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Modulation Structures*

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ABSTRACT

This paper reviews statistics of modulations in two operas, *La Dame Pique* by P. Tchaikovsky, and *Banuta* by A. Kalnins. Particular attention is paid to the role of enharmonisms in modulations.

It has been proved that the development of quantitative linguistics has also been facilitating the analysis of musical texts by means of mathematical methods. Until now, in most cases the melody has been investigated (Boroda, 1988; Detlovs, 1988, 1991; Detlovs & Klotiņš, 1985; Fucks, 1962), while the analysis of harmony has been performed much more rarely (Detlovs, 1965).

In order to statistically analyse the musical text, first, the text must be segmented. For this purpose, both context-free segmentation (Detlovs, 1991; Fucks, 1962) and context-dependent segmentation (Boroda, 1988; Detlovs, 1988) have been used. Each segment has a relevant number or number series attached, by making use of a certain semantically justified approach. The number is viewed as a random variable, and research is carried out by the mathematical apparatus of statistics.

The question may be asked whether shorter or longer segments are more advantageous for analytical purposes. If the text is divided into shorter segments, a more abundant statistical sample is acquired which may result in a higher statistical regularity. On the other hand, a very short segment contains scarcely information on music, therefore the results obtained are less interesting as to their contents. Evidently, different approaches should be used never moving too far away from *aurea mediocritas*.

The shortest melody segment is one note. If we are interested only in the aspect of pitch, one figure can be related to each note, and this fig-

ure would characterise either the *absolute pitch* (for instance, one line D) or *relative pitch* (for instance, degree 6 of major).

The first method has been applied in Fucks (1962). However, it must be admitted that in the analysis of tonal music, the pitch of acoustic sound is a less characteristic value than the relative pitch in the given tonality. When analysing the melody from the viewpoint of degrees, specific features of different degrees of the mode are revealed. Rather efficient is the approach where those intervals are analysed which follow the given fixed degree of the mode. Such research has revealed metastylistical regularities which can be seen both in folklore (Latvian folk songs) and classical music (Detlovs, 1991; Detlovs & Klotiņš, 1985).

When analysing intervalic of the melody, this means performance on the lowest level of the hierarchy of the musical form. This analysis deals with the transition from one *degree* of the given mode to another. On a higher level, an analogous possibility can be observed, namely, an analysis of transitions from one *tonality* to another may be performed, i.e., modulations can be analysed. The aim of this paper is the analysis of modulations, paying special attention to a specific viewpoint related to enharmonisms.

Due to the existence of a circle of fifths, peculiar situations are possible in the sequence of modulations, which are called modulation somersaults (*MS*). This term will be defined below. A question may be posed how to assess the

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length of a segment when analysing the sequence of modulations. A segment of the melody turns out to be conditioned by the context and can be of considerable length, namely, it covers a melody span during which one tonality change has taken place. However, a segment is characterised rather laconically, naming only the modulation performed, but ignoring separate sounds and parameters thereof encountered in the melody.

Let us define the question precisely. A certain modulation is characterised by the first tonality (*FT*) and the second tonality (*ST*). Each of them may be in major key (*M*) or minor key (*m*). The key note of the tonality may be one of the 12 sounds of the octave. These sounds, as we know, may be arranged in a circle of fifths:

$$\begin{array}{l} C - G - D - A - E - B - F \text{ sharp} = \\ G \text{ flat} - D \text{ flat} - A \text{ flat} - E \text{ flat} - B \text{ flat} - F (-C). \end{array} \quad (1)$$

Modulation step d will mean the number of steps when moving along the circle of fifths. If the moving from *FT* to *ST* takes place clockwise, *d* is positive. A negative *d* means that moving has been performed in the opposite direction, for example, when the number of flats increases.

One modulation can be recorded in the form of series *FT d ST*. For example, the transition from *C* major to *F* minor is recorded as *C -4 f* (in the event of major, a capital letter is used for designation of tonality, while in the event of minor, a small letter is used).

Under such an *absolute* approach, the number of modulations theoretically possible is $2 \times 12 \times (2 \times 12 - 1) = 552$. Furthermore, as a result of possible enharmonisms, the number of modulations should seemingly increase even more.

The situation becomes simpler if we move to the *relative* approach. Then the aforementioned modulation could be characterised as an example from the entire class of concrete modulations, namely, as a transition from major key to subdominant minor, i.e., as a modulation with step -4 , and to record the entire *class* of these particular modulations as *M -4 m*.

Then this designation would incorporate also, for example, modulation *F sharp -4 b*, etc. From now on, such classes of modulations will be called (relatively perceived) *modulations*, and designated as

$$F d S, \quad (2)$$

where *F* and *S* are symbols of *M* or *m* subject to *FT* and *ST* modes, and *d* is a modulation step. The number of different modulations recorded in this manner is $2 \times (11 + 12) = 46$, if the step is used within the limits of

$$-6 < d < +6, \quad (3)$$

which exhaustively and without any repetitions covers the entire circle of fifths. All these modulations can be found below in the lists (5), (6) and (7).

If the recording in the text of notes is literally followed, then, due to enharmonisms, this number may increase. This may be avoided when the so-called reduced modulations (*RM*) are used which are discussed in the following section.

Based on the circle of fifths (1), each modulation *MOD'* with step *d'* in the event

$$d' > 6 \text{ or } d' < -5 \quad (3')$$

may be substituted with an enharmonic equivalent modulation *MOD* whose step *d* satisfies condition (3). In this case, *MOD* is called the *reduced modulation* (*RM*) of modulation *MOD'*.

For example, let us look at a concrete absolute modulation *D flat - f sharp*, i.e., a relative modulation *M 8 m*. This is enharmonically equivalent to *M -4 m*. Thereby the increase of the number of sharps by 8 is substituted by the increase of flats by 4, thus obtaining another example of the modulation class above.

Another example: modulation *m -10 m* can be substituted by *m +2 m*, for example, reading the absolute situation *g sharp - b flat* enharmonically as a flat - *b flat*.

It is evident that in the general case both these acts are described by the formula

$$d = d' - 12 \times \text{sgn}(d'), \quad (4)$$

which allows to calculate the corresponding reduced modulation $F d S$, whose step satisfies requirement (3), for the modulation $F' d' S$.

In the event of $d' > +6$, it may be said that when reducing the modulation, firstly, a full circle of fifths is followed in the direction of flats, but afterwards the step of this modulation is carried out ($-4 = -6 \times 2 + 8$). Such a modulation, upon its reduction, can be called *modulation somersault backwards*.

In the same way, case $d' < -5$ could be named a *modulation somersault forward*. After these technical definitions we will consider the question with respect to the semantics of modulation somersaults and their reduction, namely, their musical meaning.

Since the times of J.S. Bach equal temperament and equality of enharmonic records have been acknowledged in principle both in musical practice and theory. From this viewpoint, legitimacy of reduction of a modulation would not cause any doubts. However, a performer in his practice still allows deviations from equal temperament, thus threatening also the equality of enharmonisms. This is done by a vocalist, string player, etc. Even during the process of tuning the piano, the upper octaves happen to intentionally deviate from the equal temperament.

Therefore it is natural to pose the question whether composers in their musical thinking truly and fully identify all enharmonically equal situations. This is not a trivial question, and it would be light-minded to give a categorically positive response.

Moreover, not only in musical practice but also in the theoretical literature the grounds may be found for a negative reply to this question. As an example, the harmony textbook by Rimsky-Korsakov (1921) may be mentioned, which was pointed out in Rukavišnikov (1975). Let us consider this matter in a more detailed manner. Rimsky-Korsakov has introduced a convincing classification of relationships of tonalities. Particularly, two tonalities are in the *first relationship degree* if a tonic chord of one tonality can also be found in the other tonality (see Rimsky-

Korsakov, 1921, paragraph 48). Under our conventional designations, this produces 12 modulations, which are shown below, each class being illustrated by an example, a concrete absolute modulation.

M 0 m	e.c.	C – a	m 0 M	e.c.	a – C
M +1 M	e.c.	C – G	m –1 m	e.c.	a – d
M –1 M	e.c.	C – F	m +1 m	e.c.	a – e
M –4 m	e.c.	C – f	m +4 M	e.c.	a – E
M +1 m	e.c.	C – e	m –1 M	e.c.	a – F
M –1 m	e.c.	C – d	m +1 M	e.c.	a – G.

Furthermore, following Rimsky-Korsakov, two tonalities are in the *second relationship degree* (see 1921, paragraph 58), if any chord (but not tonic) of one tonality can also be found in the second tonality. 24 modulations are formed

M –3 m	e.c.	C – c	m +3 M	e.c.	a – A
M –5 M	e.c.	C – D flat	m +5 m	e.c.	a – g sharp
M +2 M	e.c.	C – D	m –2 m	e.c.	a – g
M –3 M	e.c.	C – E flat	m +3 m	e.c.	a – f sharp
M +4 M	e.c.	C – E	m –4 m	e.c.	a – f
M –2 m	e.c.	C – g	m +2 M	e.c.	a – D
M –4 M	e.c.	C – A flat	m +4 m	e.c.	a – c sharp
M +3 M	e.c.	C – A	m –3 m	e.c.	a – c
M –2 M	e.c.	C – B flat	m +2 m	e.c.	a – b
M –5 m	e.c.	C – b flat	m +5 M	e.c.	a – B
M +5 M	e.c.	C – B	m –5 m	e.c.	a – b flat
M +2 m	e.c.	C – b	m –2 M	e.c.	a – B flat.

Finally, Rimsky-Korsakov speaks of *distant degree of relationship* in all other cases (1921, paragraph 61). These are situations when both tonalities do not have any chord in common. In his textbook, Rimsky-Korsakov does not point out a complete list of such modulations. In all, there are 10 modulations of distant relationship:

M +6 M	e.c.	C – F sharp	m +6 M	e.c.	a – F sharp
M +3 m	e.c.	C – f sharp	m –3 M	e.c.	a – E flat
M +4 m	e.c.	C – c sharp	m –4 M	e.c.	a – A flat
M +5 m	e.c.	C – g sharp	m –5 M	e.c.	a – D flat
M +6 m	e.c.	C – d sharp	m +6 m	e.c.	a – d sharp.

This is the classification of modulations created by Rimsky-Korsakov, based on his own theoret-

ical definitions and consequently holding for enharmonisms which follow from the equal temperament.

The strangest thing is that the author himself interprets his system otherwise, not always respecting enharmonisms. How is this manifested? In Rukavišnikov (1975) the theory of relationship of tonalities by Rimsky-Korsakov is analysed and discrepancies are pointed out between definitions and examples.

Indeed, in the course of harmony the following modulations are named as examples of distant relationship:

	(1)	(2)	(3)
	C – e flat,	B – B flat,	c sharp – B flat,
or	M – 6 m,	M – 7 M,	m – 6 M
	(4)	(5)	
	b flat – e,	A flat – E	
or	m + 6 m,	M – 8 M.	

In fact, examples two and five are examples of second degree relationship, and not distant relationship, since their reduced modulations are M + 5 M, M + 4 M, which can be found in list (6).

This performance by the author is difficult to comment, since this cannot be considered as a slip, if the repeated issues of the harmony course are taken into account. This means that we are dealing with a deliberate act. What does this mean? *Nolens volens* it must be admitted that the thinking of the composer has been influenced by pre-temperament notions. What is the semantic basis or the contents of such thinking? It is very difficult, maybe impossible, to give a straightforward answer to this question. Therefore, each, even rather modest, attempt to decipher the intentional or unintentional motivation of the composer by means of application of distant modulations, including modulation somersaults, may seem very enticing.

The opinion that motion towards sharps means the transition to a more cheerful emotional sphere while the increase of flats evidences the darkening of emotional colouring is a generally accepted viewpoint in the aesthetics of music. It is possible that another pair of opposites could be added here. The motion towards

sharps can facilitate the degree of cordiality, intimacy, humanity. The motion towards flats may create a solemn but alienated, maybe even horrible, impression. (Of course, in actual situations the character of the music is also influenced by numerous other parameters which we are not discussing now, therefore we can speak only of one component of reciprocal influence.)

How would this generally accepted characteristic act in the event of modulation somersault? What type of semantics can be seen, for example, in the modulation somersault forward? Different replies can be given to this question depending on the situation whether the author of the music (or, later, the listener to the music) lives in a space of equally tempered music or, contrarily, the pre-temperament musical landmarks are still alive within him.

In the first case, in spite of the writing in the score, the reduced modulation is perceived. When speaking of the forward somersault, it is the motion towards sharps of “normal amount” with all its cheerful emotional characteristics. In the second case, strictly in accordance with the text, no reduction takes place while perceiving the music. This means that the forward somersault is perceived as the motion towards flats of “significant amount,” together with all dark emotions following therefrom. The same *mutatis mutandis* applies to the somersault backwards.

Statements contained in the previous section lead to the conclusion that there exists a principal possibility to organise an experiment to determine whether a pre-temperament situation can be found in the thinking of a composer, or, contrarily, the author of the music lives in the world of consistent equal temperament.

However, in order to carry out such an experiment, we must be able to follow emotions depicted by the author continuously, at least, we must try to orientate ourselves in the aforementioned pair of opposites (“cheerful” – “dark”). This is not an easy task, and the response could be of subjective character to some extent. However, the situation should not be considered as completely hopeless. Below such an attempt is made with respect to texts of two different au-

thors. Let us consider what kind of texts would be suitable for such an experiment. Modulation somersaults can be expected in longer texts. Therefore we should try to find a corpus from among large forms of music. In order to attain a higher degree of credibility of emotional characteristic, the best choice is to consider vocal music, since the text can supply an additional key for deciphering the emotional contents. These considerations hold true, for example, for the opera. Therefore, two operas were analysed, *La Dame Pique* by the Russian composer Tchaikovsky (1840–1893), and *Banuta* by the Latvian composer Alfreds Kalnins (1879–1951). These texts will be designated by DP and BA, respectively. The summary results regarding the number of modulation somersaults are as follows.

	DP	BA	(8)
forward	16	21	
backward	5	10	
Total	21	31	

It is evident that in both cases somersaults forward are most frequently met, constituting 76% for corpus DP and 68% for corpus BA.

It is worthwhile to follow the location of somersaults in each of the operas, investigating, for instance, their regularity. Special interest can be caused by fragments of high density of somersaults.

When starting such an analysis, the unit of the time scale should be chosen. Physical time (measured in seconds) is technically inconvenient; besides, it is subjectively dependent on the performer, in this case, the conductor. Furthermore, it is known that physical time and psychological time of musical perception are far from being the same. Also, one separate sound of the melody would not serve as an ideal unit. Indeed, the informational value of short notes in quick passages is insignificant. Taking into account all this, the *bar* is chosen as the unit of time, though we are aware of the relative character of this choice.

In the opera by Tchaikovsky, there are *two striking accumulations of somersaults*. They are

formed by the first six and the final four somersaults. On an average, one somersault appears after 173 bars in the opera. But in the segment from bar 667 through bar 891, 6 somersaults can be found, i.e., one somersault per 37 bars, or a density which is 4.7 times higher than the average. In the final scene of the opera, from bar 3444 through bar 3470 there are 4 somersaults, i.e., one somersault per 6.5 bars, or a density which is 26.6 times (!) higher than the average. What events of the opera's plot are related to these two fragments?

The first fragment covers the end of scene 1 and the beginning of scene 2. This is the storm episode which follows after the ballad by Tomsky. In the perception of Herman, the story of the old countess acquires the character of a ghastly foresight. The following two somersaults can be found in the romance of Pauline which may be perceived as an indirect reflection of alarming forebodings of Lisa. The second fragment covers the episode in which the fiancé of Lisa, Yelyecky, begins a card game against Herman after his repeated victories over other players. This could be named the beginning of the end of the opera, the death of Herman.

On the other hand, we can also follow several spans with a *minimum* density of somersaults. Such is the exposition of the opera: during the first 666 bars not a single somersault can be observed. Further, during Scene 3 there are only two somersaults, namely one somersault per 410 bars, which is 2.4 times less than the average density. It can be added that within the same scene the entire pastorage (408 bars) does not contain a single somersault.

It is evident that modulation somersaults are typical of dramatic and emotionally tense situations. Practically no somersaults are observed in spans of peaceful music. However, this does not mean that somersaults would be a mandatory feature of dramatic moments. Such a thesis could be disproved by a series of counterexamples.

As it could have been expected, the question of the semantic role of the direction of somersaults is rather vague. However, some considerations could be stated. Backward somersaults constitute a minority, see (8). In what situations

of plot can they be observed? Firstly, half of them are located in the aforementioned first maximum density. Emotional colouring is related to horrible premonitions. Furthermore, one somersault can be found in the scene at the barracks prior to the appearance of the ghost of the old countess, another can be seen in the aforementioned episode of the final scene. Neither of these situations can be characterised by cheerful emotions of any type.

In accordance with the considerations stated before, this could confirm that *Tchaikovsky feels a modulation somersault as a reduced modulation*. In other words, his musical thinking seems to be consistently enharmonic and, at least in this aspect, does not reveal any pre-temperament time recurrences.

The opera *Banuta* by Alfreds Kalnins is considered as the first significant work of its genre in Latvian music. Its plot is based on the romanticised ancient history of the Latvians prior to the invasion of German crusaders. The author of the music could be characterised as a romantic whose musical thinking at the same time is closely linked with the character of Latvian rich musical folklore.

Similarly to DP, also the first span of BA (approximately 500 bars), as well as a couple of hundreds of final bars, does not contain any modulation somersaults at all. At the same time the general corpus BA is characterised by a greater number and higher density of modulation somersaults than in corpus DP. On the average, one somersault appears every 121 bars, this means that it is found one and a half times more often than in corpus DP.

The location of somersaults in the opera again cannot be characterised as evenly distributed. In contrast to DP, there are more than two segments of high density of somersaults. We can speak of six such segments. As to the plot, these are not the most dramatic moments in the opera, but rather, forebodings of such moments. For example, this refers to the raven's croaking in Act One prior to the arrival of Vizhutis and the death of Daumants. In Act Two, this is a dream of Banuta in which she suspects her destiny, burning at the stake (a somersault every 17 bars

if compared to the average of one somersault every 121 bars). The most intensive accumulation can be found in the love duet at the end of Act Three prior to Banuta's fatal confession that she must kill Vizhutis to revenge the death of Daumants. Here three somersaults are met in 18 bars.

We would like to stress that a similar conclusion, with respect to accumulations of somersaults prior to dramatic turning points in the course of the opera, was reached during the analysis of PD. There are three spans with a lower number of somersaults. In addition to those mentioned in the beginning and in the end of the opera, such a span of 522 bars is located from bar 2475 through bar 2997. This segment contains a long choir singing and an episode of a folk dance which do not directly advance the action of the opera. From the viewpoint of the plot, this segment has a similar role to that played by the pastorella in *La Dame Pique*.

In music composed by Alfreds Kalnins, somersaults backward are not so expressly related with dark emotions as it was stated in the opera by Peter Tchaikovsky. Such a semantic interpretation may be assigned only to the first three backward somersaults and the final one in text BA. Consequently, it must be admitted that BA does not allow to express the hypothesis regarding the position of the author in the perception of enharmonisms. In order to make conclusions, other texts by the same author should be analysed.

Several other aspects are possible which have not been reviewed in this paper. The connection between density of modulation somersaults, on the one hand, and modulation density in general, on the other hand, could be analysed. Attention could be drawn to the mean value of the modulation step both in the event of somersaults and of ordinary modulations. Another possibility is to compare statistics of intervals with the statistics of modulations, and through this analysis to try to link regularities governing musical forms on two different hierarchy levels. And, of course, it is advisable to expand the list of music and its authors analysed. This remains as a task for the future.

REFERENCES

- Boroda, M.G. (1988). Towards the basic semantic units of a musical text. In M.G. Boroda (Ed.) *Musikometrika 1* (pp. 11–68). Bochum: Brockmeyer.
- Detlovs, V.K. (1965). O statističeskom analize muzyki. *Latvijskij matematičeskij ežegodnik*, 3, 101–120.
- Detlovs, V.K. (1988). On microsegmentation of Tunes. Alternative units to F-Motif. In M.G. Boroda (Ed.), *Musikometrika 1* (pp. 69–82). Bochum: Brockmeyer.
- Detlovs, V.K. (1991). Modal functions and intervalic structure of melody. In M.G. Boroda (Ed.), *Musikometrika 3* (pp. 41–58). Bochum: Brockmeyer.
- Detlovs, V.K., & Klotiņš, A.E. (1985). Statističeskije issledovanija ladotonal'noj funkcion'e'nosti v latyšskich narodnych pesnjach. *Izvestija AN lat. SSR*, 10, 69–78.
- Fucks, W. (1962). Mathematische Musikanalyse und Randomfolgen. Musik und Zufall. *Gravesamer Blätter*, 6, 132–145.
- Rimskij-Korsakov, N.A. (1921). *Harmonijas mācība. "Leta"*. Rīgā.
- Rukavišnikov, V. (1975). Nekotorye dopolnenija i utočnenija sistemy tonal'nogo rodstva n.a. Rimskogo-Korsakova i vozmožnye puti ee razvitija. *Voprosy Teorii Muzyki*, 3, 70–103.