to indicate. The solution was to ask them to indicate some tension and relaxation zones by moving the mouse upwards (increase in tension) or downwards (relaxation): the tension zones were to be characterised by instability, as if taking a breath in; the relaxation zones were to be characterised by stability, as if exhaling. We asked them to identify only wide tension/relaxation zones and not the smaller tension/relaxation changes.

5. MUSICIANS AND NON MUSICIANS' MUSIC PERCEPTION

In our study we decided to examine whether there were differences between musicians and non-musicians. This variable is increasingly taken into consideration in experimental studies concerning the perception of music and involves sociological and anthropological factors (musical acculturation), psychological factors, pedagogical factors (musical training) and factors related to instrumental practice and neurosciences. Concerning the nature of musical representation "much perceptual and cognitive research in this area can be seen as showing that there are, indeed, large areas of agreement between individuals about such matters. These agreement often transcend different level of training, and sometimes, transcend cultures" (Sloboda 2005, 165). In a series of experimental phases, Deliège (2001, 2007) shows that the perceptive principles which are at the basis of the model of mental representation of music during listening in real time, that is the principles of segmentation, categorization, schematization and imprint formation, are common to both musicians and non musicians. Bigand (2003) for example, shows how the sensitivity to tonal hierarchy and to harmonic relatedness of chords, as well as the ability to detect modulation, were found to be similar in groups with different musical expertise. These findings provide some evidence that nonmusicians manage to internalize complex musical systems through passive exposure to music. Even where non-musicians took more time to solve jigsaw harmonic puzzles, their performances remained highly comparable to musicians' ones. Drake, Penel, Bigand (2000), on the contrary, showed the great ability level of musicians vs. nonmusicians in synchronize

taps with a musical sequence, use slower referent leads, and are more adept at extracting the metrical hierarchy from a sequence, and thus have more complex hierarchical representation; musicians have a more elaborate mental representation which is further from the musical surface, more hierarchically organized, and more flexible. The neurosciences of music showed that certain regions of the brain (corpus callosum, motor cortex, cerebellum) may show some form of adaptation to extraordinary challenges and requirements of musical performances (Pantev *et al.* 2001, Pascual-Leone 2001, Schlaug 2001, Habib & Besson 2009). Other studies tend to underline not so much the greater or lesser ability of the musicians in musical tasks, but rather the perceptive differences due to musical training received. Sloboda (2005), for example, concludes that in musical reading tasks the familiarity with the visual characters of music notation could be a sufficient explanation of the musicians superiority. Bamberger (1995) shows how the graphic representation of rhythmic grouping can be of a metric type (that is based on the metric accent present in western music) in the case of musicians or of a figural type (that is based on the closeness/farness of the accents) in the case of non-musicians. She shows how both subjects follow a perceptive logic, differing only in that for a musician, this logic is determined by western metric musical models learnt during training. As we can see, the results obtained vary according to the ability of the individual and the cultural cognitive processes. As far as our study on perception of macroforms and tension / relaxation is concerned, Imberty (1981) and Bigand (1997) suggested that the psychological processes involved in the musical tension/relation network experienced by the listeners in tonal music are not strongly influenced by musical training. In our previous studies on perception of macroform in post-tonal music, the difference between musicians and non-musicians was shown to be insignificant. Nevertheless, differences in the precision of the task and in the definition of motivations were noted (AddeSSI and Caterina 2000). Two groups of subjects, musicians and non-musicians, were also used in the experiment presented in this article.

6. THE MADERNA *QUARTETTO PER ARCHI IN DUE TEMPI*

The Quartet was written in 1955, commissioned by the city of Darmstadt and dedicated to Maderna's friend Luciano Berio. It was first performed by the Drolc quartet on 1st June 1955 for the tenth edition of *Ferienkurse*. Critical literature agreed that with this work, Maderna had come closest to the post-Webern ideas and compositional practice predominant in the circles of advanced musical research in the 50s. "The complex writing of the score, together with myriad of performing marks present on virtually every note, is evidence of the hard work and care that went into the writing of the Quartet, carried out in the conviction of having acquired a distinctive and personal language." (Russo, 2009). The compositional process was extremely hard work and Maderna himself commented more than once on this: «It has been an enormous job, much worse than writing the parts for an orchestral piece», and again «I believe that with this work I have truly found my path», and yet

again «Everything that I have composed before is old “kitsch”» (quoted in Russo, 2009). For Maderna, the work was a «healthy and positive “Revolution in continuity”». The second movement is, as far as pitches are concerned, the retrograde of the first, a reappraisal therefore, of the “mirror” technique which had already been experimented by Webern in the Symphony Op. 21. The second movement is, however, a “free interpretation” of the previous one, since it presents variations within the rigid duplication of the pitches through a progressive rarefaction of the sonorous material. “The two movements thus appear complementary, where the first represents the continuity of and adherence to the rigorous serial structure, albeit somewhat personalized, while the second gives a greater sensation of freedom and a «lyrical» sense” (Russo, 2009 , p. VII). Despite the relatively extensive critical literature dealing with the work, the compositional process which determines the structure still does not appear to be clear. The Quartet is a serial work, based on twelve groups of twelve notes. Identification of the series within the piece is, however, only clearly possible in the 1st movement, given that in the 2nd movement, erosion methods are applied to the material thereby eliminating many pitches.

7. THE EXPERIMENTAL STUDY

A comparison was made between the macroformal analyses of the 2nd movement of Maderna’s Quartet carried out by professional Italian analysts and those perceived by two groups of subjects, musicians and non-musicians. The relationship between memorization of the macroform and perception of tension and relaxation during real time listening has also been observed. The listening text was realised in Italy (Bologna University students) and Scotland (Edinburgh University students).

THE ANALYSTS’ MACROFORMS

Several tasks were given to the professional analysts so that they would carry out a score analysis based on explicit perceptual criteria, taking into account their personal listening experience of the piece. The analyst should nevertheless be aware of the perceptual difficulties and problems related to memory encountered by a listener and his/her task is in fact precisely to render these problems explicit (see also Cross, 1998). The analyst must therefore consider questions such as: what perception and memorization difficulties might the listener face in the piece I am analysing? Which structures can be clearly perceived? Which of them can be memorized? The 4 macroforms were obtained through the following procedure: 1. Each analyst had to autonomously follow the following procedure: a) listen to the piece as many times as he/she liked b) try and memorise the macroform, that is the entire piece and therefore the principle parts c) analyse the macroform memorised with the help of the score, indicating on the score the points of division of the parts perceived and memorised. The analyst then had to theorise about the process undertaken, make

some hypotheses about his/her own perception, draw up some criteria of analysis of the macroform based on his/her own listening experience, clarify these criteria and describe the method with which he/she applied these criteria to the score; 2. the analyses were collected, discussed and checked by all analysts; 3. only the analyses showing coherence between hypotheses, criteria and method, were accepted for the experiment.

Each analyst was free to move and follow his/her own path while respecting these rules and could use the theoretic and methodological tools which he/she retained most appropriate. For this reason, the macroforms obtained also refer to different theories and approaches, such as Deliège's theory of cue abstraction, or Imberty's dynamic approach, or *tempo* and strong segmentation criteria of perception. It was established that these tools should serve to explain each personal listening experience, and that they should not be used to expound compositional or aesthetic theories for example. The objective was not to use theoretical methods of analysis of the macroform, but to hypothesise analysis criteria of the macroform as close as possible to those of a listener. The fundamental difference with respect to the auditive analysis was that the analysts could listen to the piece however many times they wanted and analyse the macroform memorised with the help of the score. In this way, we aimed to obtain both "expert" macroforms, elaborated by professional musical analysts, and analytical hypotheses originating from listening and not from analytical and aesthetic theories. Perceptive hypotheses, therefore, corroborated by the experience of "pure" analysts. This procedure gave rise to the following macroforms, which were selected to be compared to the macroforms memorised by the listeners who were to participate in the experimental phase:

Macroform no. 1. The analyst who presented this macroform, hypothesised that the macroform he perceived and memorised after listening to the piece a number of times, was attributable to perception of "cues", as Deliège defined them, that is "brief but meaningful and significant structures, which stand out from the sound background" (Deliège 2007, p. 13), and to the dynamic phenomenon of perception of tension and relaxation, as hypothesised by Imberty (1981). In terms of analytical-structural, the author of this macroform indicated on the score that the tension/relaxation alternation was principally due to the alternation of "violent" cues (short lengths, stressed notes, *tallone*, *tremolo*, sfz, pizz., *detaché*, dense texture, intensity from *mf* to *fff*, noise sounds, not *vibrato*), prevailing in the tension zones, and "light" cues (long lengths, *ponticello*, *col legno*, intensity mp, ppppp, *con sordina*), prevailing in the relaxation zones. According to this analyst, these traits which reoccurred in certain sections and not in others, also represented cues which caught the attention of the listener and through their repetition, allow the listener to create a mental map of the piece, determining therefore the "imprinting" as Deliège defined it. According to this analyst, the tension/relaxation also depends on the length of the parts (*i.e.* when violent and light cues

follow each other closely, a moment of tension results) and on the rhetorical functions which some parts seem to suggest (introduction, climax, coda).

Macroform no. 1 divides the piece into 7 parts: each part is characterised by a certain degree of tension (1, 2 or 3) and a certain degree of relaxation (1,2 or 3). Part I, mes. 1-10 is characterised by a low level of tension (tension 1); part II, mes. 10-55, is characterised by an increase in tension (tension 2); part III, mes. 55-96, is characterised by relaxation (relaxation I); Part IV. Mes. 97-117 is characterised by medium tension (tension2); Part V, mes. 118-132, is characterised by high tension (tension 3); part VI, mes. 132-173, is characterised by medium relaxation (relaxation 2); and finally Part VII, mes. 174-199, is characterised by high relaxation (relaxation 3).

Macroform no. 2. This macroform was derived from macroform 1. The first two parts of macroform 1 can be perceived as a single part in which the tension increases (Tension 1 ->Tension 2), mes. 1-55 (increasing tension); a second part of the relaxation, mes. 55-96 (relaxation), corresponding to part III of the macroform 1; part III, mes. 97-132, which groups together parts IV and V of macroform I, in which an increase in tension is perceived (top of the tension) and finally part IV, mes. 132-199 (increasing relaxation), which groups together parts VI and VII of macroform 1.

Macroform no. 3. This macroform is based on the hypothesis of cues abstraction by Deliège (2001a, 2001b) and divides the piece into 4 parts. Each part is characterised by a very perceptual element: parts I and III are characterised by inner variability, part II is characterised by the regular beat played by the cello from mes. 73 to 87, part IV by light sounds and it's rhetorical function as a final part. The variability of parts I and III depend on the alternation of "violent" moments (characterised by strong, stressed and long notes), and "light" moments (characterised by *pedale*, high and weak notes, melodic fragments, whispers). The 4 parts are made up of the following: part I, mes. 1-72 (variability), part II, mes. 73-87 (regular beat), part III, mes. 88 – 131 (variability), part IV, mes. 132 – 199 (light end).

Macroform no. 4. This macroform is based on the strong segmentations, the groupment of sections, and on repetition of those sections. The sections are characterised by inner coherence, but every part of the macroform can be composed of further different sections. Every part is characterised by the *tempo*. The macroform is constituted by the following: part I, mes. 1-62 (*Allegro*); part II, mes. 63-96 (*Adagio*); part III, mes. 97-141 (*Presto*); part IV, mes. 142-199 (*Adagio II*).

Table n. 1 shows the 4 macroforms indicated by the analysts.

Table 1.
The analysts' macroforms

M1	M2	Bars	M3	M4
Part I: low tension	Part I: increasing tension (violent cues)	1-10	Part I: inner variability (violent moments)	Part I: Allegro
Part II: middle tension (violent cues)		11-20		
		21-30		
		31-40		
		41-50		
Part III: low relaxation (light cues)	Part II: relaxation (light cues)	51-55	Part II: pulse	Part II: Adagio
		56-60		
		61-62		
		63-70		
		71-72		
Part IV: middle tension (violent cues)	Part III. Max tension (violent cues)	73-80	Part III: inner variability (violent moments)	Part III: Presto
		81-87		
Part V: max tension (violent cues)		88-90		
		91-96		
		97-100		
		101-110		
Part VI: middle relaxation (light cues)	Part IV: increasing relaxation (light cues)	111-117	Part IV: Final (light moment)	Part IV: Adagio II
		118-120		
		121-130		
		131-132		
		133-140		
Part VII: max relaxation (light cues)		141		Coda
		142-150		
		151-160		
		161-170		
		171-173		
		174-180		
		181-190		
		191-199		

LISTENING TEST

Participants. Two groups of subjects took part in the experiment: 25 non-musicians and 32 musicians. The experiment was carried out both in Bologna (10 non-musicians, 12 musicians) and in Edinburgh (15 non-musicians, 20 musicians).

Materials. Bruno Maderna, *Quartetto per archi in due tempi*, 2nd movement (1955), duration 6'57", performed by Ex Novo Ensemble (CD Stradivarius STR 33330)

Apparatus. We made use of a special computer program called EPM (Experiments on the Perception of Music), devised at the University of Padua. This program allows each subject to listen to the piece through head-phones and indicate the point of division perceived while listening in real time by clicking on the mouse, and tension/relaxation by shifting the mouse up (tension) and down (relaxation).

Procedure. Each subject was allocated a computer and given a questionnaire which, in addition to the written answers, contained the tasks to be carried out using the EPM program. The questionnaire also contained details of how to use the program. The experiment took place in a room containing more computers. The subjects were divided into several sessions of mixed groups (musicians and non-musicians) of 5, 10, 15. An operator read out the general instructions for the use of the questionnaire. If necessary, two assistants were available to resolve individual problems. The experiment lasted for approximately 60 minutes and involved various steps and tasks. After an initial listening in order to become familiar with the piece and with the computer program (task 1), the subjects had to listen to the piece twice and identify its main sections (task 2). They were asked to do the following: "Listen to the piece once again: in your opinion, how many principle parts can it be divided into? Please indicate the length of each part along this horizontal line which represents the entire duration of the piece. Please make sure the space indicated is proportional to the length of each part. Only mark the principle, more substantial sections and not the shorter sections. The total number of parts should not be less than two and not be more than 8". During the next two listenings, they had to indicate the points of division of the sections on the computer using the EPM program and after the second listening, they saved the results (task 3). They were asked to do the following: "Listen to the piece again and try to mark on the computer the parts you indicated, marking the points of division with the mouse." In the next tasks 4 and 5 the subjects had to indicate the adjectives and type of sounds they believed characterised each section. For task 4 they were asked to do the following: "Please tick the adjectives that you think characterised each section. You can indicate any number of adjectives for each section, and you can also add a new adjective. The list of adjectives was as follows: Light (slight, faint), merry, violent, slow, relaxing, variable, tense. For task 5 they were asked to do the following: "Please tick the types of sounds that characterised each section. You can indicate as many as you like, and you may also add a new type of sound.". The list of sounds were as follows: A few

sounds, regularly repeated sounds near to each other, long sounds, weak sounds, light sounds, strong sounds, accented sounds, silences, many sounds. In the next two tasks 6 and 7 they had to indicate the largest zones of tension and relaxation they perceived by shifting the mouse. For task 6, they were asked the following: "Listen to the piece again, trying to determine the larger areas of tension and relaxation. The areas of tension will be characterised by instability, like the action of breathing in; the areas of relaxation will be characterised by their tendency towards a stable situation, like breathing out." For task 7, they were asked to do the following; "After having determined these moments, mark them on the computer by moving the mouse: when you perceive larger areas of tension, characterised by instability, like breathing in, move the little ball upwards using the mouse, when you perceive larger areas of relaxation, which tend towards a stable situation, like breathing out, move the little ball downwards. Remember that you are presented with a scale from 1 to 100, visualised on the screen. You can listen twice, the second time you must save your results." The results were recorded by moving the mouse physically up or down corresponding to the tension or relaxation perceived at the moment of listening. This was automatically registered on a scale ranging from 1-100 visible on the screen. After the second listening they saved the results.

Experimental hypotheses: 1. the macroforms perceived by the subjects are correlated to the macroforms indicated by the analysts; 2. there is a correlation between macroforms and tension/relaxation perceived by the subjects; 3. finally, the difference between musicians and non musicians is not significant.

8. RESULTS

This article shows the results of tasks 3 and 7. Generally speaking, the results show that the subjects' perceptions of macroforms were extremely heterogeneous. Most of the subjects, whether musicians or non-musicians, indicated more divisions than those hypothesized by the analysts. We first considered how similar or dissimilar the macroforms proposed by the listeners (task 3) to those suggested by the musical analysts were. The answers given in task 3 were grouped into several ranges (see Figures 1) corresponding to the areas where the subjects identified the points of division of the piece. Figure 1 does not show precise points, but rather the range of positions in the bar. The ranges show the space of time where a set of answers is grouped. An empirical index was developed to check how near or far the macroforms perceived by the subjects were from those proposed by the analysts. We took all the points of division given for each perceived macroform and compared them with those of the analysts' macroforms. The following formula was applied: $I=(c*100)/A$, where c is the number of points coinciding with the points in analysts' macroforms and A is the number of all the points of division indicated by the subjects. Given that in M1 there are more points of division than in M2, M3 and M4, in the calculation

of I for each macroform we assumed that A could never be smaller than the number of the proposed points in the analysts' macroforms. This adjustment also avoided the division by 0 error. Our data indicated that M2 was the most similar and M3 the most dissimilar compared to the macroforms perceived by the listeners. The difference between the means of correspondence concerning M1 and M3 are statistically significant according to the Wilcoxon test ($p < .001$); the difference between the means of macroform 1 and 4, 2 and 3, 2 and 4, 3 and 4 are also statistically significant (respectively $p < .01$, $p < .001$, $p < .01$ and $p < .05$ according to the Wilcoxon test). No significant differences were found between the means of correspondence concerning M1 and M2. There were no significant differences in the means of correspondence concerning the independent variables – nationality and music training – according to the Mann-Whitney test. All these results are summarised in Table n.2.

Table 2.

**Index of Correspondence* of Macroforms proposed by Musical Analysts
and Macroforms perceived by the Subjects
According to Their Nationality and Musical Education**

Macroforms	Scottish		Italians		All subjects	
	Musicians	Non Musicians	Musicians	Non Musicians	Musicians and Non Musicians	Standard Deviation
Macroform 1	37.4	35.9	33.9	33.1	35.6	18.8
Macroform 2	30.7	39.1	40.1	51.7	37.8	23.4
Macroform 3	16.3	7.2	14.6	9.3	13.0	18.3
Macroform 4	22.1	21.7	18.1	13.6	19.8	14.9

*Index of Correspondence is an empirical measure that we have adopted given by the number of the points coincident with macroforms (1, 2, 3 and 4) multiplied by 100 and divided by the number of all the points given by the subjects to define their macroforms.

We did not find a high correspondence between macroforms perceived and macroforms analysed. It is nevertheless possible to observe a general tendency confirming the points of division indicated by the analysts in M1 and M2. It can be seen from Table 2 that M1 ($I = 35.6$) and the derived M2 ($I = 37.8$) are the closest to the macroforms perceived by both musicians (M1: $I = 33.9$ Italian and $I = 37.4$ Scottish; M2: $I = 40.1$ Italian and $I = 30.7$ Scottish) and non-musicians (M1: $I = 33.1$ Italian and $I = 35.9$ Scottish; M2: $I = 51.7$ Italian and $I = 39.1$ Scottish). The results for M4 are decidedly lower ($I = 19.8$), while M3 is the furthest from the perceived macroforms ($I = 13.0$), both for musicians ($I = 14.6$ Italian and $I = 16.3$ Scottish) and non-musicians ($I = 9.3$ Italian and $I = 7.2$ Scottish).

This result seems to suggest that the analyses criteria used in M1 and 2, that is to say the cue abstraction procedure and the dynamic process linked to the perception

of tension and relaxation, could be predictive of the auditive analysis carried out in real time during listening and could guide the analyst during analysis of the score. This results allow us to confirm the results obtained by Deliège in her experimental studies. The results of M3 and M4 are interesting. Indeed, given that M3, the macroform furthest from that perceived by the listeners, was also based on Deliège's cue theory, we could hypothesise that there may be a contradiction in the results obtained. In reality, the explanation could be as follows: M3 determined parts I and III based on their internal variability which was given by the co-presence of violent elements and light elements. The subjects, on the other hand, seem to have preferred to group according to the perception of "similarity" rather than to the internal variability of each part, thereby separating the moments characterised by repetition of violent cues from the moments characterised by the repetition of light cues. M3, therefore, may not have predicted the auditive analysis, because despite referring to the Deliège model, it did not respect the principle of similarity. This conclusion is particularly important because it highlights the importance of perception of similarity in the cognitive processes of memorisation and musical processing, as confirmed by various prospects in numerous studies recently published (Toiviainen 2007). Furthermore, from Figure 1 it is clear that the division positioned at mesure 73, which indicates the beginning of the second part, based on the rhythmic pulse, was completely irrelevant from a perceptual point of view. As far as M4 is concerned, we can observe that the two criteria of analysis used for this macroform, that is strong

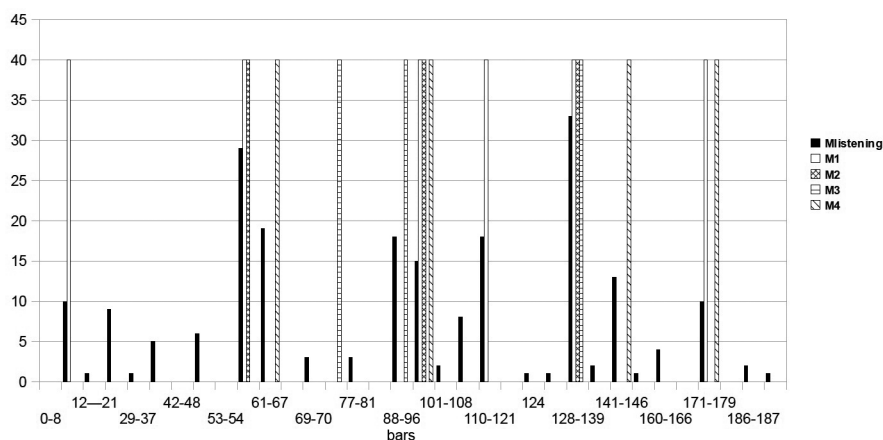


Figure 1.

The frequency of the points of division indicated by the listeners (black colons) compared with the points of division indicated by the analysts (M1, M2, M, M4). In order to obtain the point of divisions indicated by the listeners, the answers given in task 3 have been grouped into several ranges corresponding to the zone where the subjects identified the points of division of the piece. Figure 1 does not show precise points, but rather the range of positions in the bar. The ranges therefore show the space of time where a set of answers is grouped.

segmentations intended as local discontinuity, and indication of time (*Allegro*, *Adagio*, *etc.*), show a direct use of theoretical parameters rather than perceptive type. This aspect could justify the low correlation of M4 with the macroforms perceived. Furthermore, this result would confirm our initial theoretic distinction, according to which the strong local discontinuities are not necessarily perceived as divisions of parts and are not therefore decisive in the memorisation of the macroform.

TENSION AND RELAXATION

We examined the relationship between tension, relaxation and macroforms. Considering all the points of division given by our subjects, the points when tensions were indicated and the points when relaxations were indicated, we see that there is a positive and highly significant correlation between the points of division and tension. These results are summarised in Table 3.

Table 3.
Correlation Analysis Coefficient among Points of division,
Tension and Relaxation Tasks

	Points of division	Tension	Relaxation
Points of division	1.00	.7639**	.0562
Tension	.7639**	1.00	-.1483
Relaxation	.0562	-.1483	1.00

* $p < .05$ ** $p < .01$ (two tailed)

Finally, we checked to see if tension and relaxation could be predictive of the points of division. Correlations were made between points of division, tension and relaxation (3 variables, 2 d.f.). The results of multiple linear regression indicate that both tension and relaxation are predictive of points of division, as do much higher beta values when tension is taken to be the independent variable, as you can see in Table 4.

We did not observe significant differences between the different groups of subjects (Italian and Scottish, musicians and non-musicians): this phenomenon does not therefore depend on musical training. We can argue that an order effect of the tasks could have influenced these results. We assumed that the tasks 4 and 5 could have some distract qualities between task 3 and task 7. In any case, the result obtained should be confronted with the results of a new experimental protocol in which the order of the tasks is checked (by carrying out the tension/relaxation test beforehand for example).

Table 4.
Multiple Linear regression

Dependent Variable	Independent Variable	Beta	P
Points of division	Tension	.783102	.0000
Tension	Relaxation	.170434	.0156

Macroforms 1 and 2 proposed some structural characteristics to explain the alternation of tension and relaxation: “violent” cues, like short lengths, stressed notes, *tallone*, *tremolo*, *sfz*, *pizz.*, *detaché*, dense texture, intensity from *mf* to *fff*, noise sounds, not *vibrato*, which characterise the moment of tension, *vs* “light” cues, as long lengths, *ponticello*, *col legno*, intensity *mp*, *ppppp*, *con sordina*, which characterise the moment of relaxation. We can see that the sonorous organisation of timbre and density of sound is significant, as is the organisation of the duration.

CONCLUSION

The main purpose of this study was to investigate the relationships between the macroform perceived by subjects while listening to a piece of post-tonal music and the macroforms of the same piece indicated by professional analysts based on listening rather than on analytical theories. We found that the analysts’ macroforms based on the abstraction cues model and on the dynamic experience of tension and distension are the most similar to the macroforms perceived by the experimental listeners. Furthermore we observed a significant correlation between the auditive macroforms and the experience of tension/relaxation perceived during the listening in real time. It should be noted that while groupings of different hierarchical levels are present in Deliège’s work, our study has limited the field of research to the perception of the larger parts. Even if we isolate this level, the alternating violent and light cues seem to function as “implicit” invariants which repeat themselves alternatively, and this has allowed for the perception of large groupings and therefore the formation of an imprinting in the memory of the listener. In the case of the Maderna quartet, such similarities seem to be determined by particular timbres used by the strings, that is by elements which have a prevalently colourful tone, as indicated by the the analysts both in M1 and 2. This aspect would seem to be agree with Lerdahl (1989). The process of listening to and the memory of musical form seems directly linked to the dynamic dimension through which the piece is experienced by the person undergoing real time listening, and this contributes significantly to the experience of the form, even where tonal references are absent. This result is in line with Imberty (2005) and Lalitte *et Al.* (2009) and with our own previous experiment (Addessi and Caterina, 2000). Finally, not significant difference were observed between musicians and non musicians. This result confirm the experimental studies carried out by Deliège, Imberty, Bigand and our own previous studies.

These criteria could be used in explicit way by the analysts for the score analysis (Cross 1998). The aims and means employed by someone who studies score analysis (musicologists, analysts, composers) are different from those employed in the study of auditive analysis (psychological process in music) (see Clarke 1989, Sloboda 2005). Nevertheless, we believe that some analytical procedures are common in both approaches, such as those experimented in the study presented in this article - the division in parts, which we have defined as macroform. The distinction between the “implicit” competence of the listener and the explicit conceptualization of the analyst still holds true even under these conditions. The analyst tends to think in conceptual categories, transforming a categorical perception or simply a perception that obeys general cognitive laws, into definite concepts, even to the extent of setting them in areas where such concepts have not yet been definitively codified by music theory. Another essential difference between the listener and the analyst in our study was that time, for the latter, was always freely reversible. In a musical score, time is transformed into a space where it is possible to stop at any point. Moreover, as Cook pointed out (1990), the visual perception of the score may also affect the analysis of the analyst as he/she listens.

A final consideration may be made to link the experimental results obtained to an aesthetic vision of the Maderna’s Quartet. This piece is indeed particular, but also typical of the post-tonal style. It would appear not to have a macroform: the perceptual cues divide the piece into a lot of very small sections: sometimes these sections last for only a few seconds and the perceptual result is not a macroform but a fragmentary feeling. The local discontinuities would seem to dominate. On the other hand, the results concerning the dynamic articulation of tension and relaxation and the “imprinting” theory, would allow us to explain why it is possible to perceive large and coherent sections, in spite of strong local discontinuities.² The result is a quartet in which «refusal of any morphological legacy and subtle formal grace exist side by side, together with belief in a pre-established serial order and the need for improvisation.” (Berio 1957).

2 Between these two levels, one a macroformal level made up of large sections and the other a fragmentary micro-structural level, a middle level also appears, characterised by the presence of “stylistic figures” such as melodic figures, “echo”, *etc.* This intermediate level, which we can define as intertextual, creates a series of references which are external to the work (Deliège would define them as external similarities; “extraopus topics” according to Agawu 1991). The three levels seem to dialogue with each other in the Maderna quartet. A new experimental study could show how the listener could experience an interweaving of these three levels. Even if the theoretical references are different, the experimental studies carried out by Krumhansl (1996, 2009) on how the perception of musical ideas can guide the mental representation of a piece during real time listening, suggest a possible path that could be taken in this direction.

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• Análisis Auditivo del *Quartetto per Archi in due tempi* (1955) de Bruno Maderna

El presente estudio sobre el cuarteto de Maderna tiene como objetivo comparar la "macroforma" (la estructura a gran escala de una pieza musical) percibida por los sujetos mientras escuchan la pieza en tiempo real, y la "macroforma" según la percepción de los analistas. En el estudio también se examina la correlación entre la "macroforma" y la percepción de la tensión / relajación. Dos grupos de sujetos participaron en el experimento: 25 no músicos y 32 músicos. El experimento se llevó a cabo en Bolonia y Edimburgo. Para ello, usamos un programa de cómputo especial, que permite a cada sujeto escuchar una pieza a través de auriculares e indicar los puntos de división entre la tensión / relajación percibida en tiempo real. El experimento duró aproximadamente 60 minutos y consistió de varias etapas y tareas. Después de hacer una audición preparatoria que sirvió para familiarizarse con la pieza y con la interfase, los sujetos tenían que escuchar la pieza nuevamente con el fin de identificar las secciones principales. Luego se les pidió que indicasen los criterios que utilizaron en la formulación de sus soluciones. En la siguiente audición, se les pidió indicar las zonas de mayor tensión y relajación percibidas. Las macroformas percibidas por los sujetos se compararon con 4 macroformas señaladas por analistas profesionales, cuyas respuestas estuvieron basadas en lo que escucharon y no en teorías analíticas. Los datos muestran una correlación alta entre las macroformas percibidas por los sujetos y solamente 2 macroformas indicadas por los analistas, y correlación entre la macroformas y la tensión / relajación percibida por los sujetos. Las diferencias entre grupos de músicos y no músicos e italianos y de Edimburgo no fueron significativas.

• Analisi aurale del *Quartetto per Archi in due tempi* (1955) di Bruno Maderna

Il presente studio sul quartetto di Maderna si prefigge di confrontare la "macroforma" (evicé la macrostrutture di un pezzo musicale) percepita dai soggetti mentre ascoltano il pezzo in tempo reale, e la "macroforma" così come viene percepita da espects d'analisi musicale. Lo studio esamina anche la correlazione tra "macroforma" e percezione di tensione/distensione. Due gruppi di soggetti hanno preso parte all'esperimento: 25 non-musicisti e 32 musicisti. L'esperimento é stato condotto a Bologna e ad Edimburgo. É stato utilizzato un particolare programma informatico che permette a ciascun soggetto di ascoltare il pezzo tramite cuffie ed indicare i punti di divisione e tensione/rilassamento durante l'ascolto in tempo reale.

L'esperimento durava circa 60 minuti ed includeva diverse fasi e compiti. Dopo un ascolto iniziale che é servito a familiarizzare gli ascoltatori con il bravo musicale e con il computer, i soggetti dovevano ascoltare ancora una volta il pezzo ed identificarne le sezioni principali. Dovevano inoltre, indicare i criteri usati nella formulazione delle loro soluzioni. Nell'ascolto successivo dovevano indicare le piú ampie zone di tensione e rilassamento che avevano percepito. Le macroforme

percepite dai soggetti sono state confrontate con 4 macroforme indicate dagli analisti professionisti sulla base dell'ascolto piuttosto che delle teorie analitiche. I dati mostrano la correlazione piú alta tra le macroforme percepite dai soggetti e 2 delle macroforme indicate dagli analisti, nonché una correlazione significativa tra le macroforme e la tensione/distensione percepite dai soggetti. Le differenze tra musicisti e non-musicisti e tra i gruppi di Bologna e di Edimburgo non sono risultate significative.

**• Analyse auditive du
Quartetto per Archi in due tempi (1955) de Bruno Maderna**

La présente étude du quatuor de Maderna a pour objectif de comparer la "macroforme" (la structure à grande échelle de la pièce) perçue par des sujets lors d'une écoute en temps-réel de la pièce, à la "macroforme" perçue par des analystes. Cette étude examine en outre la corrélation entre "macroforme" et perception de tension / relaxation. Deux groupes de sujets ont pris part à l'expérience : 25 non-musiciens et 32 musiciens. L'expérience s'est déroulée à Bologne et à Edinbourg. Une interface informatique permet à chaque sujet d'écouter la pièce dans un casque, puis d'indiquer les points de divisions et de tension / relaxation perçus lors de l'écoute en temps réel. L'expérience, d'une durée approximative de 60 minutes, se décompose en une succession d'étapes et de tâches. Après une première écoute permettant de se familiariser avec la pièce et avec l'interface informatique, on demande aux sujets d'écouter une seconde fois la pièce afin d'y identifier les sections principales. Ils sont tenus également d'indiquer les critères utilisés dans cette première analyse. Dans une troisième écoute, il est demandé d'indiquer les plus grandes zones de tension et de relaxation perçues. La macroforme ainsi perçue par les sujets est comparée avec quatre macroformes indiquées par des analystes professionnels sur la base d'une écoute de la pièce et non de théories analytiques. Les données montrent une plus grande corrélation entre les macroformes perçues par les sujets et seulement deux macroformes indiquées par les analystes, ainsi qu'une corrélation entre les macroformes et les schémas de tension / relaxation perçus par les sujets. Les différences entre musiciens et non-musiciens et les groupes de sujets d'Italie et d'Edinburgh ne sont pas significatives.

**• Höranalyse des Stücks
„Quartetto per Archi in due tempi“ (1955) von Bruno Maderna**

Die vorliegende Studie über Madernas Quartett vergleicht das Ergebnis der in Echtzeit erfassten « Großform-Höranalyse » musikalischer Laien mit dem Ergebnis der Höranalyse musikalischer Experten (Musiktheoretiker). Die Studie untersucht auch den Zusammenhang zwischen der Wahrnehmung der „Großform“ und der von Spannung bzw. Entspannung. Zwei Probandengruppen nahmen an dem Experiment teil: 25 Nicht-Musiker und 32 Musiker. Das Experiment wurde in

Bologna und Edinburgh durchgeführt. Wir benutzten ein spezielles Computerprogramm, das es jedem Teilnehmer erlaubte, die Musik über Kopfhörer zu hören, in Echtzeit formale Abschnitte zu markieren und die wahrgenommene Spannung bzw. Entspannung anzugeben. Das Experiment dauerte ungefähr 60 Minuten und beinhaltete verschiedene Schritte und Aufgabenstellungen. Nach einer Trainingsphase, die dazu diente, mit dem Stück und dem Computerprogramm vertraut zu werden, hörten die Probanden das Stück erneut und identifizierten seine Hauptformabschnitte. Danach gaben die Probanden ihre Kriterien für die Lösung der Aufgabe an. Beim nächsten Hördurchlauf markierten sie die größten Abschnitte subjektiv empfundener Spannung und Entspannung. Die von den Versuchsteilnehmern wahrgenommenen großformalen Abschnitte wurden mit vier durch Experten-Höranalysen bestimmte Großform-Analysen verglichen. Die Ergebnisse zeigten nur für zwei großformale Abschnitte eine größere Entsprechung zwischen den Ergebnissen der musikalischen Laien und der Experten. Außerdem zeigten sich Entsprechungen zwischen den durch die Versuchsteilnehmer wahrgenommenen Großformen und dem Erleben von Spannung bzw. Entspannung. Unterschiede in den Ergebnissen zwischen Musikern und Nicht-Musikern aus Bologna und Edinburgh waren nicht bedeutsam.

