INTENSITY OF ARTISTIC CREATIVITY: PERIODICAL WAVES IN THE EVOLUTION OF EUROPEAN MUSIC, PAINTING, AND THEATRE

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ABSTRACT

Earlier in the framework of the informational approach, periodical processes with duration of cycles about 50 years were deduced, which were observed in artistic style (Martindale, Maslov, Koshkin, and other authors). As well analogous waves were predicted for the intensity of artistic life, artistic creativity, and related spheres. To corroborate this hypothesis, data on 5982 composers, 867 painters, 2741 persons of theatre, and 992 playwrights of the 12^{th} – 20^{th} centuries (relating to 40 European countries) were considered: their years of birth, together with lengths of their descriptions in encyclopedias. On the basis of these data, evolutionary curves were built for the 'intensity of artistic creativity' in each kind of art. Most curves reveal hill-like long-term trend; against the background of this trend periodical oscillations were observed, some of them being synchronous both for different kinds of art and different cultural regions. This synchronicity supports the informational model of the evolution of artistic life.

During last two decades studies of periodical processes in the evolution of art became rather widespread. In the middle of the 20th century, the attention of researchers was focused mainly on long-range periodicity, with full duration of cycles of about several centuries (see, e.g., Sorokin, 1937-1941). Later the attention turned to more 'actual' periods close to 50 years, these investigations being partly inspired by such periodical waves observed in economics, social relations, and similar fields (see, e.g., Kondratiev, 1989). Numerous cycles of such a kind in the *stylistic evolution* of art became well known primarily due to investigations of Martindale (see, e.g., Martindale, 1990, 2007). He attributes these changes to the need for constant increasing the '*arousal potential*' carried by oeuvres of each given kind of art, exactly this need being responsible for periodical stylistic changes in each kind. In his model, periodical 'switches' take place between prevalence either of 'primordial' style or 'conceptual' one.

Later studies of periodicity appeared based on the *information approach* (e.g., Maslov, 1983; Koshkin, 1997; Golitsyn & Petrov, 1997; Koptsik, Ryzhov, & Petrov, 2004; Petrov, 1992, 1998, 2001, 2003, 2004, 2006; Petrov & Boyadzhiyeva, 1996). In the framework of this approach (about its foundations see, e.g.: Golitsyn, 1997; Golitsyn & Petrov, 1995, 2005), periodical changeability in the artistic style is caused primarily by influences of *changes in the entire 'socio-psychological climate'* of the society, these latter changes being also of informational character (the need for innovations). They are raised by the necessity to realize periodical 'switches' between *two 'polar' styles of thinking*:

— 'analytic' style, when information processing takes place within the given level of the man's hierarchical system of the information processing; small portions of the information received are processed in consecutive order, with very high precision; this type of activity is characterized by rational features, an important role for logic, and so forth;

— 'synthetic' style, when the information is transmitted from one level to a higher one; this activity is characterized by a change of paradigm (rules of information processing); rather large amounts of information are processed parallel to each other, but with relatively low precision; this activity may be described as emotional, intuitive, and so forth.

A significant difference thus exists between these styles, which can be ascribed (though rather conditionally, partly metaphorically) to the left- and right-hemispheric activity, respectively. As it was shown, at every given moment, a society needs to have a definite degree of prevalence of one of these two styles, this prevalence embracing various spheres of creative activity (in music, painting, social relations, etc.). This dominating style has to change from time

to time, because each style possesses rather limited possibilities with respect to further progress of the communications in the society. Therefore, every dynamic society must, from time to time, 'switch' between left- and right-hemispheric styles of thinking (including creativity). These switches, in turn, possess a limitation, as far as their frequency is concerned, because the real carrier of any style of thinking is a human being who belongs to a definite generation and therefore has a definite degree of left or right domination. So any style of thinking lasts not less than the duration of the dominance of one generation. If a given generation dominates the creative sphere for approximately 20 to 25 years, the full period of oscillations has to be 40 to 50 years. [Similar 'generational explanation of 52-year periodicity is derived by Mallmann & Lemarchand, 1998.]

These theoretical considerations were corroborated by numerous empirical investigations: *periodical processes* with full duration of cycles about 50 years, were observed in various kinds of art belonging to various national cultures – see, e.g., Koshkin, 1997; Petrov, 1992, 1998, 2001, 2003; Petrov & Boyadzhiyeva, 1996. Meanwhile, these investigations dealt only with *stylistic features* of the art, i.e. its *qualitative characteristics*. However, besides style, there exists another aspect which seems to be also very important for the artistic evolution – its certain *quantitative characteristics*, also describing the art, but another its side. First of all, we mean the *intensity of artistic creativity*: the number of substantial events which appear in the spheres of music, painting, poetry, etc. (Really, sometimes during one or two decades no significant oeuvres appear, e.g., in music, whereas some other decades are filled by numerous great oeuvres.) So we may suppose that something like '*intensity of creativity*' in music would characterize each temporal fragment of the artistic development (e.g., each decade). Moreover, one may suppose that this 'intensity' would be connected with the above stylistic evolution. Hence, maybe the 'intensity' would also show *periodical character*? Exactly such proposed periodical changes, would become the main object of the present investigation. But how to define and to measure this intensity?

1. Intensity of creativity: prehistory of the concept

It is well known that usually the *definition* of a certain phenomenon is tightly connected with *methods* which are capable *of measuring* this phenomenon; so the definitions and measurements often occur tightly interwoven. We shall not dwell upon this problem (it is discussed in our other works, see, e.g., Petrov, 2004, pp. 339-351; Dorfman, Leontiev, & Petrov,

1997, pp. 55-62). We prefer to outline the process of formation both of measurements and definitions in this new branch of evolutionary investigations.

The very *idea* to measure the intensity of artistic creativity, appeared in the end of the 1990's when *compiling samples* for the investigation of the artistic evolution, namely a sample of Russian poets who made the history of Russian poetry. When sampling, we used a modification of a method derived by Martindale (1990): on the basis of descriptions of poets presented in several literary encyclopedias, we tried to single out the most eminent poets for each 20-year fragment of the literary evolution. In this process of sampling, the role of the '*indicator of eminence'* was played by *lengths of descriptions* of different poets: it seems reasonable to suppose that the more eminent the poet, i.e. the *more significant* his/her *creative achievements*, the *longer* the *description* of his/her life and oeuvres in each given encyclopedia. Of course, to enhance the reliability of our choice, we tried to use not sole encyclopedia, but several ones, in order to aggregate the data presented in different sources.

However, we came across the phenomenon of *non-compatibility* of different encyclopedic sources, meaning their scales (volumes) of descriptions. For instance, in one encyclopedia the lengths of descriptions vary from 40 words (for the least eminent poet) to 400 words (for the greatest poet), whereas in another encyclopedia appropriate diapason may be from 200 to 25000 words. That is why it would be incorrect to summarize these lengths (over different encyclopedia) or to calculate some average values for certain sets of poets.

In principle, to overcome this difficulty when sampling, different ways can be used. For instance, it might be possible to 'normalize' the lengths of descriptions (e.g., taking into account their average lengths in different encyclopedias), or to use not absolute lengths (which are incompatible), but their ranks (though the ranks also vary in different ranges), etc. Nevertheless, in any case it would be desirable to resort to the help of rather 'easy and transparent' procedure; first of all, such procedure would be based on the *sole literary source* used. But of course, we may suspect, that this single source would be too '*subjective*' in its attention paid to different poets? and hence, it would be incorrect to base the evolutionary investigation on the sole source?

Fortunately, it occurred that for our purposes (meaning the below evolutionary investigations) in most cases even a *sole source* is capable of forming rather *reliable empirical basis* (if to take into account some reasonable considerations – see below). In fact, usually various encyclopedias though differing in absolute lengths of descriptions relating to poets, show quite *identical hierarchies* (rankings) of these lengths. Later we shall dwell upon some details of this remarkable phenomenon. What is now important for our consideration, is the fact

of the above identity. It means that we can really work with such data – as rather reliable primary raw materials for evolutionary investigations focused on the intensity of artistic creativity. So now the last one can be defined as follows: the *intensity of artistic creativity* in the kind of art considered, can be based on the data published in the given literary source; this intensity can be ascribed to each given temporal segment of artistic evolution (e.g., each given 5-year or 10-year temporal segment) as the *total (summary) volume of descriptions* devoted to those *persons* which were *active* in the creative sphere considered during this time and hence, occurred reflected in the source used.

However, practically it is more convenient to take into account not those persons who were 'active' during this temporal fragment, but simply those active persons which were *born* 20-25 years before the beginning of the temporal fragment in question (as far as usually each creative person starts its real activity exactly after entering this age). Really, the *fact of birth* is known to be much more authentic than the active character of creative activity – at least for statistical investigations. [Of course, here we should take into account a certain 'outstripping' of the dates of birth fixed by the source, in relation to the dates of real functioning of these creative persons.]

This procedure of summing is very easy. For instance, let the investigation be devoted to the evolution of musical creativity, basing on the data presented in a definite musical encyclopedia. If during a certain 10-year fragment five composers were born (out of those ones presented in the given encyclopedia), and the descriptions of their creativity consist of 900, 800, 750, 650, and 500 words, then the intensity of creativity ascribed to this temporal fragment, equals 900 + 800 + 750 + 650 + 500 = 3600. Next, adjacent 10-year fragment may be reflected, e.g., by 2700 words, the next one – by 1900 words, and so forth. Hence, we can build appropriate evolutionary curve for the intensity of musical creativity, which would show, for this time range, constant decreasing.

Besides, it is not necessary to calculate the number of words in the description of different creative persons. As soon as the sole source is used, it occurs possible to calculate the *number of lines* devoted to each person (such procedure is easier). [So, it is not a joke that we can measure something like 'greatness in centimeters' for different creative persons.]

Now it is time to dwell upon *general contours* of behavior which are inherent to such evolutionary dependences. These general contours would be very important for *real possibilities* of the usage of such dependences in evolutionary investigations.

As a rule, each evolutionary curve possesses quite definite '*typical form*' (see the examples of evolutionary curves presented below, starting from Fig. 1). It contains *two components*:

a) *long-range trend* which is usually in general *growing,* but sometimes has a hill-like form;

b) some *short-range waves* — increasing and decreasing fragments against the background of this trend; namely these deviations from trend, should become the object of our empirical investigation focused on the intensity of creative activity.

Several words about the roots of the *long-range trend* (a). It always contains a growing constituent which describes the actual growing of creative intensity of the studied branch of art. The hill-like form may appear because of the impact, *superposition of two* quite obvious *factors*:

— the *decay of the interest* (of experts which compiled the encyclopedia) in *composers (painters, dramatists' etc.) of* more and more *remote eras*; due to this factor, the indicator of intensity – for rather remote epochs – should *show increasing with time*;

— *decreasing evaluation of contemporary composers (painters, etc.)*, because for the compilers of the encyclopedia, now it is still difficult to forecast which composers will become 'classics' of music, which creative achievements will become prospective, and therefore deserve a wordy description; due to this factor, the indicator of intensity – for the contemporary temporal diapason – should *decrease with time*.

The *superposition* of these two tendencies may result in the *hill-like behavior of the* long-range trend. These growing- and hill-like kinds of behavior embrace time diapason of several centuries.

In our further analysis we shall calculate and then eliminate this trend. The main object of our interest will be exactly *short-range waves* (b) which are observed against the background of the long-range trend. Evidently, such changes, if they are more or less *regular*, cannot be ascribed to any artifact. They characterize the *'genuine' changeability* of artistic creativity.

So, on the basis of such evolutionary curves it is senseless to study long-range processes with time constants greater then 100 years (at least without resorting to the help of certain complicated procedures), but it is possible to examine some *'fast' processes*, having time constants of about decades, e.g., 30-100 years. Beside, the time constants, which characterize the above mentioned periodical changeability of the style of creativity (it is connected with alternating left- and right-hemispherical prevalence), are about 40-50 years.

During last two decades, appropriate investigations were fulfilled dealing with the *intensity of creativity* in different arts: *literature* (Kharuto, Mazhul, & Petrov, 2000; Mazhul &

Petrov, 2002, 2004; Petrov, 2002, 2006; Petrov & Mazhul, 1998, 2002; Petrov & Tomassoni, 1998; Koptsik, Ryzhov, & Petrov, 2004); *music* (Kulichkin, 2004, 2004b, 2004c, 2004d, 2006, 2006a, 2007; Kulichkin & Tolstunova, 2004, 2005, 2006; Kharuto, Kulichkin, & Petrov, 2006); *painting* (Kulichkin, 2004d; Kulichkin & Tolstunova, 2004, 2005; Kharuto, Kulichkin, & Petrov, 2006), *theatre* (Kovalenko, 2006, 2006a; Kharuto & Kovalenko, 2006), and *playwrighting* (Kovalenko, 2006; Kovalenko & Kharuto, 2006). Moreover, some of such evolutionary dependences were used for quantitative estimations of the 'free will' of outstanding creative persons (Mazhul, Melamid, & Petrov, 2005; Mazhul & Petrov, 2007), as well as for singling out the greatest creative persons (Kulichkin, 2004d, 2007).

So, such studies became rather ordinary in quantitative investigations of artistic evolution. In the present paper we shall be focused on the problem of *temporal relations* between the intensity waves of artistic life in different kinds of art, as well as in different cultural regions. We shall start from the procedure of measurements used in the present investigation.

2. Measuring the intensity: primary empirical data

In the present investigation we used the following literary sources:

– for musical creativity – Grove's dictionary of music and musicians, in 10 volumes (Grove, 1954); in total 377597 lines were involved, relating to 5982 European composers representing 40 national schools of music;

– for creativity in painting – Ioganson' encyclopedia in 5 volumes (Ioganson, 1962-1981); 20952 lines devoted to 867 European painters, 19 national schools;

– for theatre – Encyclopedia of theatre (1961-1967) in 5 volumes; 16745 lines devoted to 737 West European actors, producers, critics, etc., and 60066 lines devoted to 2004 Russian actors, producers, critics, etc., involving in total 9 national schools;

– for playwrighting – again Encyclopedia of theatre (1961-1967); 20784 lines devoted to 580 West European playwrights and 15441 lines devoted to 412 Russian playwrights, involving in total 10 national schools.

In each case a *comparative analysis* of two or three different sources was undertaken, in order to prove whether the main source chosen is 'objective' in relation to the attention paid to different creative persons. For instance, the main source for the investigation devoted to persons of theatre (actors, producers, critics, etc.), consisted of five volumes. Persons described in each volume, were ranked in accordance with the lengths of their descriptions. Then each of these five hierarchies was compared with the hierarchy of the same persons in another encyclopedia

(Russian dramatic theatre, 2001), and Spearman coefficient of rank correlation for each pair of hierarchies was calculated; its values occurred varying from *.59* to *.92*. Finally, each of five initial hierarchies (from the main source) was compared with the appropriate hierarchy of the same persons in the third source (World of Russian culture, 1997), and the coefficients of correlation occurred varying from *.53* to *.71*. All these coefficients are statistically significant at the level better than 5%. As far as all the hierarchies examined occurred statistically identical, our main source may be considered as rather representative and reliable. That is why this main five-volume encyclopedia was chosen as the sole source of the primary data concerning persons of theatre. Quite similar checking was made for persons in other creative spheres.

It is worth noting that sometimes when comparing hierarchies of creative persons built on the basis of different encyclopedic sources, we ran with their bad agreement (low correlation), caused by different national orientation of compilers of these encyclopedias. [Evidently, compilers of Western musical encyclopedias devote much more attention, e.g., to Bach and Mozart, and neglect Tchaikovsky and Glinka, whereas these two Russian composers are highly evaluated by compilers of Russian encyclopedias.] To eliminate this effect, it occurred necessary to compare separately hierarchies of creative persons belonging to the same national school (for instance, to compare the hierarchies of Russian composers built on the data in Western encyclopedia and in Russian one). Then these hierarchies *always* occurred statistically *identical* (revealing high correlation, see also: Kulichkin, 2004d; Kulichkin, Tolstunova, & Petrov, 2002). This fact also evidence in favor of rather ‘objective’ character of each main source chosen for the investigation.

Then the data concerning creative persons in each sphere, were *aggregated* to characterize certain temporal segments, in accordance with the years of birth of these persons. As a rule, 5-year and 10-year temporal segments were used. The last ones are presented in Appendices A and B, together with observed intensities of creativity in the fields of theatre, playwriting, music, and painting. Here rather rough ‘geographic division’ is used: into creative persons of West European culture and Russian one (though separate analysis for various national schools of theatre and playwrighting was also undertaken, as well as national schools in music and painting). Analogous primary data for West European and Russian music though presented in more detailed form, can be seen in: Kulichkin, 2004d.

3. Processing primary data: in search for ways to eliminate long-range trends and too fast oscillations

Our investigation was focused on *two main aims*:

– to observe character of the *behavior* of the intensity in different spheres of creative activity in different cultural regions (all the studied curves reveal *periodical components*);

– to study temporal relations between these observed periodical processes, both for different spheres of creative activity and different cultural regions. In order to find *synchronism / asynchronism* and statistical links between various pairs of intensity curves, we'll calculate the Pearson's *cross-correlation* functions.

Both aims require, first of all, to *eliminate* the above mentioned long-range *trends* inherent in each evolutionary curve built on the basis of the above primary data. It is especially important for the second aim: evidently, without eliminating the long-range trends, we may obtain so-called 'false relation', caused not by links between our periodical processes, but simply by the artifact: similar forms of prevalent growing trends, against the background of which the periodical oscillations take place. That is why the first step in the processing primary empirical data was the elimination of these long-range trends.

There exist various ways to calculate the trend. In our investigation we resorted to the help of *polynomial approximation* of each trend curve with the use of minimal mean square error criteria (see also Kharuto, 2006).

Decomposition of any evolutionary curve into two components, 'trend part' and 'oscillating part,' means a presentation of this curve by the model:

$$Y(t) = F_{tr}(t) + F_{osc}(t),$$

where $F_{tr}(t)$ is the trend function, and $F_{osc}(t)$ is the 'oscillating part.'

The 'trend part' $F_{tr}(t)$ should represent slow-varying 'mean line' of the evolutionary curve, which will be described as a polynomial of degree *'N'*:

$$F_{tr}(t) = b_0 + b_1 \times t + b_2 \times t^2 + b_3 \times t^3 + \ldots + b_N \times t^N;$$

$b_0, ba_1, b_2, \ldots b_N$ being constant coefficients.

The simplest trend form is a straight line ($N = 1$). The next one is the quadratic parabola ($N = 2$), a more complex trend line is the 3rd power parabola and so on. As it is well-known, increasing of the polynomial power N will cause better and better coincidence of empirical and approximating curves and, therefore, *decreasing* of mean square error, $\varepsilon(N)$.

The 'oscillating part' of $Y(t)$ can be presented as a sum of trigonometric functions:

$$F_{osc}(t) = a_1 \times \sin(\omega_1 t + \varphi_1) + a_2 \times \sin(\omega_2 t + \varphi_2) + \ldots + a_M \times \sin(\omega_M t + \varphi_M),$$

where $a_1, a_2, \ldots a_M$ are the amplitudes of oscillating components, $\omega_1, \omega_2, \ldots \omega_M$ — its frequencies, and $\varphi_1, \varphi_2, \ldots \varphi_M$ — phases of sinusoidal oscillations.

Parameters $a_1, a_2, \ldots a_M$ relating to the frequency points $\omega_1, \omega_2, \ldots \omega_M$ are responsible for the *spectrum* of 'oscillating part' $F_{osc}(t)$. In case of strong periodical function $F_{osc}(t)$, spectrum will contain a set of components with frequencies $\omega_1, 2\times\omega_1, 3\times\omega_1$ and so on — the well-known Fourier row. If the period is T_p, the 'fundamental' frequency of oscillations ω_1 will be equal to $2\pi/T_p$. In more complex cases (many oscillating components with different periods), spectrum will contain a set of such rows.

The main goal of our investigation is to study the '*oscillating part*', which should be detached from the 'trend part' of the empirical curve. In order to make the separation, we have firstly to calculate a polynomial approximation of the trend line with the given power N, and then to subtract the trend curve from the empirical one (this pair of operations will be named 'centering'). For every given N we'll get a certain set of trend polynomial coefficients $b_0, b_1, b_2, \ldots b_N$ and an appropriate value of $\varepsilon(N)$. The oscillating part $F_{osc}(t)$, which is equal to the difference $Y(t)-F_{tr}(t)$, changes in dependence of N. Let's note, that the parameters of its spectrum, $a_1, a_2, \ldots a_M$ and $\omega_1, \omega_2, \ldots \omega_M$, depend also from N. The question is, *what* power, i.e., the value of N must be chosen, what trend is 'genuine'?

We may expect that in all the cases trend curves vary *much slower* then the 'oscillation parts,' and in a certain range of N, the error values $\varepsilon(N)$ and the sets of spectrum parameters will become *relatively stable*. In this range, the polynomial power N will be high enough to provide a precise approximation of the 'true' mean line of the evolutionary curve, but not high enough to represent high-speed changes of oscillating components.

Our investigation based on empirical data relating to the intensity of creativity in Russian and West European music, painting and theatre showed that the above 'stability interval' *does really exist* for each curve. For example, on Fig. 1, the evolutionary curves for West European 'painting intensity' and some variants of trend evaluation are shown. Fig. 1a corresponds to primary data with the trend model like quadratic parabola ($N = 2$). On Fig. 1b, the trend for $N = 7$ is shown (this is the beginning of the stability interval).

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Insert Figure 1

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Fig. 2a presents the dependence of mean square approximation error $\varepsilon(N)$ for the same primary curve and N from 1 to 9. On Fig. 2b, the tracks of spectral peak positions are shown in dependence of N. (As it was shown above, the form of 'oscillating part' of evolutionary curve

varies in dependence of *N*. Therefore, the spectrum of the curve will be changed also. For every value of *'N'*, a table of positions of pronounced spectral peaks have been compiled, and Fig. 2b is the graphical representation of this table. The parameter 'T_p' on Fig. 2b is the period of oscillations corresponding to spectral peak on frequency $\omega = 2\pi/T_p$.)

The study of $\varepsilon(N)$ on Fig. 2a shows that the increasing of *N* after $N = 4$ does not cause significant variety of the error value, but spectral peak positions on Fig. 2b become stabile only after $N = 7$. In this case, we use as the trend model a polynomial of the 7th power.

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Insert Figure 2
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The second problem when preparing primary data for the study, is the presence of *'too fast' oscillations* commensurable with the size of primary temporal segments used. The maximal oscillation frequency, which can be represented with a step of Δt, is (according to the Kotelnikov-Nyquist-Shannon sampling theorem) $1/(2\times\Delta t)$. Appropriate low-frequency filtration can help avoiding the influence of higher frequencies, which deform the spectrum (this fact is predicted by the same theorem). This task was solved by means of '*smoothing*' of each curve in time domain with the use of triangle weight function. The effective width of this function (smoothing time) was chosen about $\tau = 37$ years, because the periods to be studied are not less than 40–50 years. All the needed procedures of polynomial approximation, centering and smoothing, and also spectrum analysis were realized with the help of a special computer program '*Waves_Ex*' (Waves Examination) derived by Dr. Alexander Kharuto.

4. Intensity of creativity: evolution of West European art

In our investigation, we studied and compared evolutionary curves for Russian and West-European intensity of creativity on the fields of music, painting, theatre, and playwriting. All these curves, before to be compared and examined on synchronism, were processed by means of the above mentioned procedures. Firstly, the (minimal) polynomial power *N* for the trend model was determined, which belongs to 'stability interval' of $\varepsilon(N)$ and spectral peak positions. Then, the curve was centered according to this trend model. The third step was the triangle smoothing using the time interval τ not less than 35 years.

On Fig. 2c, the evolutionary curve for West European 'painting intensity' is shown after centering (for the trend with polynomial degree $N = 7$) and smoothing ($\tau = 37$ *years*).

Fig. 2d represents the spectrum of this curve (vertical axis: amplitude of oscillations; horizontal axis: frequency $f = 1/Tp$). Even at the first glance, this curve reveals rather featured

periodical behavior. Spectral peaks are strongly pronounced, which evidences in favor of the existence of periodical components in the curve, but peak positions on the frequency axis do not form arithmetic progression; this means that the evolutionary curve contains oscillations caused by *several independent sources* — 'socio-cultural clockworks'. (The most powerful spectral peaks are marked with appropriate values of oscillation periods T_p and relative amplitudes A_m.)

The evolution of West European 'music intensity' is shown on Fig. 3a, and Fig. 3b presents its spectrum. (The first-step processing parameters are the same: $N = 7$, $\tau = 37.5$.) Spectrum peaks positions on frequency axis are strongly pronounced, but not equidistant. This evidences in favor of several asynchronous sources of oscillations.

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Insert Figure 3
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On Fig. 4, the mutual Pearson-correlation between West-European intensity of creativity in music and painting is shown. Oscillation of the correlation function is caused by oscillations in both compared curves. Maximal correlation coefficient is *.56* (for time shift *–200* years). Fading of this oscillation may be explained as the interaction of two source oscillations with very close frequencies (periods) values. In this case, cross-correlation function will have a character of harmonic beating. [The problem of such harmonic beatings is theoretically analyzed in Appendix C.] Mean distance between correlation function extremums is *108.3* years. This period corresponds to main spectral peaks on Fig. 2d, where $T_p = 107$ years, and on Fig. 3b with its $T_p = 109$ years. The maximum at $T_s = 10$ years indicates the lag of 'music curve' against the 'painting curve,' with moderate value of the correlation coefficient (*.33*).

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Insert Figure 4
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The intensity of creativity in West-European theatre (excluding playwrighting) is shown by Fig. 5a. For this curve, the threshold of spectrum stability is the power value $N = 7$. (Mean square deviation is stable after $N = 7$.) Eliminating the trend and smoothing with $\tau = 37.5$ years gives the curve representation shown by Fig. 5b. The main spectral peaks for this curve are indicative of the presence of oscillating components with periods $T_p = 76.6$ years (relative amplitude $A_m = 1$), *49* years ($A_m = 0.57$) and *133* years ($A_m = 0.52$).

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Insert Figure 5
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The next field of artistic life, which also has been studied in our investigation, is the intensity of playwrighting. The evolutionary curve (primary data) is shown on Fig. 6a, and the same curve after trend elimination ($N = 7$) and smoothing (triangle weight function, $\tau = 37.5$

years) — on Fig. 6b. The main spectrum peaks respond to periods of oscillations $T_p = 74.5$ years (maximal amplitude A_m), $T_p = 50$ years ($A_m = .98$), $T_p = 60$ and $T_p = 96$ years ($A_m = .82$), $T_p = 143$ ($A_m = .67$), $T_p = 38$ ($A_m = .54$).

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Insert Figure 6
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Comparing 'oscillating parts' of 'theatre life intensity' and 'playwrighting intensity' shown by Fig. 5b and Fig. 6b, we get mutual correlation function with complex oscillating character presented by Fig. 7a. The maximal correlation is observed at time shifts $T_s = -10$ years (.63) and $T_s = -40$ years (–.57). The first point means *outstripping* of 'playwrighting intensity' curve in relation to the 'theatre life intensity' curve on *10* years and high correlation between these two branches of artistic life.

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Insert Figure 7
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Comparing music-, painting- and theatre intensities for West-Europe, we come to the following results (for the time interval 1470–1910, where music- and painting- intensity have been measured, time step $\Delta t = 10$ years). On Fig. 7b, mutual correlation function between music- and theatre- intensity of creativity is shown. The correlation function has oscillating character with mean period of *72.5* years, which may be the harmonic beating frequency between main oscillation component in theatre evolution curve ($T_p = 76.6$) and the second-order component of music intensity curve with $T_p = 68.4$ years and relative amplitude *0.82*. The maximum at $T_s = -20$ years is indicative of *outstripping* of 'music waves' against 'theatre waves' with moderate correlation (.31).

Fig. 7c presents mutual correlation between 'painting intensity' and 'theatre intensity.' This correlation function is very low (less then .16) inside the time shift intervals ±*50* years and begins to oscillate (with amplitude about .4) only outside this interval. The maximal values of the correlation between painting and playwrighting and between music and playwrighting (appropriate curves are not presented) seem to be rather high: .52 and .51, respectively.

5. Intensity of creativity: evolution of Russian art

On Fig. 8a, the intensities of creativity for Russian music (above) and painting (below) are presented, together with their trends ($N = 6$ for both curves). Each curve shows rather featured oscillating component; spectral analysis of these dependences comes to the main periods of *52* and *45* years, for music and painting, respectively. The correlation function between Russian

music and painting intensity (after centering and smoothing of both curves with $\tau = 37.5$ years) is presented by Fig. 8b. (The variable T_s is the time shift between evolutionary curves to be compared.) The oscillating character of correlation function is alike the West-European music- and painting- correlation, but the (mean) period is $T_p = 46.7$ years, which corresponds to the spectrum peak (only one) for Russian music with its *52.26*-year period and that of Russian painting, which main spectrum peak points to oscillation period $T_p = 45.28$ years. The maximum at $T_s = 0$ means *near to synchronous* waves of music- and painting- intensity on the studied time interval (1740–1910) with high correlation coefficient (*.75*).

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Insert Figure 8
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Russian 'theatre life intensity' is presented (with a step $\Delta t = 5$ years) by Fig. 9a. Using the polynomial trend model with the highest power $N = 9$ and smoothing with $\tau = 37.5$ years, we get the oscillating part of the evolution curve shown on Fig. 9b. The appropriate spectrum function is shown on Fig. 9c. The main peaks of it corresponds with oscillating components with periods $T_p = 43.36$ years (maximal amplitude), $T_p = 62.3$ ($A_m = .81$) and $T_p = 29.6$ ($A_m = .34$).

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Insert Figure 9
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The primary evolutionary curve for the intensity of creativity of Russian playwrighting is shown on Fig. 10a. The same curve after centering and smoothing is shown on Fig. 10b, and the spectrum of this curve on Fig. 10c. Main spectral peaks accord with oscillating components possessing periods and amplitudes $T_p = 74.47$ years (maximal amplitude), $T_p = 52.4$ ($A_m = .7$), $T_p = 39.9$ ($A_m = .54$) and $T_p = 29$ ($A_m = .18$).

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Insert Figure 10
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On Fig. 11a, mutual correlation function between Russian 'theatre life intensity' and 'playwrighting intensity' is shown. This function has oscillating 'harmonic-beating' character with mean period *42.5* years. Maximal correlation (*.76*) appears at $T_s = -45$ years, but the next maximum lies at zero time shift (correlation coefficient *.44*).

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Insert Figure 11
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Cross-correlations between intensity of creativity in different branches of Russian artistic life are shown on Fig. 11b–e. All the correlation functions are of *oscillating type* with varying periods from *30* to *50* years and high correlation coefficients (*.77 – .80*). The calculations were

possible in time interval 1740–1900 years (17 points with the step $\Delta t = 10$ years), where all the evolution curves have been represented.

Mutual correlation between Russian 'theatre life intensity' and 'music intensity' (Fig. 11b) shows *conterphase* oscillations of evolution curves; the maximum correlation coefficient being *.86* at $T_s = 20$ years.

The cross-correlation function for Russian 'theatre life intensity' and 'painting intensity' (Fig. 11c) shows *lateness* of 'theatre intensity' against the 'painting intensity' on *10* years with the correlation coefficient about *.73 – .78*.

Mutual correlation of Russian 'playwrighting intensity' and 'music intensity' is shown on Fig. 11d. This function discovers *conterphase* oscillations of two intensities with the period *40* years and correlation coefficient – *.80*.

At last, the cross-correlation between Russian 'playwright intensity' and 'painting intensity' is shown on Fig. 11e. This function also reveals *conterphase* oscillations of two intensities; the period of oscillations being *40* years and correlation coefficient – *.77*.

Finally, let us *compare* the artistic creativity in *Russia and West Europe*, in order to estimate quantitatively the impact of international communications (between these two regions) into the artistic life. On Fig. 12a–d, the appropriate cross-correlation functions are shown. All the functions have oscillating character with periods about 40-50 years and different maximums of correlation coefficients.

Mutual correlation of Russian and West European 'music intensity' presented on Fig. 12a shows high correlation coefficient (± *.72*) and period of oscillations *40–50* years. At zero time shift ($T_s = 0$), the source curves are in counterphase, but at the time shift *20* years (½ of period) the correlation coefficient becomes positive *(+ .72*). This means *20*-year *lateness* of Russian 'music intensity' curve against West European one.

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Insert Figure 12

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Comparison of Russian and European 'painting intensity' gives the cross-correlation function shown on Fig. 12b. This function discover *relative low* degree of correlation between two evolution curves (we should remind that only oscillating parts of evolutionary curves are compared). The *lateness* of Russian 'painting intensity' against the European is about *10* years, and the correlation coefficient *.38* (maximal absolute value – *.40*).

The mutual correlation between Russian and European 'theatre intensity' shown on Fig. 12c, possesses oscillating (harmonics-beating) character with period *45–60* years and

relative high correlation coefficients about *.65*. This function shows *outstripping* of Russian 'theatre intensity' curve of about 15 years (or *lateness* on *45* years).

Comparison of Russian and European 'playwright intensity' (Fig. 12d) shows very high correlation coefficient (from – *.88* to + *.82*), which means their coordinated evolution. The period is approximately *50* years, and the possible 'Russian outstripping' is about *5* years.

6. Discussion

The most important result of the investigation is the quantitative confirmation of real *existence of periodical processes* in all the fields of creative activity considered. The main spectral peaks observed respond to the following periods:

– in painting – *107* years for West Europe and *45* years for Russia;

– in music – *109* years for West Europe and *52* years for Russia;

– in theatre – *77* years for West Europe and *43* years for Russia;

– in playwrighting – *75* years for West Europe and *74* years for Russia.

These values show certain disagreement with about 50-year periodicity in the stylistic evolution of art, meaning the above mentioned periodical switches between left- and right-hemispheric waves. Netherless, exactly oscillations with periods of several decades are *typical* for various kinds of stylistic changes observed in '*high arts*' (see, e.g., Martindale, 2007).

As well, very interesting are the results concerning *internal links* within each cultural regions considered. Tables 1 and 2 present the values of maximal correlation coefficients (i.e., their maximal absolute values) observed for the links between different kinds of creative activity in West Europe and Russia, respectively.

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Insert Tables 1 and 2
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One can easily see that West European region is characterized by not very strong links (varying in the range from *.43* to *.63*), whereas in Russia these *links are much stronger* (from *.75* to *.86*), average values being *.51* and *.79*, respectively. (The coefficients presented respond to two diapasons of values, without any overlapping.) Of course, there may be various reasons capable of causing such a difference (for instance, the heterogeneity of West European cultural region). However, another interpretation seems to be possible, dealing with rather *'synthetic' character of Russian national culture* (see, e.g., Berdyaeyv, 1909). Within each cultural region, its cultural life looks like a certain *entity*, possessing rather pronounced internal links.

As for *cross-cultural interactions*, we observe their rather featured impact in the evolution of Russian artistic life: appropriate correlation coefficients occur rather high (absolute values from *.40* to *.88*). As a rule (and this regularity has been mentioned in our early investigations which dealt with stylistic features), Russian artistic life shows lateness in relation to West European one. However, to corroborate this conclusion, it is desirable to realize the comparison of waves of intensity with stylistic waves in both cultural regions.

In general, the next step of the investigations in the direction considered, should involve stylistic parameters of art in connection with the changes in the intensity of artistic creativity.

Acknowledgements

The authors wish to express their deep gratitude to Prof. Colin Martindale for numerous fruitful discussions while working on the problems of this paper.

Tables

Table 1. Links between different fields of creative activity: West European artistic life, maximal absolute values of the correlation

Field of creative activity	Painting	Music	Theatre	Playwrighting
Painting	1.00	.56	.43	.52
Music		1.00	.44	.51
Theatre			1.00	.63
Playwrighting				1.00

Table 2. Links between different fields of creative activity: Russian artistic life, maximal absolute values of the correlation

Field of creative activity	Painting	Music	Theatre	Playwrighting
Painting	1.00	.75	.78	.77
Music		1.00	.86	.80
Theatre			1.00	.76
Playwrighting				1.00

Appendixes

Appendix A. Intensity of artistic creativity, West Europe: persons of theatre, dramatists, music (composers) and painters (number of lines in encyclopedia, devoted to persons born during 10 years)

Years of birth	Persons of theatre	Playwright	Music (composers)	Painting
1480	76	46	61	276
1490	41	129	436	76
1500	62	124	134	64
1510	76	98	844	106
1520	0	36	3727	54
1530	44	112	1035	0
1540	48	112	1235	0
1550	72	218	2076	15
1560	696	1164	3866	48
1570	207	303	1971	81
1580	105	431	3354	26
1590	123	123	1137	201
1600	91	443	1581	103
1610	316	356	597	138
1620	504	192	1785	19
1630	36	133	1983	0
1640	517	290	1673	6
1650	116	85	2302	47
1660	169	139	5709	37
1670	76	158	2950	0
1680	157	177	11746	130
1690	127	513	3720	142
1700	383	146	2316	97
1710	851	761	6375	58
1720	651	540	3913	101
1730	609	329	12285	83
1740	185	142	5339	51
1750	530	747	14036	125
1760	730	882	4753	49
1770	410	450	14338	117
1780	530	477	8074	138
1790	725	706	13357	211
1800	1203	887	9585	294
1810	465	555	17001	330
1820	515	508	5427	207
1830	509	455	9798	321

1840	1082	649	5638	357
1850	783	656	5498	194
1860	1604	1315	12306	430
1870	1771	1100	8873	156
1880	1004	765	6193	503
1890	1701	966	7444	149
1900	1738	881	5495	102
1910	1073	952	1063	103

Appendix B. Intensity of artistic creativity, Russia: persons of theatre, dramatists, music (composers) and painters (number of lines in encyclopedia, devoted to persons born during 10 years)

Years of birth	**Persons of theatre**	**Playwright**	**Music (composers)**	**Painting**
1740	125	214	67	96
1750	315	118	38	136
1760	194	164	37	17
1770	446	223	8	208
1780	381	162	56	183
1790	926	337	117	163
1800	1409	1136	744	128
1810	1442	1126	274	229
1820	2230	1391	678	89
1830	1294	693	3166	576
1840	1479	470	4287	550
1850	2285	171	874	539
1860	3623	968	824	686
1870	4693	1026	1492	1016
1880	6017	1259	2103	1084
1890	8437	1239	1254	675
1900	12077	1742	1298	836
1910	8141	2036	219	398

Appendix C. Mutual correlation of two sinusoidal waves

In order to explain the appearance of ‘harmonics beating’ in cross-correlation functions let’s consider two sinusoidal waves with periods T_1 and T_2 given on finite time interval T ($T>T_1$ and $T>T_2$). The theoretical study of this case gives a bulky formula which includes some members like

$$B(\tau) = B_0 \sin [(\omega_1-\omega_2)/2\times\tau] \times \cos [(\omega 1+\omega 2)/2\times\tau)],$$

where $\omega_1=2\pi/T_1$, $\omega_2=2\pi/T_2$, and B_0 is constant.

Formula members with arguments $[(\omega 1+\omega 2)/2\times\tau)]$ describe oscillations with a 'mean' period

$$T_p = 2(T_1\times T_2)/ (T_1+T_2),$$

which lies between T_1 and T_2.

Formula members with arguments $[(\omega 1-\omega 2)/2\times\tau)]$ describe oscillations with mach more *lower* frequency; the appropriate period is $T_m = 2(T_1\times T_2)/ (T_2-T_1)$. These multipliers produce a kind of harmonic-form *amplitude modulation* of 'high-frequency' oscillation with period T_p, and the period of modulation is $T_m>>T_p$.

On following figures, two examples of pairs of sinusoidal waves and its mutual correlations are shown. Fig. C-1 represents two waves with periods *100* and *95* years, 'measured' on time interval *500* years with the step $\Delta t=5$ years. Fig. C-2 shows mutual correlation of these two waves.

[Insert Fig. C-1]

[Insert Fig. C-2]

In second case, we examine pair of waves with greater difference between wave periods (*100* and *75* years). In this case, cross-correlation function is of the same 'harmonics-beating' type, but with lower correlation coefficients (Fig. C-3).

[Insert Fig.C-3]

Figure captions

Figure 1. West European painting: primary data concerning the evolution of intensity, with trend approximated by a polynomial of the 2nd power (a) and the 7th power (b).

Figure 2. Processing the primary data concerning the intensity of West European painting:

a) Mean square approximation error vs the trend polynomial power.

b) Magnitudes of spectral peaks when using different trend approximations. Different curves relate to peaks ordered according to the power of the approximation (from above to beneath at $N = 1$).

c) The evolutionary curve after centering (trend model: polynomial of the 7th power) and triangle smoothing ($\tau = 37.5$ years).

d) The spectrum of the evolutionary curve. The greatest spectral peaks are marked with their values of oscillation periods T_P and relative amplitudes.

Figure 3. West European musical creativity – evolution of intensity:

a) The evolutionary curve, after centering (trend approximation by a polynomial of the 7th power) and triangle smoothing ($\tau = 37.5$ years).

b) The spectrum of the evolutionary curve.

Figure 4. Mutual Pearson-correlation between the evolutionary dependences describing the intensity of West European music and painting.

Figure 5. Evolution of the creativity in West European theatre:

a) Primary data (representation step $\Delta t = 5$ years).

b) The evolutionary curve after subtracting trend ($N = 7$) and smoothing (triangle weight function, $\tau = 37.5$ years).

Figure 6. Evolution of West European playwrighting:

a) Intensity – primary data.

b) Evolutionary curve after trend elimination and smoothing.

Figure 7. Mutual correlation between West European evolutionary curves describing the intensity of creativity in the fields of:

a) theatre and playwrighting;

b) music and theatre;

c) painting and theatre.

Figure 8. Russian music and painting – comparison of the evolution of the intensity:

a) Primary evolutionary curves for music (above) and painting (below), together with their trends ($N = 6$ for both curves).

b) The cross-correlation function of the evolutionary curves for music and painting.

Figure 9. Russian theatre – intensity of creativity:

a) The primary evolutionary curve, together with trend approximated by a polynomial of the 9^{th} power.

b) The same evolutionary dependence after centering and smoothing.

c) The spectrum of the evolutionary curve.

Figure 10. Russian playwrighting – intensity of creativity:

a) The primary evolutionary curve.

b) The same evolutionary dependence after centering and smoothing.

c) The spectrum of the evolutionary curve.

Figure 11. Mutual correlation between Russian evolutionary curves describing the intensity of creativity in the fields of:

a) theatre and playwrighting;

b) theatre and music;

c) theatre and painting;

d) playwrighting and music;

e) playwrighting and painting.

Figure 12. Mutual correlation between Russian and West European evolutionary dependences describing the intensity of creativity in the fields of:

a) Russian and West European music;

b) Russian and West European painting;

c) Russian and West European theatre;

d) Russian and West European playwrighting.

In Appendix C:

Figure C-1. Two sinusoidal waves with periods 100 years (above) and 95 years (beneath)

Figure C-2. Mutual correlation of two sinusoidal waves shown of Fig. C-1

Fig. C-3. Mutual correlation of two sinusoidal waves with periods 100 and 75 years

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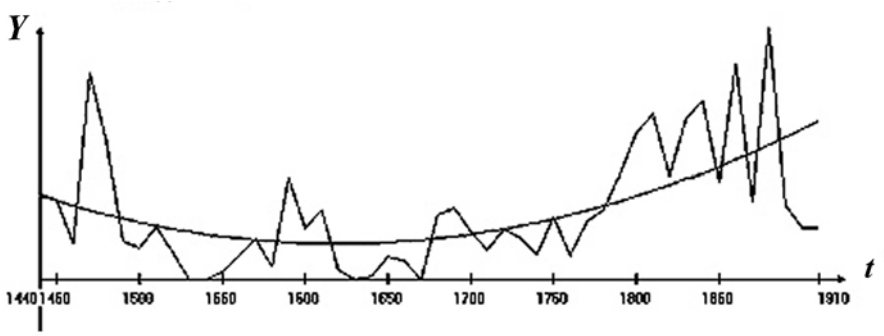
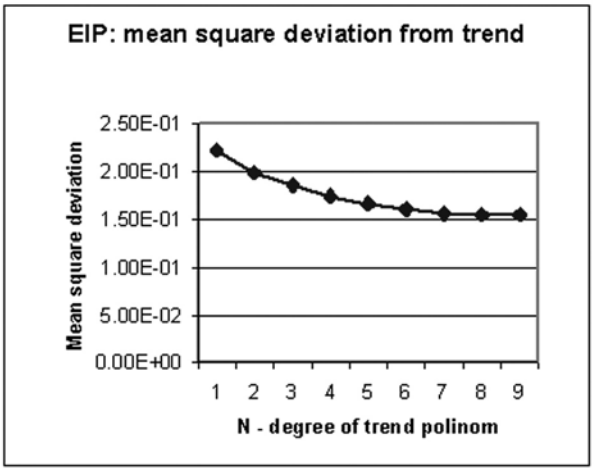


Figure 1a. [Fig1a.jpg]

Figure 1b. [Fig1b.jpg]



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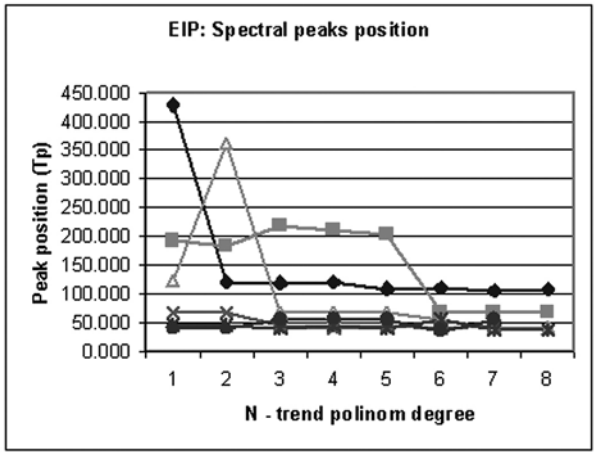

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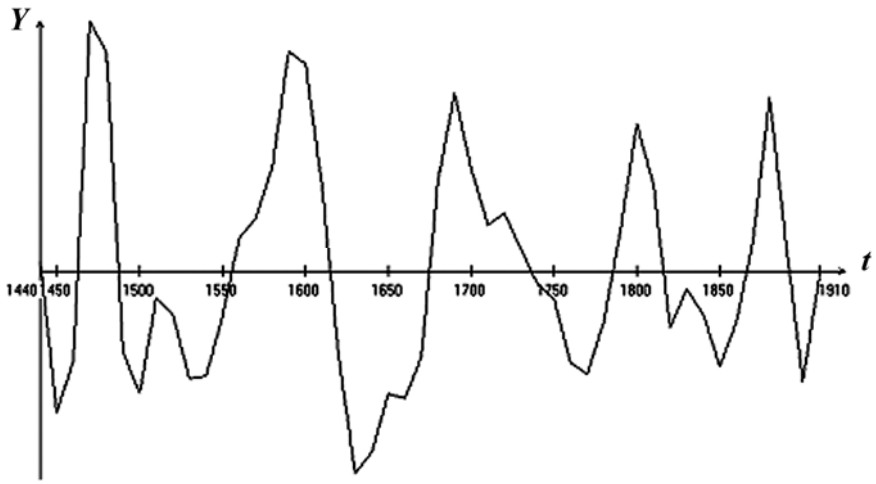
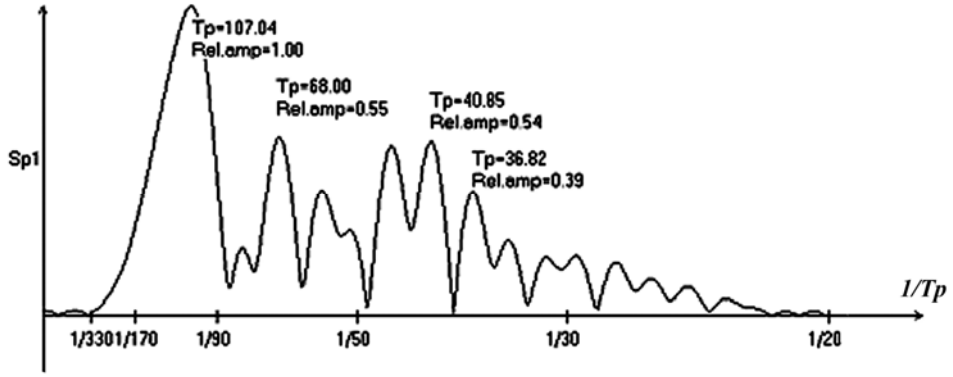


Figure 2c. [Fig2c.jpg]



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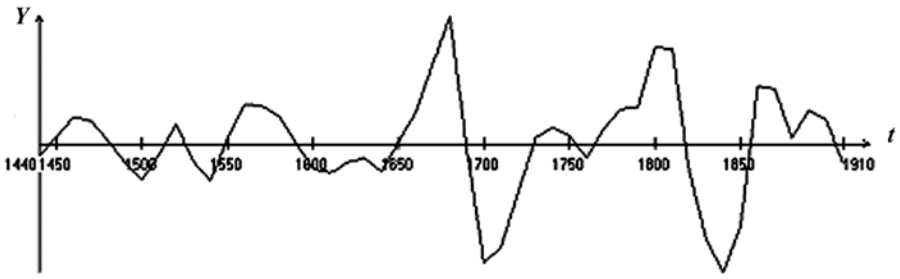


Figure 3a. [Fig3a.jpg]

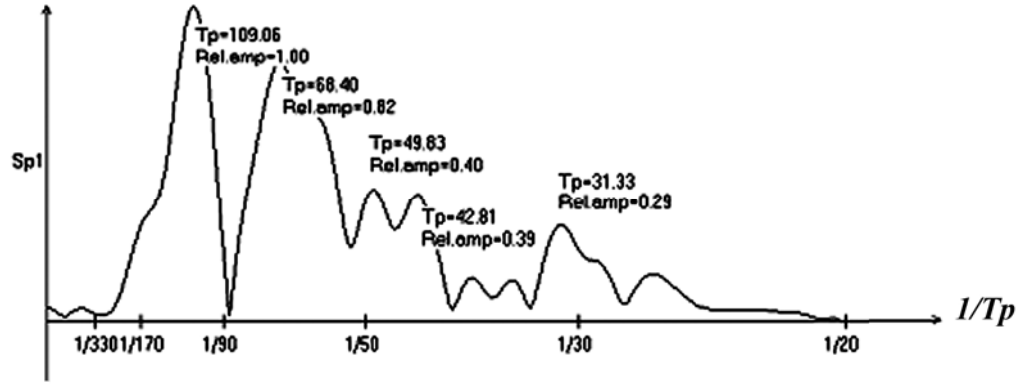


Figure 3b. [Fig3b.jpg]

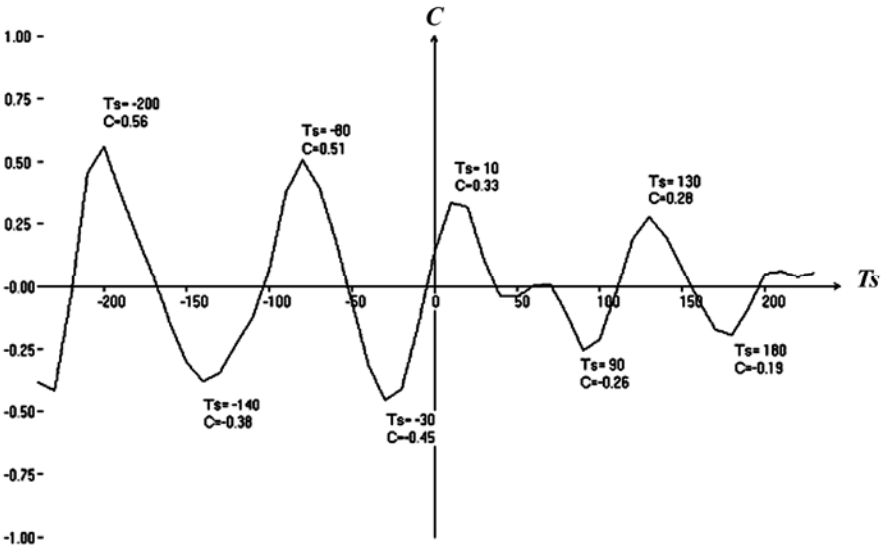


Figure 4. [Fig4.jpg]

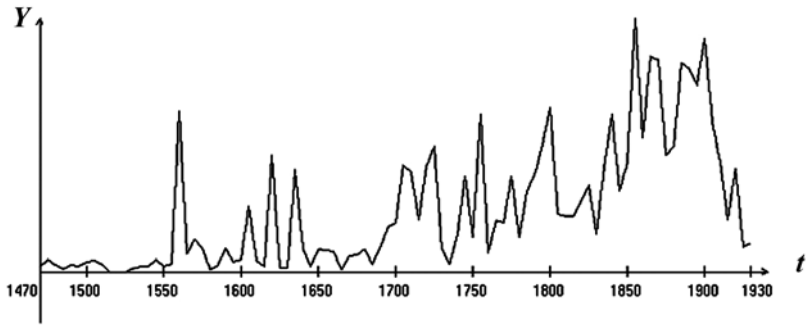
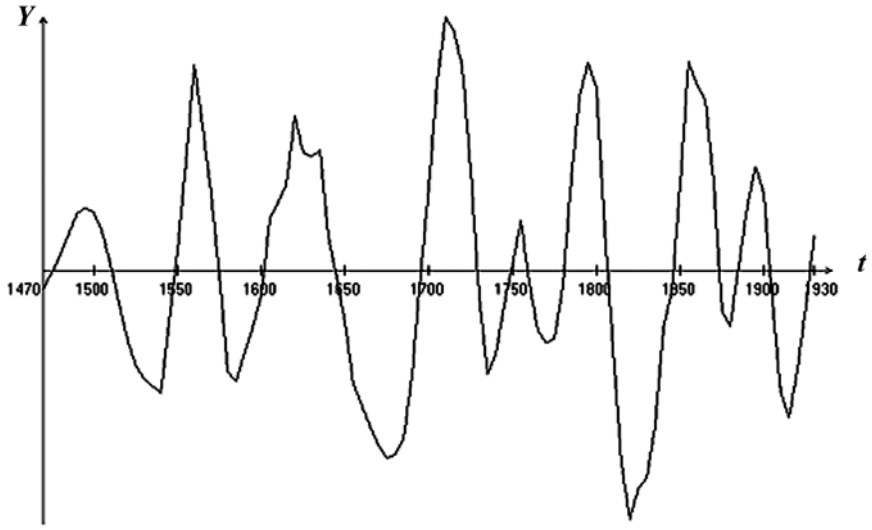


Figure 5a. [Fig5a.jpg]



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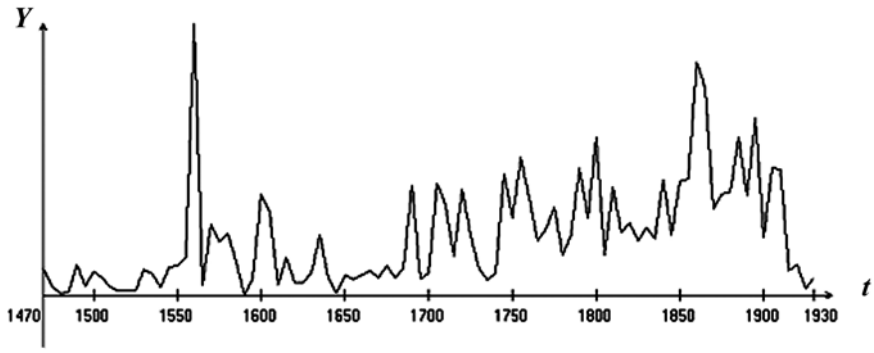
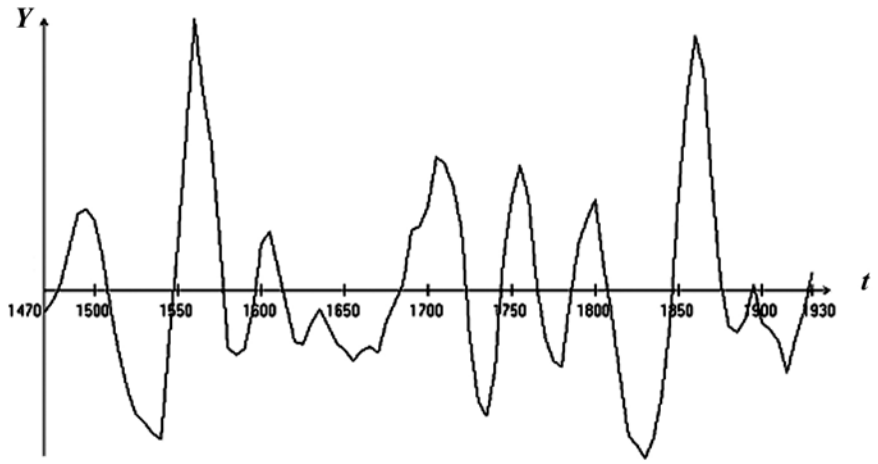


Figure 6a. [Fig6a.jpg]



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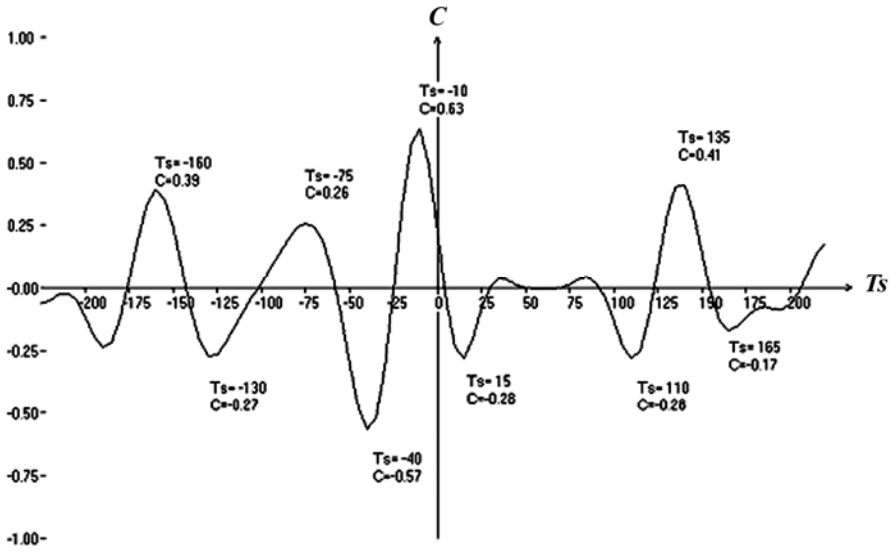
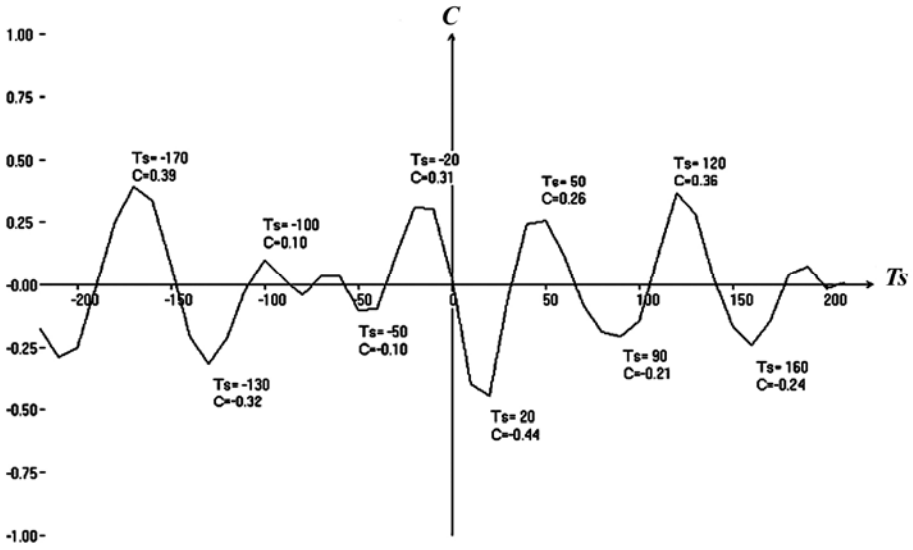


Figure 7a. [Fig7a.jpg]



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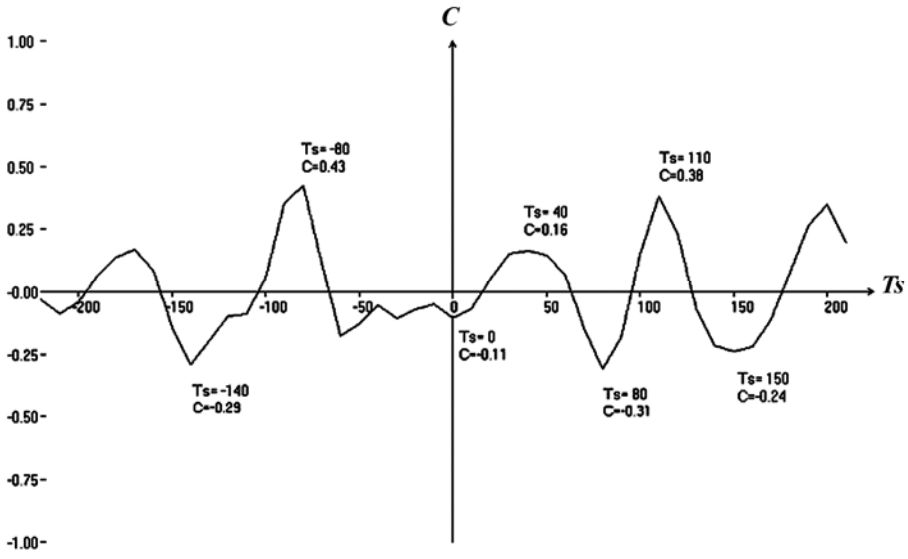


Figure 7c. [Fig7c.jpg]

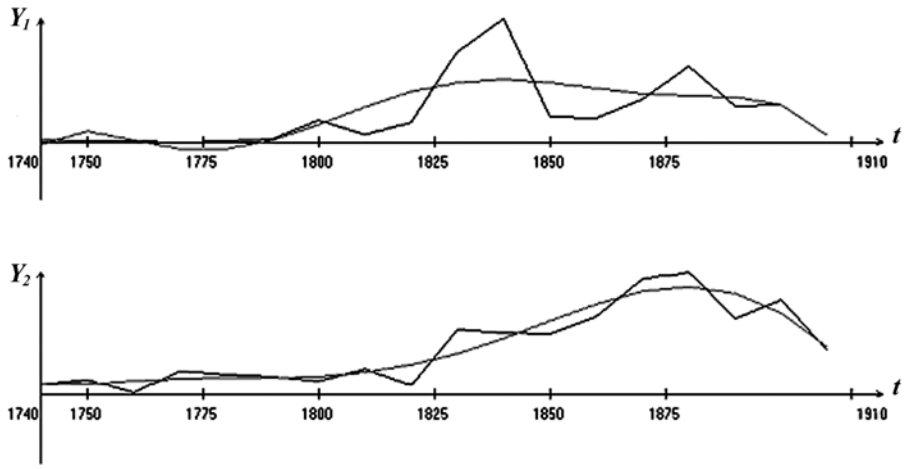
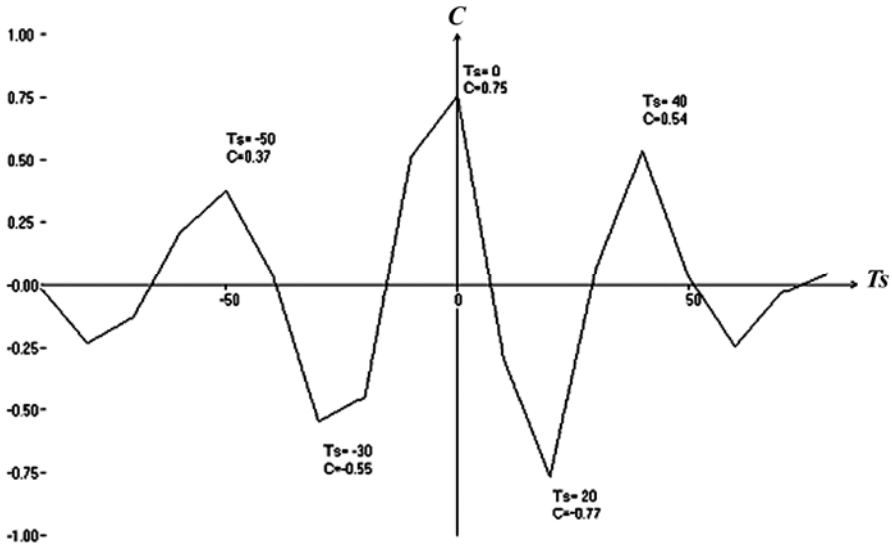


Figure 8a. [Fig8a.jpg]



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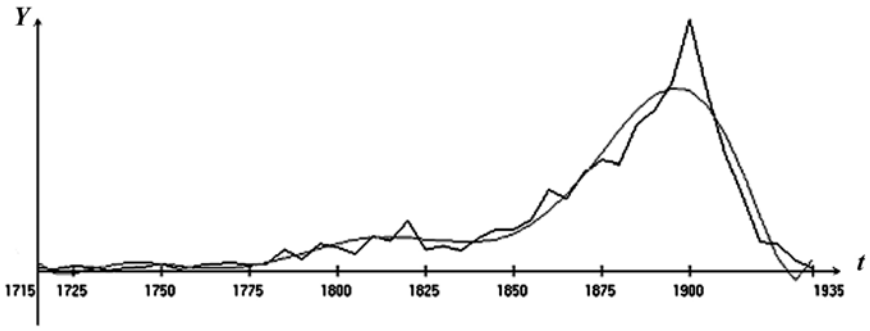
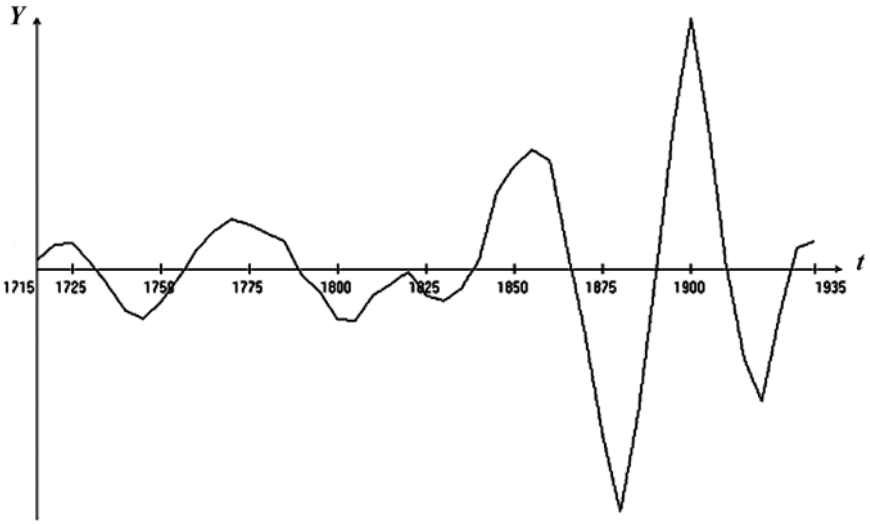


Figure 9a. [Fig9a.jpg]



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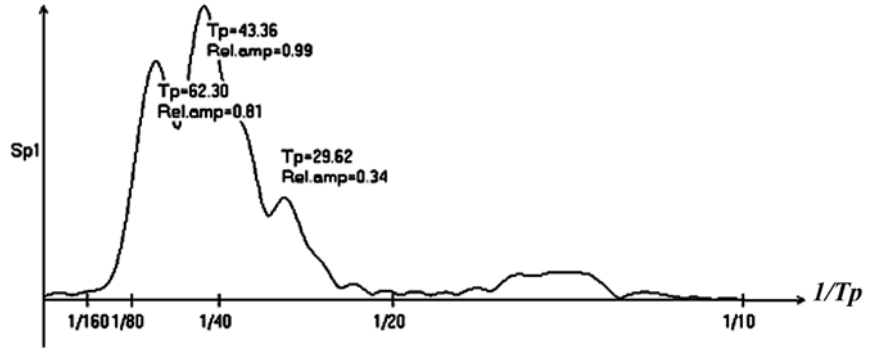

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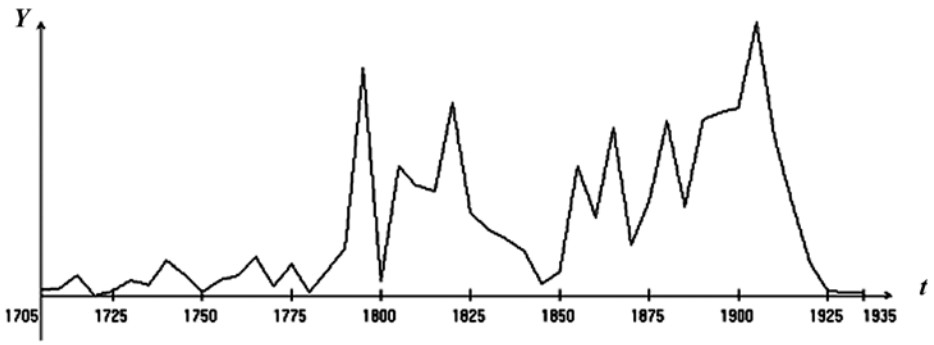


Figure 10a. [Fig10a.jpg]

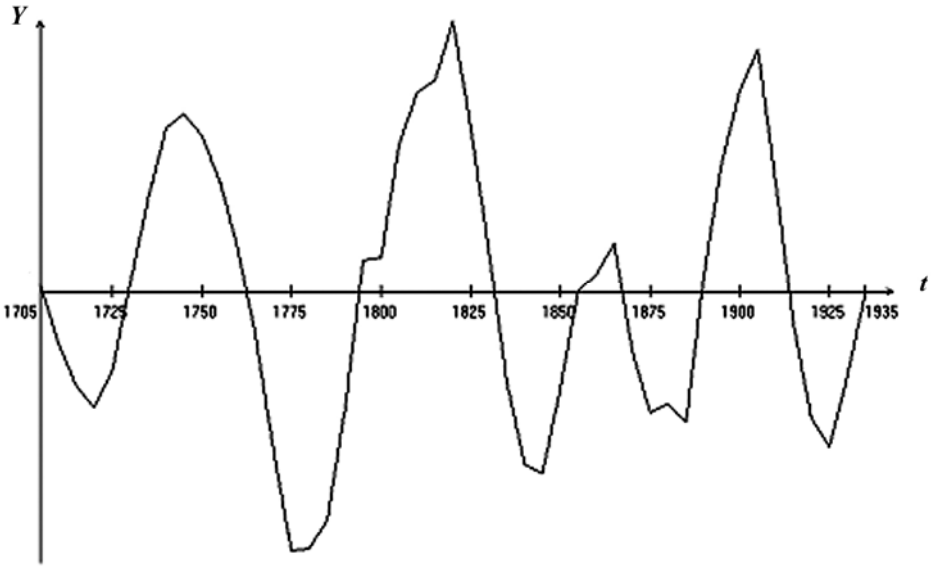


Figure 10b. [Fig10b.jpg]

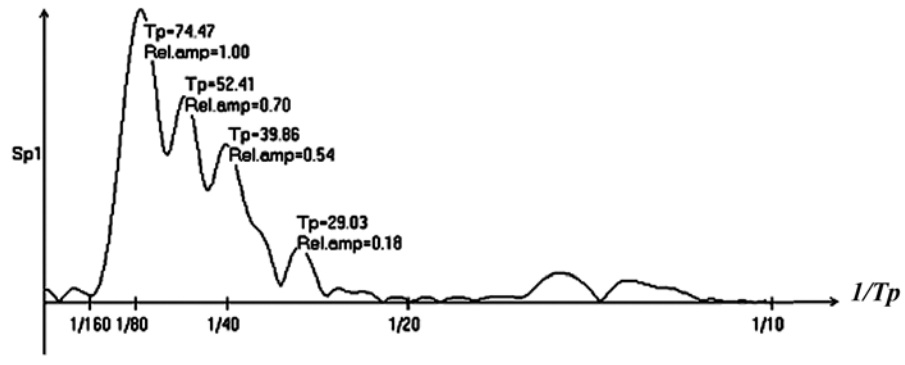


Figure 10c. [Fig10c.jpg]

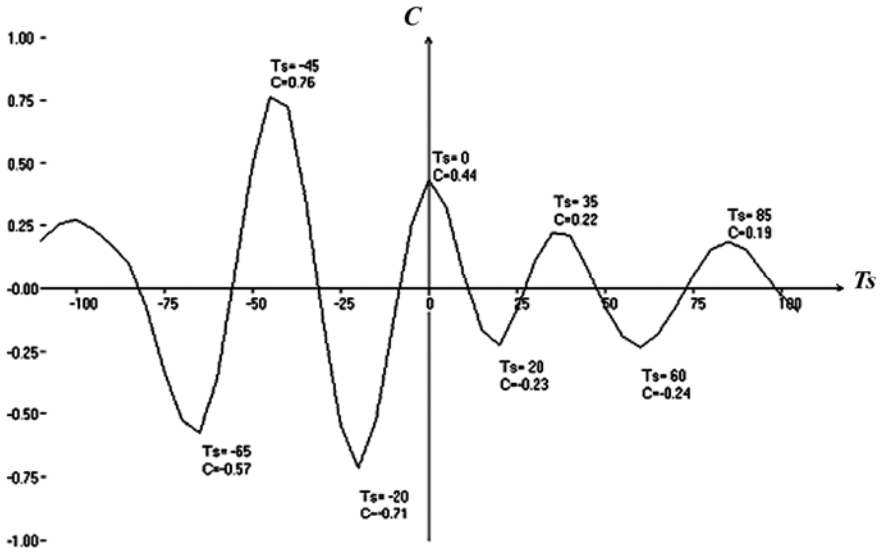
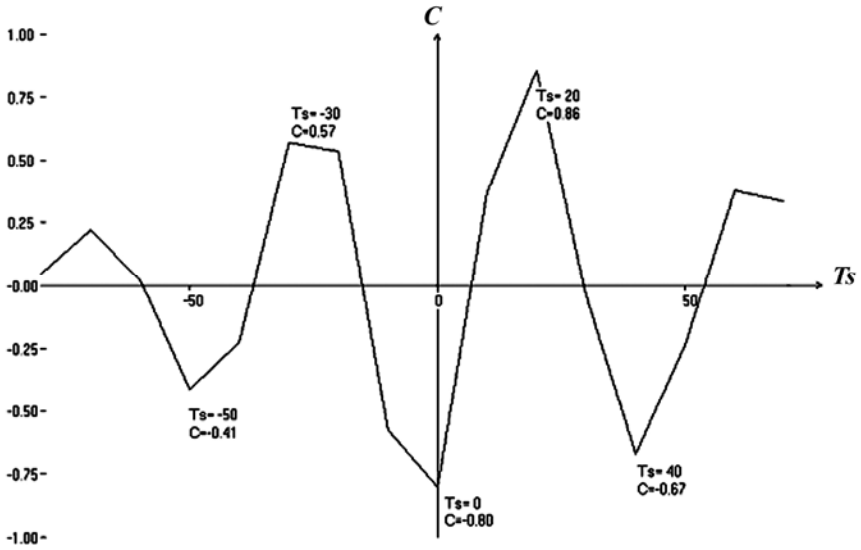


Figure 11a. [Fig11a.jpg]



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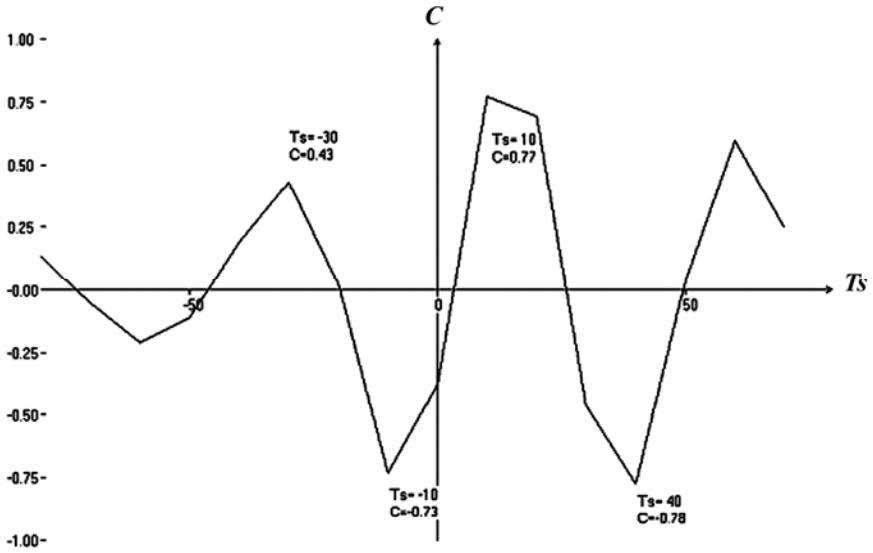


Figure 11c. [Fig11c.jpg]

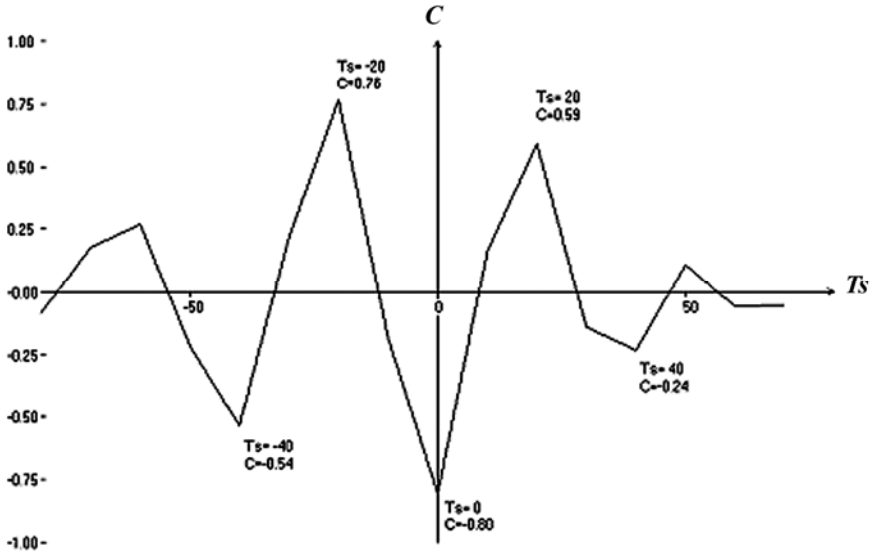


Figure 11d. [Fig11d.jpg]

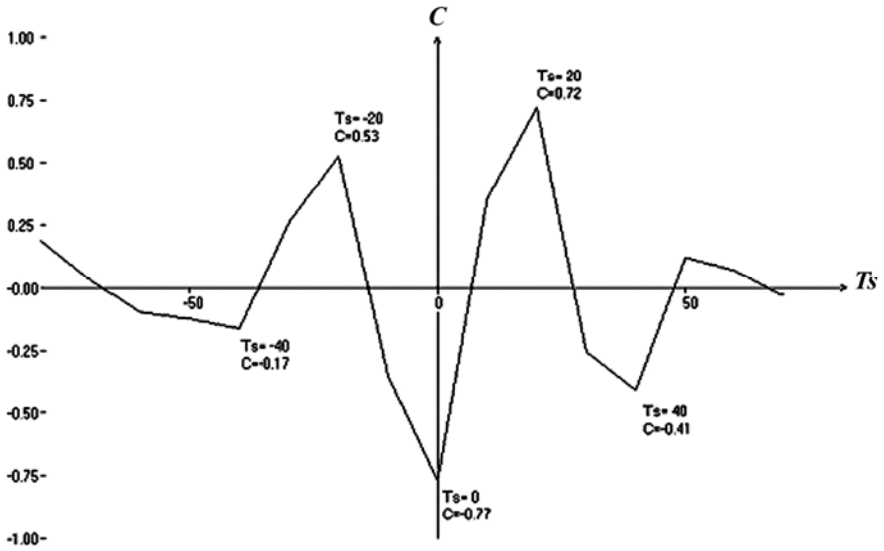


Figure 11e. [Fig11e.jpg]

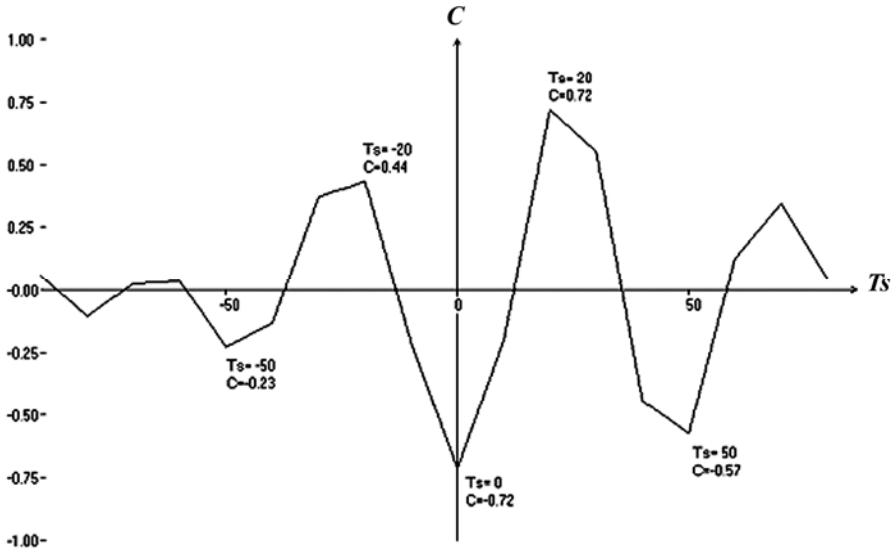


Figure 12a. [Fig12a.jpg]

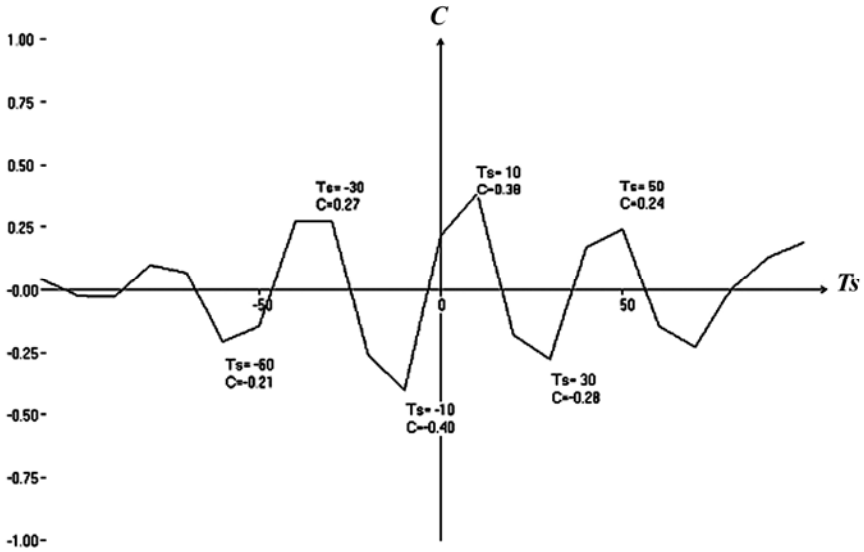


Figure 12b. [Fig12b.jpg]

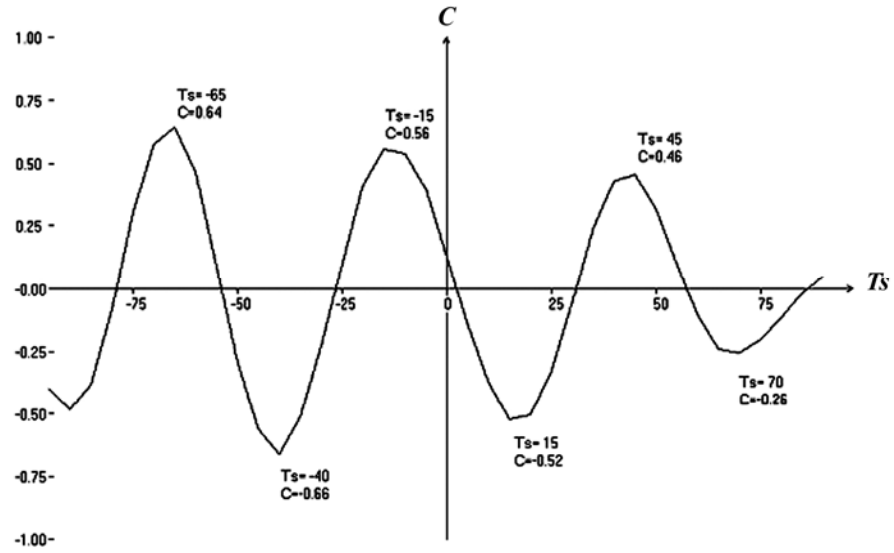


Figure 12c. [Fig12c.jpg]

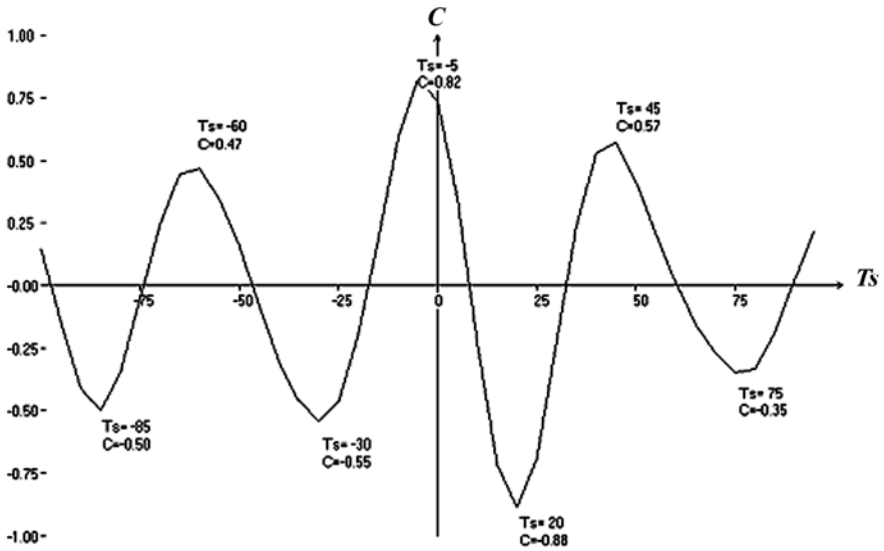
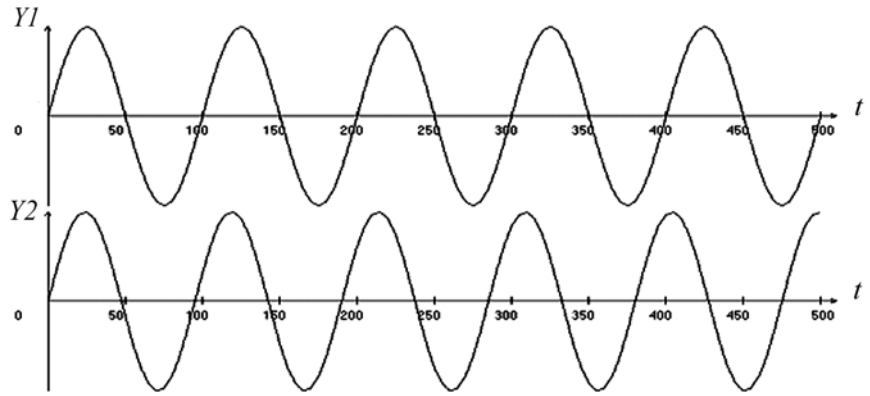


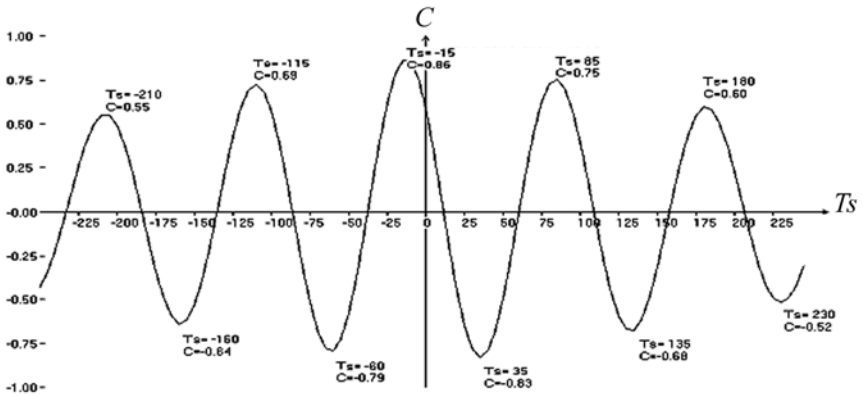
Figure 12d. [Fig12d.jpg]

In Appendix C:



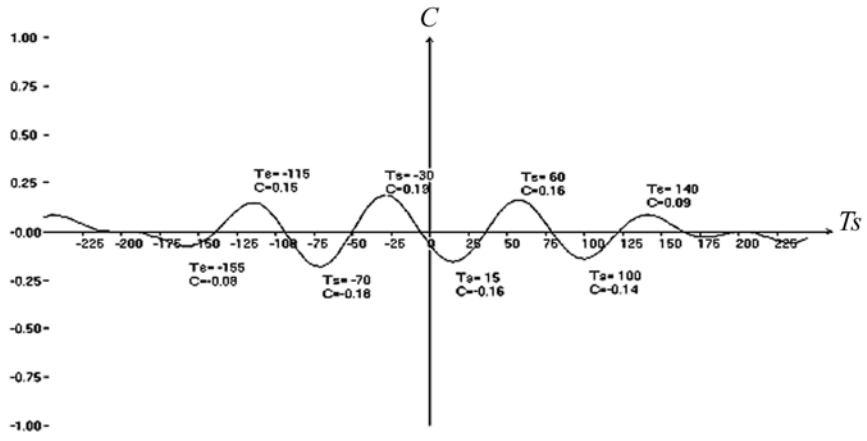
[FigC-1.jpg]

Figure C-1. Two sinusoidal waves with periods 100 years (above) and 95 years (beneath)



[FigC-2.jpg]

Figure C-2. Mutual correlation of two sinusoidal waves shown of Fig. **Ошибка! Источник ссылки не найден.**



[FigC-3.jpg]

Fig. C-3. Mutual correlation of two sinusoidal waves with periods 100 and 75 years