

Free number generation and creative thinking

Faiciuc Lucia

Institutul de Istorie „George Bariț”, Cluj-Napoca

1. Introduction

Two important related questions were at the origin of the research reported in this paper. Is there a general pattern in the structure and the dynamics (assumed to be associated with attentional processes) of the various networks of connections between an individual's mental representations for different stimulus domains? Is it possible that such a general pattern could be revealed both in some features of a number series produced by that individual in a free number generation task and in her/his performance in a task that supposedly requires a superior creative thinking in order to be completed? In case the answer is „yes” for both questions, then we would expect an association between the her/his performances in the two tasks.

In order to give a tentative answer to the above mentioned questions, the present study will be initially concentrated on a theoretical analysis of the discussed issues. Then, the results of two empirical studies will be presented. For the first one, the findings were presented in a greater detail in a previous paper¹, in the present one being reported only those considered to be the most important. The second empirical study, which is closer to the status of a pilot research, will be presented here in an extensive manner for the first time.

1.1 *Creativity and the performance in free associative thinking and in generating and synthesizing discrepant information*

The theoretical ground that was considered relevant in order to sustain the assumed relationship between free number generation and creative thinking makes reference to two categories of studies, each of them approaching the creativity issue from a rather different

¹ L. Faiciuc, *Relația dintre performanța într-o sarcină de generare liberă a unei serii numerice și performanța la două probe care solicită în mod ipotetic gândirea divergentă*, în „Studii și cercetări din domeniul științelor socio-umane”, Cluj-Napoca: Edit. Argonaut, 2001, 73-85

point of view. My endeavour in this paper was to find connections between the two resulting perspectives.

The first category of relevant studies includes research regarding the relationship between the divergent and creative thinking, an important link between them being the idea of free association or variation. That same idea could bridge both of them with some aspects of the less investigated domain of the non-directional style of thinking, and implicitly with the performance in a free number generation task. The second category is referring to research that relates the janusian thinking (the ability to integrate opposing elements, as a distinct type of thinking in comparison with the convergent thinking ability) – a concept introduced by Rothenberg² - with creativity. This kind of studies is based on data from neuropsychology and some speculations concerning possible applications of the nonlinear dynamic systems theory on the creativity issue. It could be said that the two research directions concentrate on two creativity aspects that were only at the first sight unrelated. In order to integrate opposing elements (janusian thinking) a person has to be capable to generate opposing elements (probably by free associations, as in some divergent thinking tasks) in the first place. On the other hand, it could be presumed that a great number of distant associations would not lead, by themselves, to more creative products, without an ability to integrate them. That would be a reason to think that, in defining a creative solution, the most important criterion should be not its frequency (rarity), but its integrative power. Even though, at first, it is important to generate local or temporary solutions as various, original and numerous as possible, such a variability would not be sufficient as an index for creativity. Maybe the most creative people are those that are capable to find only a single solution, the only one that can accommodate multiple lines of thinking. It is true, such a solution could be a rare one, but it can be assumed that is qualitatively different from other rare responses, requiring maybe different processes in order to be generated. The traditional creativity research, centred on divergent thinking research, puts a greater accent on the variability engendering stage in a creative process. It supports an operational definition for creativity that insists on the amount and the variety of the solutions that were given to an ill-defined task. For example Wallach and Kogan³ considered that „two variables should permit us to index individual differences in creativity: the number of associations that the persons can generate in response to given tasks and the

² A. J. Cropley, *Creativity and Cognition: Producing Effective Novelty*, in „Roeper Review”, 1999, 21(4), 253-264

³ M. A. Wallach, N. Kogan, *A new look at the creativity – intelligence distinction*, in „Journal of Personality”, 33, 1965, pp. 348–69, republished in P. E. Vernon (ed.), „Creativity”, Harmondsworth, Penguin Books, 1970, 235-257

relative uniqueness of the associations that he produces” (pp. 238). But an unique or original associative response, a relatively infrequent one, it is not necessarily a very different one, a disparate one, in comparison with the previous generated responses.

Given the above considerations, in the present study, two possible alternative ways to define operationally a creative performance were envisioned in order to improve its assessment. One of them, which corresponds to the janusian thinking aspect of creativity, presupposes that a creative performance could be evaluated by the quality (the level attained in synthesis) of an unique required solution in a task that constrains the investigated subjects to integrate a large number of disparate or opposing elements. In addition, it is considered that in creativity tasks of an associative type, an important index for creativity should be a preference for generating contrasting or distant responses, which are not necessarily unique or rare ones.

1. 2. *A task for the investigation of the free associative thinking*

The kind of thinking not directed toward a goal and the individual differences regarding its way of manifestation seems to be topics that were rather ignored by the mainstream research in psychology. Of the research that has been carried on until now, those studies that were initiated in a psychoanalytical frame, trying to reach the unconscious thoughts and feelings by free associations, and those investigated creativity through divergent thinking tasks could be considered to be closer to the above mentioned topics. In the divergent-production line of research, the stream of ideas (solutions) generated by people in order to accomplish tasks in which the correct answers could not be clearly defined was characterised by Guilford⁴ using attributes like fluency, flexibility, originality and elaboration. He considered that creative people are those for whom the above mentioned attributes are manifested in a higher degree in their ideational flux. Implicitly, it was recognized that creative solutions occur as a consequence of a free association process, that is thinking not directed by a goal, whose products are then assessed for their quality. So, such a kind of thinking can be considered important feature of the creativity, named by Goertzel⁵ as the heterarchical aspect of creativity, defined as a free flow of thoughts from an idea to another, more or less related to the previous one. But, particularities of such a free thought flow for the creative people are hard to be investigated using the traditional divergent

⁴ J. P. Guilford, *The Nature of Human Intelligence*, New York, Mc Graw-Hill Book Company, 1967

⁵ B. Gortzel, *From Complexity to Creativity*, New York, Plenum Press, 1997, <http://gortzel.org/books/main.htm>

thinking tests. An argument in that direction is that performance in such tests is influenced in a high degree by the level of knowledge and experience an individual has related with the material and the task of such tests. For example, the performance in those divergent thinking tests that require graphical production may be influenced by the ability to draw (when assessing fluency) or greater experience with drawing particular objects, as a consequence of some family or culture differences, which in the mainstream culture are less frequent or odd (when assessing originality). Or in verbal creativity tests, performance could be influenced in an important manner by the verbal ability of the investigated person. In addition, when investigating flexibility it is hard to categorize response in a precise manner so that it could be reliably assessed. In general, in such tests it is difficult to separate the effect of some peculiarities in the free associational thinking (that can supposedly exist, independent of the thought content, in the more creative person) and the effect of knowledge and experience with a specific semantic content or task. So, that is why in Faiciuc⁶ I tried to identify a task that is similar with those employed for traditional divergent thinking assessment that is less dependent on the knowledge and experience differences, using a generally known material and a very simple task, which require no special ability. Regarding the stimulus material, natural numbers seemed to me to satisfy such a condition. They are learned by almost every person since childhood and it can be assumed that there are no major differences in the numbering (counting) performance. The task of a free generation of a natural number series, the only constraint being that of choosing from a given natural numbers interval, could be considered sufficiently simple, because it does not require special knowledge, skills or effort. Furthermore, in such a task the idea of performance is missing, with all motivational problems that are associated, the emphasis being on the „stylistic” aspects, more exactly on the way the task is carried on. In the same time, it is similar with the more traditional divergent thinking tests because it implies a free transition between mental representations that were previously organized and memorized. In such a case variability (a concept which can be related with the traditional flexibility concept) can be easily and objectively assessed, the numeric material being processed with special standardized mathematical techniques. So, in contrast with other free associative tasks in which are used words, the differences between two responses are easily quantifiable. Though, there is also a big difference in comparison with some divergent thinking tasks: it does not require production of new responses or

⁶ L. Faiciuc, *Relația dintre performanța într-o sarcină de generare liberă a unei serii numerice și performanța la două probe care solicită în mod ipotetic gândirea divergentă*, in „Studii și cercetări din domeniul științelor socio-umane”, Cluj-Napoca: Edit. Argonaut, 2001, 73-85

solutions for some kind of problems. The „novelty” produced is only that of the order of the numbers from the given set in the generated series. Thus, compared with the more traditional creativity tasks, in the proposed task there is no constraint regarding the adequacy of the resulted combination of the given elements. We considered that the formal aspects of the free associational thinking, uncontaminated by factors such as the level of knowledge or experience from a certain stimulus domain, and their relationship with the creative performance could be identified more easily with such a task.

1.3. *A task for the investigation of the ability to generate and integrate discrepant information*

Another important aspect regarding creativity that was commented in the scientific literature, but was investigated in a lesser extent empirically, is the ability to generate and to synthesize disparate, opposing or contrasting ideas. In this case, in order to be creative it is not sufficient to produce more different ideas, more quickly, but the emphasis is on how different are the produced ideas or how easily or frequently opposing or disparate ideas can be integrated in an integrated whole. Among the first that noticed that aspect of the creativity was not a psychologist, but a poet. Coleridge⁷ thinks that the poetic image has as a dominant characteristic the equilibrium or the reconciliation of opposing or discordant features. In the same direction Tsur⁸ considers that a fundamental aesthetic principle for a poetic work is that it must be paradoxical: it has to merge incompatible aspects. Wallach et al.⁹ the authors of the traditional divergent thinking tests, were aware of that aspect, defining creativity as a mental function of the associational fluency, new solutions being found through distant ideational associations. Some authors (Rothenberg, 1979; Thagard, 1984; Ward, Finke, Smith, 1995, apud Ward¹⁰), based on observations and empirical data, considered that creative ideas can be frequently attributed to the mental fusion of some disparate or discrepant concepts. For example, Rothenberg (1979, apud Cropley¹¹ and Kaufman¹²) suggests that such mental fusion characterizes two kinds of thinking that are fundamental for creative thinking: janusian thinking (the ability to conceive in an active manner multiple oppositions and to unify

⁷ J. A. Plucker, *Is the Proof in the Pudding? Reanalysis of Torrance's (1958 to Present) Longitudinal Data*, in „Creativity Research Journal”, 1999, 12 (3), 103-107

⁸ R. Tsur, *Toward a Theory of Cognitive Poetics*, Amsterdam, Elsevier Science Publisher, 1992

⁹ M. A. Wallach, N. Kogan, *op. cit.*

¹⁰ T. B. Ward, *Creative Cognition, Conceptual Combination and the Creative Writing of Stephen R. Donaldson*, in „American Psychologist”, 2001, 56(4), 350-354

¹¹ A. J. Cropley, *Creativity and Cognition: Producing Effective Novelty*, in „Roeper Review”, 1999, 21(4), 253-264

¹² J. C. Kaufman, *The Sylvia Plath effect: Mental illness in eminent creative writers*, in „Journal of Creative Behavior”, 2001, 35(1), 37-50

conflictive, mutually exclusive ideas) and homospatial thinking. (the ability to process simultaneously information pieces that do not normally occur together –in space or time-, creating new concepts by a distinct entities juxtaposition). For Koestler¹³(1964) the janusian thinking is equivalent with what he calls bisociative thinking. In the verbal domain creativity was operationally defined by some authors (Bogen & Bogen, 1969; Maini, 1973; Tegano, 1990, apud Atchley, Keeney & Burgess¹⁴) as the ability to maintain a representation that contains multiple potentially incongruous aspects. An argument for such a definition given by Atchley et al¹⁵ is the fact that recalling lexically ambiguous words requires activating multiple incongruous meanings of that word. In a similar vein Gabora¹⁶ suggests that the most fundamental source of creativity is the tension that guides the efforts to reconcile and unify from a global perspective discordant elements. Some empirical data support the position expressed by the above mentioned authors. For example, Getzels & Jackson¹⁷ (1962) showed that the more creative children prefer in a much greater extent a kind of humour that is based on perceiving contrasts and contradictions. Hastie, Schroed and Weber¹⁸ (1998) showed that the more incongruous are the components of a combination, the more numerous are the emergent properties that are generated through such a combination. It can be noticed from what has been said above that more emphasis was placed in the theoretical work on the part of unifying contrasting ideas and in constructing psychometric measures for creativity a greater emphasis was placed on the part of generating different ideas (even though sometimes by combining some given elements that were not necessarily disparate), although a measurement of how different those ideas are was not, in general, considered, a possible reason for that being the fact that in almost all cases it is hard to obtain such a measurement. That is why I tried, in Faiciuc¹⁹, to elaborate a task that would allow me to assess the creative performance of an individual taking in view a definition of creativity in which a synthesis of dissimilar components is required. A first step in the direction that I followed was made by

¹³ A. J. Cropley, *Creativity and Cognition: Producing Effective Novelty*, in „Roeper Review”, 1999, 21(4), 253-264

¹⁴ R. A. Atchley, M. Keeney, C. Burgess, *Cerebral Hemispheric Mechanisms Linking Ambiguous Word Meaning Retrieval and Creativity*, in „Brain and Cognition”, 1999, 40(3), 479-4999

¹⁵ R. A. Atchley, M. Keeney, C. Burgess, *ibidem*

¹⁶ L. Gabora, *The Beer Can Theory of Creativity*, în P. Bentley, D. Corne (eds.), „Creative Evolutionary Systems”, Morgan Kauffman, 2000, <http://www.vub.ac.be/CLEA/liane/PAPERS00/beercan.htm>

¹⁷ W. C. Hoffman, *The dialectics of giftedness. Gifted Intellect and Creativity*, „Roeper Review”, 1995, 17 (3), 101-107

¹⁸ T. B. Ward, *op.cit.*

¹⁹ L. Faiciuc, *Relația dintre performanța într-o sarcină de generare liberă a unei serii numerice și performanța la două probe care solicită în mod ipotetic gândirea divergentă*, in „Studii și cercetări din domeniul științelor socio-umane”, Cluj-Napoca: Edit. Argonaut, 2001, 73-85

Mednick²⁰(1962) with his Remote Associations Test (RAT) that was devised to study the verbal creativity. The task was to find a fourth word which has common associative links with three stimulus (rather disparate) words. The test included a list of such combinations of three words for which a solution was to be found. Unfortunately, the test is hard to be translated in Romanian because its solutions are based frequently on English homonyms and founding Romanian correspondents in a massive adaptation could not permit a safe generalization of the results obtain with the English version of the test. In addition, synthesizing only three words based on rather superficial semantic features may be is not a task that resembles too much with the most common ways of manifestation of creativity in the every day life (when more opposing elements have to be synthesized by integrated them in a new whole, rather by finding a common element. An argument would be the evidence cited by Cropley²¹ which suggest that RAT is more related to conventional verbal skills than to divergent thinking. So, in order to obtain a measure for the creativity aspect that I wanted to assess I tried the combine an aspect from the task of Mednick (1962, ²²) with an aspect from another creativity test constructed by Barron²³, named by him as the „Word Rearrangement Test”. In that test the subjects were given 50 words (randomly selected from a list of nouns, adjectives and adverbs) and they have to elaborate a story in which to include as many words as they can from the given set. In my task I considered necessary that the randomness selection is not sufficient, so I selected, initially at random, a list of 50 words from dictionary (nouns, adjectives and adverbs), but then I chose for the final set of 15 words those words that were semantically more dissimilar from each other. It was hypothesized that a smaller number of only 15 words puts more pressure on participants to synthesise those words that were dissimilar than when they have a much larger set that gives them the liberty to choose only those words suited with an idea that in that way does not to be changed in order to integrate apparently unsuited ones. In addition a number of 15 words does not put a pressure on their memory (it is hard to manipulate in the working memory such a large set) Another difference between the task used by me and that of Barron²⁴ is the requirement to elaborate any kind of literary composition (poem, short dialogue etc.) not only a story. The participants’ performance was not judge only using the number of words integrated in the story and the originality in word synthesis as in Barron’s test, but also criteria that intended to assess the figurative language and metaphorical thinking, originality of some fragments of the

²⁰ A. J. Cropley, *S-R Psychology and Cognitive Psychology*, in P. E. Vernon (ed.), *Creativity*, Harmondsworth, Penguin Books, 1970, 116-125

²¹ A. J. Cropley, *ibidem*

²² A. J. Cropley, *ibidem*

²³ F. Barron, *Creativity and Personal Freedom*, Toronto, D. Van Nostrand Company, 1968

²⁴ F. Barron, *ibidem*

composition, logical coherence and the existence of a global perspective (a theme concept) that supports the word synthesis, compared with a strategy in which the words are synthesized only by a set of events that are linked only by a spatial-temporal contiguity. In the literature on the creativity issue such a kind of task was also cited, but without clear specifications regarding the exact procedure that was used, by Wallach et al.²⁵ They investigated whether the low incidence of thematizing (relational or thematic criteria for grouping objects, when the relationships among the objects is important, as contrasted with abstracted similarities based criteria, when each object is considered independently) by the high intelligence, low creativity group of children is due to an inability to thematize or an avoidance of it. In order to clarify this issue they assessed the ability of the children to integrate a set of words into a unified theme in story telling, when the thematizing was required in order to succeed in the task. They showed that in such a case that the considered group thematizes as well as the group high both in creativity and intelligence. Their conclusion is that for this group there is a bias against thematization, not an inability to thematize. Only when the option not to thematize is available the high intelligent, low creative group has a lower performance in thematizing. Their result raises the question if the creativity should be operationally defined based on aptitude or based on aptitude. In the case of their study they label the group as low in creativity based only in their performance in the more traditional divergent thinking tests in which the subjects could choose whether they use their creative abilities or not, greater weight being put on assessing rather the creative attitude. In a task such is the one in which the participants are forced to integrate very dissimilar elements, as in the literary composition task proposed by us in our study, the attitude aspect decreases in importance and the ability aspect becomes prominent in the assessment of creativity. The participants are forced to transform in a higher degree the given elements, that is to generate variations whether they prefer or not to do so when they have the freedom to choose, so that they could integrate them and to succeed in completing the task. In that direction, it could be said that the high intelligence, low creativity group was not so low in creativity after all, considering their ability to thematize, which is required in a creative performance, when forced to do it.

Kasperson²⁶(1978) showed that those people that have a high level performance at the Remote Association Test (Mednick, 1962, apud Huey²⁷) have also a superior ability to

²⁵ M. A. Wallach, N. Kogan, *op .cit.*

²⁶ N. Huey, *Teaching Creativity*, Degree of Master of Art Thesis, The University of Texas at Austin, 2000, <http://www.ciadvertising.org/studies/reports/future/nathan.html>

²⁷ N. Huey, *ibidem*

maintain, simultaneously, multiple lines of thinking, having at the same time a larger attention span.

The purpose of the present research was to investigate the relationship between various features that could characterize the free associative thinking (studied through the free generation task) and the creativity aspect that refers to the ability to synthesize disparate elements (studied through a literary composition task in which participants had to integrate in a whole words from distant semantic fields).

1.4. Hypothesis

A **general hypothesis** of the research was that those participants with a higher creative performance at the composition literary task should present the signs of a greater variability in the generated numeric series, as expressed by some descriptive indices of those series.

Several arguments could support such a hypothesis. One of them is the correspondence that could be established between the variability in a number series and flexibility as an index used to assess creativity through divergent productions.

Another one is that people with a lower creative performance should have a tendency towards stereotyped answers. In the case of free number generation task that means that they should tend to generate numeric sequences based on counting stereotype and to have a higher frequency for those numbers that occur more often in their daily life (which are modal responses in the general population such is the number 1). More creative people should surpass such stereotyped number sequences more easily. Cooperstein²⁸ has established a relationship between the two lines of arguments, considering that less creative individuals tend to generate more stereotyped responses because they miss the associative flexibility that would allow them the access to some more distant associations (less stereotyped associations).

A different line of argumentation is based on the results of some previous empirical studies that revealed an association between the performance in some creative tasks and variability in some neurophysiological and physiological measures of arousal. For example, Bowers and Keeling²⁹(1971) established a connection between creativity and variability in the cardiac frequency. Similarly, Martindale³⁰(1977) established a relationship of creativity with

²⁸ M. A. Cooperstein, *The conjoint evolution of consciousness and creativity*, in „Journal of Creative Behavior”, 1985, 19, 215-217

²⁹ L. Gabora, *op.cit.*

³⁰ L. Gabora, *ibidem.*

the spontaneous galvanic skin response. Finally, Martindale³¹(1978) showed there is a link between the EEG alpha waves amplitude and creativity.

In a similar vein, Csikszentmihalyi, Rathunde and Whalem³² suggest a relationship between creativity and attention (precisely its dynamics and distribution), as a psychological manifestation of arousal. They suggested that creative people have a more flexible and mobile attention, which is distributed on larger fields, so that it allows connections among a greater number of elements, and also, among more distant or dissimilar ones. An indirect empirical support of their idea is provided by Zegans, Pollard and Brown³³(1967). They showed that administration of the LSD psychotropic drug results in a decreased ability to concentrate attention on a clearly defined perceptual field (evidenced by a lower performance in tachistoscopic and hidden figure tasks) and in an increased ability to access discrepant ideas or words, to generate unique or distant word associations.

Gabora³⁴ elaborated a theory concerning creativity that is based, also, on some distinctive characteristics of creative people regarding their attentional processes. That theory is grounded on a synthetic study of Martindale³⁵(1999), in which the cited author associates creativity with a cluster of four fundamental attributes, which are identified by reviewing empirical data from the scientific literature of the creativity domain. Supporting the above mentioned idea of Csikszentmihalyi et al.³⁶, the first considered attribute associated with creativity is defocused attention, an attribute mentioned in empirical studies by various authors (Dewing & Battye, 1971; Dyker & McGhil, 1976; Mendelsohn, 1976, apud Gabora³⁷). The second attribute concerns an increased sensibility for details (sustained by authors like Armstrong, 1974; Martindale, 1977, apud Gabora³⁸). The third one is considered to be the presence of flat associative hierarchies, a property identified and investigated mainly by Mednick³⁹(1962), through its Remote Association Test. Sensibility to subliminal stimuli was the fourth considered attribute, its association with creativity being supported mainly by the research of the Smith & Van der Meer⁴⁰(1994). Gabora⁴¹ suggests that when the first and

³¹ L. Gabora, *ibidem*

³² M. Csikszentmihalyi, K. Rathunde, S. Whalem, *Talented Teenagers. The Roots of Success and Failure*, Australia, Cambridge University Press, 1993

³³ S. Krippner, *The Psychedelic State, The Hypnotic Trance, and the Creative Act*, in C. T. Tart, „Altered States of Consciousness”, London, John Wiley & Sons, 1972

³⁴ L. Gabora, *op.cit.*

³⁵ L. Gabora, *ibidem*

³⁶ M. Csikszentmihalyi, K. Rathunde, S. Whalem, *op. cit.*

³⁷ L. Gabora, *op.cit.*

³⁸ L. Gabora, *ibidem*

³⁹ L. Gabora, *ibidem*

⁴⁰ L. Gabora, *ibidem*

the second attribute are present we, also, could expect the presence of the third attribute. His argument is that when information is memorized or recalled from multiple memory locations, based on a greater number of features, so that information irrelevant for the current goal is remembered in a greater amount, then continuous flows of abstract thought are longer and more frequent, which is equivalent with a flat associative hierarchy property. That is, a concept whose representation is placed at the periphery of the memory region activated at a given moment could lead directly to another concept, whose representation is placed at a very distant zone from that region. As a consequence, in the case of a defocused attention, the conceptual network is not only penetrated at a deeper level, but is traversed (overpassed) more quickly, so that there is an increased probability that in a free thinking, a thought could engender another thought, unrelated with the first one at the first sight, in a more shorter period. So, it can be said that there is a low correlation between a thought and the next one when the conceptual fluidity is high. At the same time, the conceptual fluidity associated with defocused attention could explain the elaboration of a conceptual network in memory with a more detailed structure (in other words, with an increased sensibility to details) and the building of unique perspectives. As a conclusion, Gabora⁴² suggests that there are reasons to think that creativity is placed at the edge of chaos, a concept borrowed from dynamic systems theory, which in plain words would mean that there should be an intermediary level of connectivity in a network or among the components of a system. In that case, the amount of information that could be learned about a component by investigating another component from the same system is at an intermediary level. With a defocused attention that condition is satisfied in a greater extent. So, the cited author considers that in order to be at the edge of chaos the conceptual domains activated by a stimulus should have an intermediary level of expansion. In other words, the stimulus should not activate a single memory location, nor all the memory locations in an equal manner, but it should activate several of them, the level of activation decreasing gradually toward periphery of the region with a central zone which is activated the most. Spreading the activation on a larger area around the central maximum requires a lower activation threshold of the neurons. So, Gabora⁴³ thinks that at the edge of chaos, the experiential flux is such that its sequences of various lengths are self-similar, that is they correlate with each other, but they are not identical, one sequence being a variation of a previous one. In order to reach the edge⁴⁴ of the chaos to obtain new ideas, Gabora⁴⁴ suggests that the connections of a conceptual network have to be weakened by decreasing the neuronal

⁴¹ L. Gabora, *ibidem*

⁴² L. Gabora, *ibidem*

⁴³ L. Gabora, *ibidem*

⁴⁴ L. Gabora, *ibidem*

activation threshold. In that way the conceptual fluidity is increased and, as a consequence, any thought could trigger a continuous chain of new associations. On the other hand, the effect of an increased conceptual fluidity (or, equivalently, of weaker connections in the conceptual network) depends on the density of the connections in the conceptual network. In Gabora's⁴⁵ view, that is why, maintaining a state at the edge of chaos requires that conceptual fluidity to be tuned to the conceptual density, so that the connectivity among concepts to remain relatively constant.

The task of free number generation seemed to me an appropriate task in order to study the property named by Gabora⁴⁶ conceptual fluidity or defocused attention. In this case, the conceptual network is that network that links the mental representations of the natural numbers. The free transition from a number to another should depend on some characteristics of that network. Moreover, my supposition is that it is possible that the some properties (like the intensity of the connections or the way it is changed) are similar, no matter what conceptual network is considered. Such general properties regarding the conceptual fluidity in the conceptual networks of various semantic fields could sustain the assumption made in my research that the conceptual fluidity in the number field could be associated with the conceptual fluidity in those semantic fields activated by the words given in the literary composition task (as a matter of fact, both result from a higher ability to maintain a defocused attention). A higher conceptual fluidity would allow a greater creative performance in the literary composition task because it engenders activation of figurative meanings for the given words and more distant associations that could lead to some semantic connection between words that are from distinct semantic fields. In the free number generation task, a greater conceptual fluidity could be associated with several characteristics of the generated number series. An obvious one is that the difference between two successive numbers from a series should be greater (in average) for those people characterized by a higher ability to maintain a defocused attention (and, possibly, with a higher creativity) than for those with a lower ability of this kind. That expectation is based on the assumption that a greater difference between two successive numbers means that they are more distant in the conceptual network that corresponds to the number representation. Another characteristic is that fewer stereotyped numeric sequences based on the counting skill should occur for those with a greater conceptual fluidity due to weakened connections (greater fluidity) in the number representation network. Implicitly, those two characteristics should lead to an increased

⁴⁵ L. Gabora, *ibidem*

⁴⁶ L. Gabora, *ibidem*

variability in the generated numeric series (at least on its lower scales), as was expressed in the general hypothesis formulated above. As Gabora⁴⁷ suggests that creativity implies defocused attention, and that creates condition for a mental state placed at the edge of chaos, that supposedly would lead to an representational flow characterized by self-similarity, another hypothesis that can be advanced is that the generated number series of those participants with a higher creative performance should have the self-similarity property (when the fluctuation pattern at various scales –in this case sequences length – is similar, but not identical), which implicitly means that they could be characterized by long distance correlations. That is, the number generated at a given moment will depend on a number generated many moments ago. It could be associated to a superior ability to integrate information on longer time intervals, as a consequence of a more distant influence in time of the activation of an element on the activation of other ones with which it is connected.

To test the above mentioned hypotheses I used for the free number generation task a version ij which the given set of numbers was the natural numbers between 1 and 99 and the required length of the generated number series was of 200 numbers. The present study continues a previous similar research of mine (in Faiciuc⁴⁸). In that research in the free number generation task the given numeric interval was the natural numbers between 1 and 9, and the generated series were of a 500 number length. Then, the participants had to write down on the paper, by themselves, the generated numbers. In the present study the numbers were dictated to a colleague. Another (maybe) relevant difference was that the participants were students in mathematics. Also, in that research, besides the literary composition task was used a task that required completing in a meaningful way several given numeric sequences of three numbers, by inventing rules that hold also for the initial numeric sequence. The participants had to generate as many such rules as they can, with the explicit requirement that those rules have to be as different as possible.

I considered that it was necessary to change the free number generation task because in my first study the relatively short numeric interval (of only nine numbers) made unlikely the generation of series with long range positive correlations so that it was not possible to investigate the hypothesis regarding the association between the generation of such number series and the level of creative performance. In addition, in the case of a small sets of given numbers all of them could be held in the short term memory and accessed directly from there. In contrast, in the case of a large set of given numbers their generation is made by a different

⁴⁷ L. Gabora, *ibidem*

⁴⁸ L. Faiciuc, *Relația dintre performanța într-o sarcină de generare liberă a unei serii numerice și performanța la două probe care solicită în mod ipotetic gândirea divergentă*, in „Studii și cercetări din domeniul științelor socio-umane”, Cluj-Napoca: Edit. Argonaut, 2001, 73-85

process than by simply accessing them in the short term memory. It can be hypothesized that such a process could imply a direct access to a representation of the number from the long term memory and/or that it could presuppose a combinatorial process, placing successively for units and decimals one of the nine digits (that may be held in the short term memory). Having a larger numeric interval, an additional hypothesis can be formulated. It can be expected that those participants that have a higher creative performance in the word synthesis to cover in their series more of the given numeric interval, that is a greater percentage (ratio) of the number between 1 and 99 will be generated and there would be smaller difference between the frequencies of each of them (that is, a more even distribution). That would be a sign of a greater variability in the generated number series. As was shown before, another sign would be the frequency of occurrence of great differences between two successive numbers. So, we expect that those with superior creative performance to show higher frequencies for such differences. Another sign, mentioned also before, is due to a tendency to resist to stereotypes that are influenced by the counting skills at those with superior creative performance. So they should generate relatively more negative differences and less positive differences (especially a difference of one unit) between two successive numbers than those with an inferior creative performance. It could be expected also, that those with higher creative performance tend to repeat successively the same number more often than those participants with a lower performance. The more creative ones should have a lower preference for those numbers that are modal responses in the general population. Also, it can be expected on the arguments presented above that those with a superior creative performance to tend to generate number series with long range correlation, that is with a higher level of self-similarity.

2. Method

In general, the present research is a correlational study. Although more sophisticated methods of data analysis would have been useful (such as some multivariate analysis methods), they were difficult to apply due to a small sample volume and to a raised number of variables.

2.1. *Participants*

26 students (20 girls and 6 boys) in the first year at the History Faculty participated at the research

2.2. Tasks and scoring procedures

Participants were required to carry on two tasks in a collective session.

The first task was that of creating a literary composition (of any kind) in which to integrate as many as possible words, in an interesting way, from a given set of 15 words. The words were: apron, fly (as an insect), illusive, outright, galaxy, oozy, recital, fresh, continuous, icon, contrast, spawn, thorn, compact, mask. It was allowed changing the given order of the words and the inflexion of the words so that they could be more easily integrated in a phrase. There was a time limit of 20 minutes.

Although I did not have the opportunity to analyze the validity or the reliability of such a task as a creativity probe by studying its predictive or convergent validity, there are some arguments that could sustain the possibility to use it as a rough measure for creativity. In the first place, it is very similar with the Barron's (1968) Word Rearrangement Test, which in his research has the highest correlations with two other originality measures used by him: T.A.T. Originality ($r = .41$) and Anagrams ($r = .33$). Interestingly, it does not correlate with other classical measures for creativity, that are less verbal in nature, such as those that are based on unusual uses, plot titles and finding consequences if some sudden changes were suddenly to take place. However, it has one of the highest correlations among the originality measures used by Barron (1968) with the originality assessed by several observers of the investigated subjects ($r = .45$). In addition, in Faiciuc's⁴⁹ research there was a statistically significant relationship between the performance in literary composition task, especially that concerning the stylistic performance and the performance in the numeric sequence completion task, that also was hypothesized to require creativity for its execution.

The second task was that of a free number generation. The free number generation task is a task in which I asked participants to report whatever number (from a given numeric interval) is in their mind, successively, that is to say (or write) those numbers that freely pass through their minds until a number series of a given length is completed. That task differs from the random number generation task used by other researchers (for example, Towse⁵⁰) to study working memory, in which in the number generation there was the constraint to generate random number series, that is series that have the randomness property. In the case

⁴⁹ L. Faiciuc, *ibidem*

⁵⁰ J. N. Towse, *On random generation and the central executive of working memory*, in „British Journal of Psychology”, 1998, 89, 77-101

of this study the given interval was that of the natural numbers between 1 and 99, and the required length for the series was of 200 numbers. The generated numbers were dictated to a colleague that registered them on the paper.

In my previous research there was a significant stability for the values of the majority of the indices used to describe the properties of the generated number series. This stability was assessed by comparing the number series generated at a month interval by the same subjects, the linear correlation coefficients having values greater than 0,5, significant at a level $p < .001$. So, it can be said that there are reasons that the values obtained for the descriptive indices are associated with some constants of the processes involved in the generation of the numeric series.

In order to describe the generated numeric series there were used two computer programmes that perform an analysis for data in a number series form: RgCalc and DFA.

The first one was elaborated by Towse and Neil⁵¹ and it offers a description of a numeric series by providing several descriptive indices. Some of them, with relevance for the present study are presented here, based on the description made by the above mentioned authors:

- *Redundancy* (with two limit values: 0, it indicates no redundancy, that is perfect equality of response alternative frequencies, and 1, it indicates complete redundancy, when the same response choice is used for the entire series);

- *The response frequency* for each alternative response;

- *Random number generation (RNG)*: it describes the distribution of the response pairs, or in other words the dependency between one choice and the next one, its values being between 0 (no dependency between the two choices) and 1 (complete predictability or dependency of pair sequence); since it reflects the pairs of the possible responses that were used repeatedly, it is an indirect measure for the number of the pairs of successive responses that were not used by a participant when generating a sequence.

- *Analysis of Interleaved Digrams (RNG2)*: it involves the pairing of every alternate response, resulting in a frequency matrix, the obtained pairs being processed as for the RNG index.

- *Adjacency* (sometimes referred to as a stereotype score) which indicates the percentage of the neighbouring pairs (pairs of numbers that are separated only by a minimal

⁵¹ J. N. Towse, D. Neil, *Analyzing human random generation behavior: A review of methods used and a computer program for describing performance*, in „Behavior Research Methods, Instruments, & Computers”, 1998, 30, 583-591

difference of one unit). Two other similar indices are calculated: one for the percentage of ascendant adjacent pairs of numbers (when the first value is smaller than the second one) and other for the percentage of descendent adjacent pairs of numbers (when the first value is greater than the second one).

- *Turning point index (TPI)*: it indicates the number of responses that, as numerical values, mark a change between ascending and descending sequences (local peaks and troughs) and is expressed as a percentage that shows the correspondence between the number of observed turning points and the number expected to occur in a theoretical distribution of random responses. In accord with the Azouvi et al⁵²(1996) that showed that patients with closed head injuries produced a lower TPI than did controls, it can be said that TPI indicates the runs strategy where individuals produce an arithmetic chain of responses (based on the counting skills);

- *Phase length*: it indicates the frequency of occurrence of intervals between two turning points that are of a certain length, together with the expected frequency for that phase length in a random theoretical distribution.

- *Runs*: it describes the variability in the phase length

- *The first-order differences*: indicates the frequencies for the arithmetic difference between each response and its preceding value.

- *Repetition distance*: it shows the distribution of distances or lags between item repeats, the mean, mode and the median of the repetition distance

Besides those indices provided by the RgCalc, I computed, like in my previous research, based on them, other descriptive indices: the percentage of large or small first-order differences (greater or smaller than 20 as an absolute value or greater or smaller than 10 as an absolute value), the percentage of large or small positive first-order differences (greater or smaller than 20 or 10) and the percentage of large or small negative first-order difference (smaller or greater than - 20 or -10), the percentage of null differences between two successive numbers and the minimum and maximum absolute difference between two successive numbers. There were computed differences smaller or greater than 20 and 10 in an absolute value because those values for the difference between two consecutive numbers proved to be closer to some thresholds that marked a significant decline in the mean frequency of the differences with greater values, both for positive and for negative differences. Beyond a difference of approximately 20 the mean frequency is extremely small, rarely surpassing a value of 1. Differences smaller than 10 had mean frequencies in the interval between 4 and 8.

⁵² J. N. Towse, D. Neil, *ibidem*

It could be noticed that all the described indices could be useful for assessing the variability in a generated number series, offering information regarding its randomness and roughness.

The second computer programme, DFA, was designed by Peng, Hausdorff and Goldberger⁵³, based on what they called the Detrended Fluctuation Analysis method. It computes a fractal scaling exponent α , that provides a measure of the „roughness” of a time series. The larger its value, the smoother it is the time series. In the same time, it can be said that it is a measure of the level of the self-similarity in the series and, implicitly it indicates the occurrence of the long correlations in the series. In other words it indicates the relationship between the fluctuation on smaller scales and the fluctuation on larger scales. When α is 0.5, it indicates that the investigated series has the properties of the white noise, being completely random, when a value at one instant is completely uncorrelated with any previous values. When α is between 0.5 and 1 in the series occur persistent long-range power-law correlations. where relatively large observations tend to be followed after some interval by additional larger observations. When $\alpha = 1$, we have a special case, named the 1/f noise (or pink noise), a kind of noise that is frequently meet in several time series obtained by measuring natural phenomena, inclusively neuropsychological ones. It indicates the properties of a time series generated by a fractal process, which result in irregular fluctuations across multiple scales, a property indicating self-similarity. It is the case of a series possessing dependencies at many, or all, time scales examined. When α is smaller than 0.5 the series is characterised by long-range power law anti-correlations, when large values are more likely to be followed by small values and vice versa, such that large and small values of the time series are likely to alternate."

The same computer programme provides several indices, that are used for computing α , which will be named dfa indices (from DFA1 to DFA19), each of them indicating the characteristic fluctuation at a given window size (the numeric series being divided into subsets of independent windows of the same size), or in other words, at a given scale. Such indices are useful for a more refined analysis regarding the variability in the obtained number series.

The performance in the creative literary task was assessed using several evaluative dimensions: the number of the given words integrated in composition, the number of given

⁵³ C. K. Peng, J. M. Hausdorff, A. L. Goldberger, *Fractal mechanisms in neural control: Human heartbeat and gait dynamics in health and disease*, in J. Walleczek (ed.), *Nonlinear Dynamics, Self-Organization and Biomedicine*, London, Cambridge: University Press, 1999

words used with a figurative meaning, the number of the stylistic figures used in composition (comparisons, metaphors, interesting epithets), the logical coherence and its indivisible, unitary character, the existence of a global perspective or a theme that supports the integration of the given dissimilar words employing a different strategy than a simple description or narration that reach the integration only by spatio-temporal contiguity (the level of thematization) and the global originality. By some of these dimensions I tried to quantify in a certain degree the assessment of the originality, beyond a subjective global score. Theoretical arguments for the meaning and the importance of the thematic thinking (or of an ability to thematize) for the creativity assessment could be found in Faiciuc⁵⁴. The last three dimensions were evaluated on a scale of seven points. In general some of the above mentioned dimensions correspond to those criteria considered necessary by Bessemer and Treffinger⁵⁵(1981) in order to assess a creative product when they elaborated the Creative Product Analysis Model. The first criterion refers to novelty (surprise, originality). The second criterion was named by them resolution (how logical, useful, valuable and meaningful is a creative product). The third one is the level of elaboration and synthesis, that is how well distant elements are integrated in coherent whole, resulting in an organic, refined and elegant product.

Two evaluators assessed on the seven dimensions the literary composition for each participant. One was the author, the other was a literature teacher. However, in the data processing only the scores obtained from the author were considered.

3. Results

The data obtained at the literary composition task by the evaluation on the above mentioned scales were synthesized using the factorial analysis, employing the principal components method with a rotated solution using the Varimax method. Three factors were retained that had eigenvalues greater than the unit value. The first factor explained 50% of the variance in the results and could be associated with the stylistic (metaphorical thinking) and divergent thinking (especially originality) aspect of the creative performance, because it correlated the most with the assessed dimensions for global originality, figurative meanings of the words, stylistic figures and original images. The second factor covers 21% of the total variance and it can be associated with a synthetic aspect of the creative performance (the ability to integrate disparate elements in a coherent whole). It correlated the most with the

⁵⁴ L. Faiciuc, *Rolul organizării tematice a cunoștințelor în performanța creativă*, in „Studii și cercetări din domeniul științelor socio-umane”, Cluj-Napoca: Edit. Argonaut, 2001, 73-85

⁵⁵ S. P. Bessemer, K. O'Quin, *Confirming the Three Factor Creative Product Analysis Matrix Model in an American Sample*, in „Creativity Research Journal”, 1998, 12 (4), 105-109

evaluative dimensions regarding the logical coherence and the existence of an integrative theme. The third factor explained 16% of the variance and correlated the most with the number of the given words that were integrated in the composition. For assessing the creative performance a composite score was obtained by simply adding the correspondent scores obtained by participants for the each of the above mentioned factors.

The main specific hypotheses of the present study were that there should be a association between some descriptive indices for the variability in the generated series and the level of the creative performance in the literary composition task. It was expected a positive correlation between the creative performance and the frequency of occurrence of large differences between consecutive numbers (we considered the cases of differences larger than 10 and larger than 20), the frequency of null differences, the frequency of the local peaks and troughs, the frequency of occurrence of negative differences between two successive numbers and the value of the self-similarity α coefficient. A negative correlation was expected between the level of the creative performance and redundancy, the probability of predicting a sequence of two consecutive numbers (RNG), the probability of predicting a sequence of two alternate numbers (RNG2), the frequency of the ascending pairs of numbers, the phase length, the mean of the differences between two successive numbers (expressing the ration between the negative and positive differences), the mean frequency of negative differences smaller than 10, the mean frequency of negative differences smaller than 20 As in our previous study there was an association between some DFA indices and the creative performance it was expected that they should appear also in the present study, indicating the characteristic fluctuation at a given window size.

Considering the small volume of our sample and the fact that sometimes some variables had an asymmetric distribution we preferred to compute nonparametric correlation coefficients in order to estimate the association between the investigated variables. There were computed correlation coefficients for each creative performance measure (the composite score for the literary composition, stylistic factor, coherence factor, number of figurative meaning of the given words, number of stylistic figures, number of original images, the level of coherence, the presence of a theme, the global originality) with all the above mentioned descriptive indices for the generated number series computed by the RgCalc and DFA.

The values for the Spearman coefficient of correlation (or the Kendall tau-b coefficient, which was preferred when multiple tied ranks existed) that were statistically significant (one-tailed), or were at the limit of the statistical significance threshold of $p = .05$, are presented in the tables 1, 2, 3, 4, 5 and 6.

Table 1 Correlation coefficients for the composite creative performance score

	RNG	RNG2
Composite creative performance score	$\rho = -0,330$ p = .05	$\tau = -0,231$ p = .049

Table 2 Correlation coefficients for the stylistic factor score

	DFA6	DFA7	DFA8	Mean frequency of the null differences
Stylistic factor score	$\rho = 0,348$ p = .04	$\rho = 0,374$ p = .03	$\rho = 0,361$ p = .03	$\rho = 0,378$ p = .028

Table 3 Correlation coefficients for the coherence factor score

	DFA10	Mean frequency of negative differences smaller than 20	Mean frequency of negative differences smaller than 10
Coherence factor score	$\rho = -0,329$ p = .05	$\rho = -0,395$ p = .023	$\rho = -0,383$ p = .027

Table 4 Correlation coefficients for the number of original images score

	Mean frequency of the null differences	Mean frequency of ascending pairs of successive numbers
Number of original images score	$\tau = 0,318$ p = .03	$\tau = -0,279$ p = .036

Table 5 Correlation coefficients for the coherence score

	DFA10	DFA11	DFA12	Mean frequency of negative differences smaller than 20	Mean frequency of the null differences	Mean repetition length
Coherence score	$\tau = -0,263$ p = .036	$\tau = -0,257$ p = .04	$\tau = -0,237$ p = .053	$\tau = -0,291$ p = .025	$\tau = -0,293$ p = .024	$\tau = -0,228$ p = .063

Table 6 Correlation coefficients for the global originality score

	Mean frequency of the null differences	Mean of the differences between two successive numbers
Global originality score	$\tau = 0,308$ $p = .032$	$\tau = - 0,284$ $p = .029$

In order to appreciate the level of agreement between the two evaluators (the inter-rater reliability) the nonparametric correlation coefficient Kendall –tau between the scores of the two raters was computed for each evaluative dimension. For all of them there was a powerful positive association. The values obtained for each dimension are to be found in the table 7.

Table 7 Inter-correlation coefficients between the scores given by the two raters for each the seven dimensions used to assess the creative performance in the literary composition task

The number of words integrated in composition from the given set	The number of the words used with a figurative meaning from the given set	The number of stylistic figures	The number of original images	The level of logical coherence and integration	The level of thematization	The global originality
$\tau = ,756$ $p < .001$	$\tau = ,854$ $p < .001$	$\tau = ,848$ $p < .001$	$\tau = ,712$ $p < .001$	$\tau = ,598$ $p < .001$	$\tau = ,848$ $p < .001$	$\tau = ,814$ $p < .001$

4. Discussion and conclusions

Of the specific hypothesis, data supported only several of them. As expected, there was a negative association between a global score for the creative performance at the literary composition task and the level of predictability of a sequence of two numbers in the generated series (RNG, a measure of the series randomness), the probability of predicting a sequence of two alternate numbers (RNG2, another measure of the series redundancy). It is worth mentioning that such an association was found in the first study only as a tendency, the correlation being only very close to the statistic significance threshold of $p = .05$. In the hypothesis that for larger sets of given numbers the generation is based on a separate choice

of a number for units and decimal digits joining them together, the association with RNG and RNG2 could be explained by a greater combinatorial (associative) play at those with a higher creative performance. Also, there was not found, as it would have been expected, a negative association between the creative performance and redundancy, and also, the phase length and the number of ascending pairs of successive numbers. A possible explanation for the redundancy case would be that, as redundancy in a series is found by determining the extent of deviation from an ideal random distribution of the numbers from the given set and in our case this set was rather large and the series length rather short, the redundancy index is not very informative regarding the series randomness. A similar reason could be invoked to explain the missing association with the phase length. There were many numbers to choose, so that the shorter phases were less likely to occur than in our previous study. Maybe a similar explanation would hold in the case of the absent association with the ascending pairs of successive numbers, than with a large set of numbers are less likely to occur. However, in the ascending pairs case, there was found the expected negative association, but only in the case of the score for the number of original images. There was not a negative association as expected between the mean of the differences between two consecutive numbers and the creative performance measured with a composite score, but only with the global originality score. The negative association with the mean frequency of differences smaller than 20 or 10 in absolute value was obtained only for the case of the negative differences and for the coherence factor or the coherence score.

Only a positive association between the mean frequency of null differences (the number of consecutive repetitions) and the stylistic factor, the number of original images and the score for the global originality, but not for the composite score of the composition task, as it was expected. No positive correlation was found between any of the creativity scores and the mean frequency of differences larger than 20 or 10 in absolute value, frequency of the peaks and troughs, mean frequency of the negative differences or the self-similarity α coefficient. The first three of the missing expected associations maybe could be explained, as above, considering the large set of the given numbers. When the given number interval is large we could be expecting that some combinatorial operations are involved, so that a generated number does not depend exclusively on a presumed process of activation spreading in a representational network, as it may have been in our first research. So, large differences between consecutive numbers could occur based on activation spreading maybe only for differences as large as 20 or somewhere around. For the issue of the occurrence of an association only between the level of coherence and the mean frequency of negative differences lower than 20 could be several answers. The first one is based on the fact that for

differences greater than 20 in an absolute value the incidence was extremely low, so that it would have been hard to find an association investigating such a small sample (although there was a tendency in the direction of the expected differences, the values being close to the statistic significance threshold). The second one considers a tendency in the general population to prefer positive differences (there was a significant differences when the mean frequencies for positive and negative differences greater than 20 in absolute value were compared: $t(25) = -7,225$, $p < .001$, the mean frequency for the positive ones being double the mean frequency for the negative ones). So, we could have been expected that for those with higher levels of creative performance, at least in what regards the coherence factor, that tendency to be manifest in a lesser extent (by avoiding this general stereotype), being harder to count in the opposite direction (data support such a view by a result that tend to be close to the significance threshold of $p = .05$). But seems that such a preference to generate negative differences, tend to be manifested rather in the benefit of the much larger absolute negative difference, at the expense of the smaller ones, which would tend to have a lower incidence.

Also, in the case of a large number set, the frequency of the turning point is likely to decrease, and the required series being shorter, the peaks and troughs may have been in a lesser amount than in our first research. Considering the missing association between self-similarity coefficient and the creative performance it could be noticed that in the present study such an association was hard to be made evident based on a reason that is opposed to the reason invoked for the first study. In the first one, only a few of the subjects (three of them) had value greater than 0.5 for the self-similarity coefficient, the majority of them generating series characterized by anti-correlation (α coefficient smaller than 0.5). By changing the free number generation task in one with a larger set of given numbers, almost all participants had series with an α coefficient greater than 0.5, characterized by long-range positive correlations (only four of the subjects had $\alpha < 0.5$). So, due to such asymmetric distributions, it was hard to find an association between creative performance and one of the three types of series defined based on the α coefficient. The present data tend to show by the association of the creative performance with RNG and RNG2 that the tendency is that the more creative persons generate more random numeric series (as measured by the RNG and RNG2 indices). But that result is not reflected in a greater frequency of participants with superior creative performance that also have an α coefficient closer to 0.5 (another measure of randomness). Anyway, such a result would be in contradiction with the hypothesis that the more creative people are likely to have a higher level of self-similarity and as, a consequence, α coefficients closer to the value 1. Partially, the issue lies in the fact that, at present, there is

no unique measure or definition for randomness. So, with different tasks and different measures we can obtain different results if we want to characterize the randomness in a number series.

In comparison with our previous study, in the present one appeared a positive association with some DFA indices, but separately, for the coherence and the stylistic factor and not for the entire composite score. Another difference was that the association occurred for windows of different sizes. So, if in the previous study there was a positive association for window sizes of 5 or 6 numbers, whereas in the present study there was a positive association between the stylistic factor and the level of the fluctuation for window sizes of approximately 10, 11 and, respectively 12 numbers (which correspond for the DFA6, DFA7 and DFA8 indices). The change it is possible to be related also to the larger set of alternative responses for choice, which does not facilitate obtaining fluctuation differences on the shortest sequences. In contrast, a negative association appeared between the index value for DFA10 and the coherence factor and between the values for the indices DFA10, DFA11 and DFA 12 (corresponding to window sizes of approximately 19, 23 and 27 numbers, respectively) and the coherence score. So, it seems that different aspects of the creative performance are associated with the characteristics in the free number generation performance in a conflicting way. A higher performance in what respects originality and the ability to generate variation is associated with a higher level of fluctuation on the lower scales (more variability on the short term). But a higher performance in the ability to integrate disparate elements is associated with a lower fluctuation on higher scales (less variability on the long term). So, a person with a maximum creative performance, that supposedly should have both the above mentioned abilities in a free associative task should present a greater variability in the free generated responses on the shorter time intervals, and lower variability (which could mean a more patterned sequence of response) on the longer time intervals. It was said that the α coefficient indicates how „rough” it is a temporal or numeric series on its various scales. Following our results there is reason to believe that for those with creative performance the generated series is „rougher” only for some of the scales, the somewhat smaller ones. In our first study the tendency toward lower variability for higher window sizes was not manifested because, supposedly, in that case, due to the small set of the given numbers there was a ceiling effect regarding the level of the variability in the long run. A possible explanation for the differences between the two studies regarding the positive association of the fluctuations on smaller window sizes with the total global score for composition in one case and only with the stylistic in the other is that, in comparison with window sizes of 5 or 6 numbers (for which there was an association in the first study with the global score) where there was no

correlation between the coherence score and DFA indices for those window sizes, in the case of windows of 10, 11 or 12 numbers (for which a positive correlation occurs only with the stylistic factor in the second study) there was a tendency toward a negative association between coherence score and the DFA indices for those window sizes, the correlation coefficients being very close to the statistic significance threshold of $p = .05$ in both studies. So, as the global score was a sum that has as terms the stylistic and the coherence score, and one score correlated positively and the other negatively with the DFA indices for window sizes of 10, 11 and 12 numbers, the global score had in the end no association with those indices. Such contradicting results regarding the characteristics of the generated series on different scales that are associated with different aspects of the creative performance could serve as a partial explanation for the absence of the expected positive association between the self-similarity coefficient and the creative performance. It could be possible that there is a nonlinear relationship between the two, taking in view some tendencies that were manifested in both our studies. In the present one, the results that approached only the statistic significance threshold of $p = .05$ for a one-way analysis of variance that was performed in order to reveal some possible effect of the stylistic performance level on the value of α coefficient indicated a tendency for those that had a medium level of stylistic performance to have lower α values (close to the 0.5 level of the random series) compared both to those that have higher or lower levels of stylistic performance (that had values close to the value of 1, characteristic for series with fractal properties, long-range positive correlations). So, I tried to see whether there is some variable which with its influence could mask a relationship between α and the creative performance score. Because the α coefficient is influenced in an important degree by the percentage of the various differences between two successive numbers and because data revealed a significant difference regarding that aspect between those with different levels of creative performance, I chose to investigate the influence of the computed variable that measured the frequency of the absolute differences lower than 20. Computing a partial correlation between the global score for the creative performance and α , controlling for the effects of the above mentioned variable, there was obtained a positive association at the limit of the statistical significance (the obtained value of the correlation coefficient was significant at a level of $p = .057$), indicating that the more creative participants in the given task maybe tend to present long-range positive correlation, when relative frequency of great or low differences between two consecutive numbers is held constant.

Comparing the results of the two studies it can be said that there are both similarities and differences. The most important similarities are the obtained positive association between

the stylistic factor and the tendency to repeat the same number successively (the mean frequency of null differences), the positive association between the creative performance measured with the composite score and the tendency to produce less predictable numeric sequences (more random series), the association between the tendency to generate more variable sequences on the short term (smaller window sizes in the generated number series) and the global creative performance (in the first study) or the stylistic factor (in the second study). The two studies revealed both an association between the creative performance or its investigated aspects and the mean frequency of some differences between two consecutive numbers. But in the first study, a higher diagnostic value for the creative performance had those differences that occurred for relatively larger differences, whereas in the present study, the significant associations were for the relatively smaller differences, specifically for the negative ones. The most important differences were those regarding the absence of an association in the present study between the creative performance and the turning point index, an important measure for the variability and the associations obtained for the frequency of ascending pair of numbers (in the first study they correlated with the coherence factor, in the present study with the frequency of the original images). So, it could be said that certain descriptive indices of the numeric series are more revealing regarding their relationship with the free associative thinking properties for those series generated with smaller sets of given numbers (TPI and the phase length for example) and other indices for those generated with larger sets of given numbers (RNG and RNG2, for example).

There are several explanations for the most constant result from the two studies, the one referring to the null differences. To have a higher incidence of repetitions of two consecutive numbers could mean a tendency to override the stereotype of the counting skills, which require a difference between successive numbers. The same result could reflect a tendency to surpass a general tendency to avoid repetitions in generating series of random numbers, which was revealed by several studies (for example, Towse⁵⁶). A more speculative explanation would be that for those that had a higher level of creative performance there is a tendency for the activation of a number representation to persist longer, or to be more intense, so that the corresponding number will continue to be generated several times consecutively until its activation fades away, and possibly a sudden transition to a very distant number occurs.

A general conclusion would be that there are some signs of an association between the creative performance in the literary composition task and the variability of the series

⁵⁶ J. N. Towse, *On random generation and the central executive of working memory*, in „British Journal of Psychology”, 1998, 89, 77-101

resulted from a free number generation task. But there are only signs, and not very clear results. The expected associations were not manifest with the anticipated power and for all the computed variability indices. Multiple reasons could explain the obtained results. First of them was that the volume of the sample was rather small and there are reasons to suspect that the participants were rather homogenous in their performance at a rather medium level of creativity (there were extremely few cases – one or two – that had a somewhat remarkable creative performance). So, it was difficult to reveal all the expected differences. An argument in that direction is the fact that many of the envisioned differences were close to the statistic significance threshold of $p = .05$. Another possible explication is that the scores obtained in the literary composition task could not be considered a valid and reliable measure for the creative performance, and especially for that aspect of creativity that refers to the ability to integrated discordant elements in a coherent whole. It is a plausible explanation considering that an important methodological flaw of the study (unavoidable due to some pragmatic reasons) was the absence of at least one more evaluator for the assessment of the creative performance. Or, they are a reliable and valid measure only in the case of the verbal creativity and not in general. The traditional dispute between general and specific creativity has relevance in this case. A general creativity that may be associated with a greater intensity with some characteristics of the free associative thinking is maybe hard to be made evident with specific creativity tasks, in which the specific creativity is the dominant factor in performance. As it was remarked in the introductory part of the study, conceptual fluidity (the ability to generate variations) is not sufficient for a creative performance. It is required, also a dense conceptual network which is acquired by learning the specific knowledge of a domain. In addition, that defocused attention that could be manifested in some of the features of the series generated by free number generation, being considered at the same time one of the most distinctive attributes of the creative people, may not be a permanent or constant property in the psychic activity of an individual. As was shown by Martindale⁵⁷, such a defocused attention could occur predominantly when a person is in a creativity state, some time before and during a creativity task. So, it may be hard to leave marked traces in the performance of a free number generation tasks when the person is not in a state of „inspiration“. Also, the attitudinal aspect of creativity may have played a role in the obtained in the obtained results.

⁵⁷ C. Martindale, *Creative Imagination and Neural Activity*, in R. G. Kunzendorf, A. A. Sheikh (eds.), *The Psychophysiology of Mental Imagery. Theory, Research and Application*, New York, Baywood Publishing Company, 1990

As it was shown in the Wallach et al.'s⁵⁸ research presented in the introductory part of the paper, there are some people that although they have the ability to think creatively when motivated or forced to do so, they do not prefer that kind of thinking when they have the freedom to choose. So, in our free number generated task, in case that some conscious attitudes matter in performing the task, they will not intentionally avoid stereotyped responses as some with a higher creative attitude would prefer to do. On the other hand, when forced to make use of their creative ability in the composition task, they will have a similar creative performance with those that are additionally creative from an attitudinal point of view. For this issue a distinction made by Guilford⁵⁹ between spontaneous and adaptive flexibility is relevant. In the spontaneous flexibility case a person produces a great variety of ideas even if it is not necessary for her/him to do so. Adaptive flexibility is the one that facilitates solving problems that require a most unusual type of solution and which may seem soluble by more conventional methods (Guilford⁶⁰)

The same considerations maybe true for the descriptive indices computed for the series resulted from the free number generation task as regards their ability to reflect what was named as conceptual fluidity, as characteristic that could be manifested in free associative thinking. An important factor in that respect could be the role played by some more or less conscious strategies adopted by the participants in the generation of the numbers, in spite of the explicit instruction that they should be as spontaneous as they can. As a consequence, some of the obtained results could be explained less by an effect of a defocused attention and more by some rather conscious attitudes that lead to some preferential choices. It is also true, that it is less likely that some of such choices that would consider the frequency of previous responses are hard to be made systematically, due to that length of a generated series that makes harder memorizing previous responses or sequences of responses. But, maybe the individual differences regarding the generated series may be partially explained also by the ability to memorize the previous responses, followed by a tendency to compensate what may seem too patterns, intentionally simulating a what the participant thinks to be a free generated sequence. In addition, pragmatic reasons made impossible to ask the participants to generate series with a greater length than 200 numbers, which is a relatively a very short length considering that the given interval was of 99 numbers and some computed indices are not very informative in such a case.

⁵⁸ M. A. Wallach, N. Kogan, *op. cit.*

⁵⁹ J. P. Guilford, *Traits of Creativity*, in H. H. Anderson (ed.), *Creativity and its Cultivation*, Harpen, 1958, 142-161, republished in P. E. Vernon (ed.), „Creativity”, Harmondsworth, Penguin Books, 1970, 235-257

⁶⁰ J. P. Guilford, *ibidem*

So, the obtained results did not offer a clear answer to the question advanced by the general hypothesis of the present study. But they may seem encouraging for an extension of the research, with a sounder methodological design. They are encouraging because, it may be surprising that there are still some common features (even if only a few) of those that show similar levels of performance in a literary composition task with respect to the way they freely generate numbers in a spontaneous fashion, as they come to their mind, seemingly at random (when no regularity would be expected by many observers).