FREE NUMBER GENERATION AND CREATIVE THINKING

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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 the both questions, we would expect an association between 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 focused on a theoretical analysis of the discussed issues. Then, the results of two empirical studies will be presented. Whereas the results of the former were presented in a greater detail in a previous paper[1], only those of main importance are included in the present one. The latter which is rather a pilot research, is presented here in an extensive manner for the first time.

1.1. CREATIVITY IN RELATION WITH FREE ASSOCIATIVE THINKING, JANUSIAN AND HOMOSPATIAL THINKING

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 approaches the creativity issue from a rather different point of view. My endeavour in this paper was to find out connections between the two resulting perspectives.

[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*, „Studii și cercetări din domeniul științelor socio-umane", Cluj-Napoca, Edit. Argonaut, 2001, p. 73-85.

The first category of relevant studies includes research regarding the relationship between divergent and creative thinking, an important link between them being the idea of free association or variation. This would bridge both of them with some aspects of the less investigated domain of the non-directional style of thinking, and implicitly, with the performance of a free number generation task.

The second category of studies is referring to research that has related the ability to generate and synthesise discrepant information or distant elements with creativity. For such an ability, Rothenberg's[2] concepts of janusian thinking and homospatial thinking, offer a concise denomination. The former refers to a process of integration of disparate and inconsistent information. The latter refers to a process of superposition of elements which are not normally contiguous in space and time. This kind of studies is based on data from neuropsychology and some speculative ideas 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 at the first sight seem to be unrelated. But, in order to obtain creative products which integrate discrepant or distant elements a person has to be capable of generating such elements (probably by free associations, as in some divergent thinking tasks) in the first place, in case they were not given. On the other hand, it could be presumed that a large number of distant associations would not lead, by themselves, to more creative products, without an ability to integrate them. This would be a reason to think that, in defining a creative product, the most significant criterion should not be 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 that unique solution which can accommodate multiple lines of thinking in the best way. It is true, such a solution could be a rare one, or it may be obtained with a higher probability by those that generate many ideas. But it can also be assumed that such a solution 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, lays a greater stress 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 Kogan[3] considered that „two variables should permit us to index individual differences in creativity: the number of associations that the persons can generate

[2] A. J. Cropley, *Creativity and Cognition: Producing Effective Novelty*, "Roeper Review", 1999, 21(4), p. 253-264.

[3] M. A. Wallach, N. Kogan, *A new look at the creativity – intelligence distinction*, "Journal of Personality", 33, 1965, p. 348–69, republished in: P. E. Vernon (ed.), *Creativity*, Harmondsworth, Penguin Books, 1970, p. 238.

in response to given tasks and the relative uniqueness of the associations that he produces". But a unique or original associative response, a relatively infrequent one, not necessarily a very different or disparate one, in comparison with the previous generated responses, nor it is an integrative response necessary.

The above-mentioned considerations emphasize the importance of the generation and integration of not just any elements, but of the most dissimilar ones, in obtaining a creative product. Based on that, in the present study, two possible alternative ways to define operationally a creative performance have been envisioned, in order to improve its assessment. One of them presupposes that a creative performance could be evaluated by considering the quality (the level attained in synthesis) of unique required solution in a task which constrains the investigated subjects to integrate a large number of disparate or distant elements. The other one considers that in creativity tasks of an associative type (like divergent thinking tasks), an important index for creativity should be the preference for generating contrasting, or distant responses, which are not necessarily rare (as for the originality index) or simply different others (as for the flexibility index).

In what follows, two tasks are presented, which were designed such that the assessment of the two proposed criteria for judging the creative potential to be facilitated. One of the tasks is of a non-directional thinking type, the other one is more goal directed, but both of them could reveal aspects regarding janusian and homospatial thinking. The two empirical studies presented below were carried on in order to find out whether there is a relationship between the results obtained by a person in the two tasks, as it would be expected if both had the hypothesized connection with creativity.

1.2. A FREE ASSOCIATIVE THINKING TASK: FREE NUMBER GENERATION

The kind of thinking not directed toward a goal and the individual differences regarding its form of manifestation seem to be topics rather ignored by the mainstream research in psychology. Of the research carried on until now, the studies initiated in a psychoanalytical frame, trying to reach unconscious thoughts and feelings by free associations, and those that investigated creativity through divergent thinking tasks could be considered to be closer to the above mentioned topics. But in those cases, nondirectional thinking was not considered as a subject-matter worth being investigated in itself.

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 Guilford[4] using attributes like fluency, flexibility, originality and elaboration. He considered that creative people

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

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, in other words thinking not directed by a goal, whose products are then assessed for their quality. So, such a kind of thinking could be considered an important aspect of the creative thinking. It was named by Goertzel[5] as the heterarchical aspect of creativity and defined as a free flow of thoughts from an idea to another, more or less related to the previous one. But, the particular way in which such a free thought flow could be manifested in the more creative people seems to be hard to investigate by using the traditional divergent thinking tasks. An argument in that direction is that the performance in such tasks is influenced in a high degree by the level of knowledge and experience an individual has related with the material and the task in hand. 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 by a greater experience with drawing particular objects, as a consequence of some family or culture differences, those objects being in the mainstream culture less frequent or odd (when assessing originality). Similarly, in verbal creativity tests, performance could be influenced in an important manner by the verbal ability of the investigated person, by its vocabulary and reading level. In addition, when investigating flexibility, it is hard to categorize a response in a precise manner so that it could be reliably assessed. In general, in such tests, it is difficult to separate in the creative performance the effect of some distinguishing features of the free associational thinking (which would supposedly be manifest, independent of the thought content, at the more creative persons) and the effect of knowledge and experience with a specific semantic content domain or task.

That is why, in Faiciuc[6], I tried to identify a task which would be similar with those employed in the traditional assessment of the divergent thinking, but, at the same time, whose performance would be less influenced by knowledge and experience differences. In order to accomplish that, I searched for a generally well learned material and a very simple task, which requires no special ability.

Regarding the stimulus material, natural numbers seemed to me to satisfy such a condition. They are learned by almost every person in her/his childhood. It can also be assumed that there are no major differences in the counting performance of various people in the general population, as the case of the verbal or graphical production.

The task of a free generation of a natural number series (the only constraint being that of choosing from a limited interval of natural numbers) could be considered sufficiently simple, because it does not require special knowledge, skills or effort. Furthermore, in such a task, the idea of performance with all motivational

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

[6] L. Faiciuc, *op. cit.*, p. 73-85.

problems that are associated with it, is missing, the emphasis being on the "stylistic" aspect, more exactly on the way the task is carried on. At the same time, it is similar with the more traditional divergent thinking tasks because it implies a free transition between mental representations that were previously (before the task was performed) organized and memorized. In its case, variability in responses (a concept which could be related with the traditional flexibility concept) can be easily and objectively assessed by several indices, the numeric data being processed with special standardized mathematical techniques. So, in contrast with other free associative tasks in which words could be used, the differences between two responses are easily quantifiable. There is also another big difference in comparison with some divergent thinking tasks: it does not require production of new responses or solutions for any kind of problems. The free association is not produced in the framework of a task that requires a goal directed thinking (even if the goal is less clearly defined, as it is in divergent thinking tasks). The "novelty" produced is only that of the order of the numbers in a generated series. Thus, compared with the more traditional creativity assessment procedures, in a free number generation task there is no explicit constraint regarding the adequacy of the resulted combination of elements that were given as a stimulus material.

In conclusion, it could be said, based on the above mentioned arguments, that in a free number generation task, some possible distinctive features of the free associational thinking and their relationship with the creative performance would be identified more easily, uncontaminated by factors such as the level of knowledge or experience with a certain stimulus domain.

1.3. JANUSIAN AND HOMOSPATIAL THINKING IN A GOAL-DIRECTED THINKING TASK: WORD SYNTHESIS IN A LITERARY COMPOSITION

An important aspect regarding creativity that was commented in the scientific literature, but was investigated to a lesser extent empirically, is the ability to generate and synthesise discrepant information or distant elements, related to the above mentioned janusian and homospatial thinking. In this case, in order to be assessed as creative, it is not sufficient to produce more different ideas, more quickly. The emphasis is shifted on how different the produced ideas are or how easily, or frequently, distant or disparate ideas can be integrated in a unified whole.

Among the first that have noticed this creativity aspect was a poet. Coleridge[7] suggested that the poetic image has as a dominant characteristic the equilibrium or the reconciliation of opposing or discordant features. In the same direction, Tsur[8]

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

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

has considered that a fundamental aesthetic principle for a poetic work is that it is paradoxical: it has to merge incompatible aspects. Wallach et al.[9], the authors of some of the traditional divergent thinking tests, were aware of the above mentioned aspect, defining creativity as a mental function of the associational fluency, new solutions being found through distant ideational associations.

Some authors (for example, Rothenberg, 1979; Thagard, 1984 şi Ward, Finke, Smith, 1995[10]), based on observations and empirical data, considered that creative ideas can be frequently attributed to the mental fusion of some disparate or discrepant concepts. As it also was mentioned above, the first cited of them, Rothenberg[11, 12] (1979), suggested that such mental fusion characterises two kinds of thinking that are fundamental for creative thinking: janusian thinking (ability to conceive in an active manner multiple oppositions and to unify conflictive, mutually exclusive ideas) and homospatial thinking (ability to process simultaneously information pieces that are not normally contiguous in space or time, creating new concepts by juxtaposition of distinct entities). For Koestler[13](1964) janusian thinking is equivalent to what he calls bissociative thinking.

In the verbal domain, creativity was operationally defined by some authors (for example, Bogen & Bogen, 1969; Maini, 1973 şi Tegano, 1990[14]) as the ability to maintain a representation that contains multiple potentially incongruous aspects. An empirical support for such a definition is given by Atchley's et al.[15] findings referring to the fact that recalling lexically ambiguous words requires the activation of multiple incongruous meanings of those words. In a similar vein, Gabora[16] advanced the hypothesis that the most fundamental source of creativity is the tension that guides the efforts to reconcile and unify discordant elements from a global perspective. Some empirical data indirectly support the position expressed by the above mentioned authors. For example, Getzels & Jackson[17] (1962) showed that more creative children prefer to a much greater extent a kind of humour that is

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[9] M. A. Wallach, N. Kogan, *op. cit.*, p. 235-257.

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

[11] A. J. Cropley, *Creativity and Cognition: Producing Effective Novelty*, "Roeper Review", 1999, 21(4), p. 253-264.

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

[13] A. J. Cropley, *Creativity and Cognition: Producing Effective Novelty*, "Roeper Review", 1999, 21(4), p. 253-264.

[14] R. A. Atchley, M. Keeney, C. Burgess, *Cerebral Hemispheric Mechanisms Linking Ambiguous Word Meaning Retrieval and Creativity*, "Brain and Cognition", 1999, 40(3), p. 479-499.

[15] R. A. Atchley, M. Keeney, C. Burgess, *op. cit.*

[16] L. Gabora, *The Beer Can Theory of Creativity*, 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), p.101-107.

based on perceiving contrasts and contradictions. Also, Hastie, Scroed and Weber[18] (1998) found that the more incongruous are the components of a combination, the more numerous are the emergent properties that are generated through such a combination. Kasperson[19] (1978) showed that those people that have a high level performance at the Remote Association Test (Mednick, 1962[20]), a traditional measure of creativity, had also a superior ability to maintain, simultaneously, multiple lines of thinking, having at the same time a larger attention span.

It can be noticed from what has been said above that janusian and homospatial thinking, as associated to creativity, have been approached mainly theoretically or experimentally, but in a much lower degree psychometrically. Even when some divergent thinking tasks required as a response an integration of multiple elements from the stimulus material, those elements were not purposefully chosen to be inconsistent, or very dissimilar. In addition, such tasks allowed for multiple responses, which were assessed nether for their integrative performance, nor for their distinctiveness. As in almost any divergent thinking task, a measurement of how different were the produced ideas was not, in general, considered. A possible reason for that would be the fact that in almost all cases of divergent thinking tasks it would be hard to obtain such a measurement, namely to quantify in a precise manner how dissimilar two responses were.

In view the above considerations, in Faiciuc[21], I tried to elaborate a task that would allow the assessment of an individual's creative performance, considering as criterion the level of synthesis attained in a unique response when the integration of dissimilar components is required. A first step in the direction that I followed was made by Mednick[22] (1962), with his Remote Associations Test (RAT), which was designed to study verbal creativity. The task requires finding a word which has common associative links with three other stimulus words (with rather dissimilar semantic fields). The test contains a list of such combinations of three words, for which a solution is to be found. Unfortunately, it is hard to be translated in Romanian, because its solutions are frequently based on English homonyms. Finding Romanian correspondents in a massive adaptation would not allow for a safe generalization of the results obtained with the English version of the test. In addition, synthesizing only three words, based on rather superficial semantic associations, would not be a task that resembles too much the most common ways of creativity manifestation in everyday life. In such cases, many more elements are synthesized by discovering an integrative global perspective, rather than by finding out a common associative link. An argument for that would be the evidence cited

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[18] T. B. Ward, *op. cit.*

[19] 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.

[20] *Ibidem.*

[21] L. Faiciuc, *op. cit.*, p. 73-85.

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

by Cropley[23] which suggested that RAT is more related to conventional verbal skills than to divergent thinking. So, I tried to combine an aspect from Mednick's[24] (1962) RAT task (dissimilarity of the stimulus words) with the task of another creativity test, constructed by Barron[25] and named by him "Word Rearrangement Test". In this test, the subjects are given a set of 50 words (randomly selected from a list of nouns, adjectives and adverbs). They have to elaborate a story in which to include as many words as they can from the given set. I adapted this task, because I considered that selection at random is not sufficient. So, I initially selected at random a list of 50 words from a dictionary (nouns, adjectives and adverbs), out of which I finally settled for 15, words that I appreciated to be semantically dissimilar from each other. My hypothesis was that a smaller number of words would put more pressure on participants to synthesise the dissimilar words than when they would have a much larger set. With a set of 50 words, the participants would have more freedom to choose only those words suited with an idea of theirs, without the need to change the meaning of the apparently unsuited ones in order to integrate them. In addition, 50 words are hard to be stored and manipulated in memory, participants being forced to select for the integration task only a few of them. Another difference between the task used by me and Barron's[26] one is the requirement to elaborate any kind of literary composition (poem, short dialogue etc.), not only a story. Moreover, the participants' performance was not judged only by using the number of words integrated in the story and the originality in the word synthesis, as in Barron's test. Other criteria were added, which intended to assess the figurative language and metaphorical thinking, originality of some fragments of the composition, logical coherence and the existence of a global perspective (a theme concept) that supports the word synthesis (as compared with a strategy in which the words are synthesized only by narrating a succession of events that are linked only by spatial-temporal contiguity). In the scientific literature on the creativity issue, such kind of task was also cited by Wallach et al.[27], though without clear specifications regarding the exact procedure that was used. 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 criteria based on abstracted similarities, when each object is considered independently) of 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 thematizing was required in order to succeed in the task. They showed that in such a case both the considered group and the one high both in creativity and intelligence thematize. Their conclusion was that the

[23] *Ibidem.*
[24] *Ibidem.*
[25] F. Barron, *Creativity and Personal Freedom*, Toronto, D. Van Nostrand Company, 1968.
[26] *Ibidem.*
[27] M. A. Wallach, N. Kogan, *op. cit.*

respective group displays a bias against thematization, though no inability to thematize. Only when the option not to thematize was available, the high intelligent – low creative group had a lower performance in thematizing. Their finding raises the question whether creativity should be operationally defined on the basis of aptitude or on that ofattitude. In their study they labelled a group as low in creativity by merely talking into account the participants' performance in more traditional divergent thinking tests. In the case of such tests, the participants had more freedom to choose whether to use their creative abilities or not. As a consequence, greater weight was laid on assessing their creative attitude. But in a task in which the participants are forced to integrate very dissimilar elements in a unique response, as in the literary composition task proposed in the present study, the attitude aspect decreases in importance and the ability aspect becomes more prominent in the assessment of creativity. The participants are constrained to change the meaning of the given words (that is, to generate variations of the stimulus material as in any divergent thinking task), whether they prefer it or not when having the freedom to choose. Changing the meaning of the words is needed in order to integrate them and to succeed in completing the task. In that respect, 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 would be required in a creative performance, when forced to do it.

1.4. HYPOTHESES

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

A general hypothesis of the research was that participants with a higher creative performance in 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 this 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 is that people with a lower creative performance should have a tendency towards stereotyped answers. In the case of a free number generation task that would mean that they should tend to generate numeric sequences based on the counting stereotype. More creative people should more easily surpass such stereotyped number sequences generated by counting more easily. Cooperstein[28]

[28] M. A. Cooperstein, *The conjoint evolution of consciousness and creativity*, "Journal of Creative Behavior", 1985, 19, p. 215-217.

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 access to some more distant (less stereotyped) associations. So, in its view, a stereotyped behaviour is primarily due to an ability factor and not to an attitudinal one.

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 Keeling[29] (1971) established a connection between creativity and variability in the cardiac frequency. Similarly, Martindale[30] (1977) demonstrated a relationship between creativity and the spontaneous galvanic skin response. Finally, Martindale[31] (1978) showed there is a link between the EEG alpha waves amplitude and creativity.

In a similar vein, Csikszentmihalyi, Rathunde and Whalem[32] suggested a relationship between creativity and attention (namely its dynamics and its level of distribution), as a psychological manifestation of arousal. This idea was that creative people should have a more flexible and mobile attention, which is distributed over larger fields, so as to allow for 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 Brown[33] (1967). They showed that administration of the LSD psychotropic drug resulted 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.

Gabora[34] elaborated a theory concerning creativity that is also based on some distinctive characteristics of creative people regarding their attentional processes. That theory is grounded on a synthetic study of Martindale[35] (1999), in which the cited author associated creativity with a cluster of four fundamental attributes, identified by reviewing empirical data from the scientific literature of the creativity domain. Supporting the above mentioned idea of Csickszentmihalyi et al.[36], the first attribute was defocused attention, mentioned in empirical studies carried on by various authors (Dewing & Battye, 1971; Dyker & McGhil, 1976; Mendelsohn,

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[29] L. Gabora, *op. cit.*

[30] *Ibidem.*

[31] *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 (ed.), *Altered States of Consciousness*, London, John Wiley & Sons, 1972.

[34] L. Gabora, *op. cit.*

[35] *Ibidem.*

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

1976, apud Gabora[37]). The second attribute concerns an increased sensitivity to details (sustained by authors like Armstrong, 1974; Martindale, 1977, apud Gabora[38]). The third one is considered to be the presence of flat associative hierarchies, a property identified and investigated mainly by Mednick[39] (1962) who considered that more creative individuals tend to have degrees of connectedness among ideas (representations) more uniformly distributed a less creative persons. Sensibility to subliminal stimuli was the fourth considered attribute, its association with creativity being supported mainly by the Smith & Van der Meer's[40] (1994) research.

Gabora[41] suggested that when the first and the second attribute are present we could also expect the presence of the third attribute. Her argument is that flows of conceptual thought are longer, more frequent and continuous 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. That would be equivalent with a flat associative hierarchy property. That is, a concept whose representation is placed at the periphery of the memory area activated at a given moment could lead directly to another concept, whose representation is placed at a very distant zone from that area. As a consequence, in the case of defocused attention, the conceptual network is not only penetrated at a deeper level, but it is traversed more quickly. Consequently, there is an increased probability that in a free thinking task, a thought could engender another thought, apparently unrelated with the former, over a shorter period. That would mean more variability in a free generated flow of ideas and representations. So, it could be said that there is a low correlation between a thought and an ensuing one, when conceptual fluidity is high. At the same time, the conceptual fluidity associated with defocused attention could explain the elaboration of conceptual networks with a more detailed structure (in other words, with an increased sensibility for details) and the building of unique perspectives.

As a conclusion, Gabora[42] suggesed that there are reasons to think that creativity is a property that is characteristic of those dynamic systems (in our case the cognitive system) that are placed at the edge of chaos. This concept was borrowed from the nonlinear dynamic systems theory. In plain words, a system is placed at the edge of chaos when there is an intermediary level of connectivity among the components of that 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. As a consequence, we could expect that

[37] L. Gabora, *op. cit.*
[38] *Ibidem.*
[39] *Ibidem.*
[40] *Ibidem.*
[41] *Ibidem.*
[42] *Ibidem.*

for a network of representations or concepts, the most creative behaviour is obtained when the connectivity is at an intermediary level in that network (in other words the connections are more evenly distributed, as required for a flat associative hierarchy property). So, the cited author considered that in order that a person may have a behaviour characteristic for 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 the periphery of the region with a central zone, which is the most activated. With a defocused attention, that condition would be satisfied to a greater extent. Spreading the activation on a larger area around the central maximum requires a lower activation threshold of the neurons. In such a state, when the cognitive system is at the edge of chaos, Gabora[43] suggested that the experiential (representational) 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. Gabora[44] considered that in order to reach such a state the connections of a conceptual network have to be weakened, by decreasing the neuronal activation threshold. 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 a conceptual network) depends on the density of the connections in that conceptual network. In Gabora's[45] view, that is why, maintaining a state at the edge of chaos requires that the conceptual fluidity to should tuned to the conceptual density, so that the connectivity among concepts may remain relatively constant.

The task of the free number generation seemed to me an appropriate one in order to study the property named by Gabora[46] conceptual fluidity or defocused attention. In this case, the conceptual network is the one that links the assumed 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 could be possible that some properties (like the intensity of the connections, the way they are changed or the mean activation threshold of the network neurons) are about the same, no matter what conceptual network is considered. This assumption was at the origin of the presupposition 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 would result from a higher ability to maintain one's attention defocused). A higher conceptual fluidity would

[43] *Ibidem.*
[44] *Ibidem.*
[45] *Ibidem.*
[46] *Ibidem.*

allow for a greater creative performance in the literary composition task, because it engenders activation of figurative meanings of the given words and more distant associations that could lead to some semantic connection between words that are from distinct semantic fields.

In a free number generation task, a greater conceptual fluidity could be associated with several characteristics of the generated number series. An obvious one would be that the difference between two successive numbers from a series should be greater (on average) for people characterized by a higher ability to maintain their attention defocused (and, possibly, of a higher creativity) than for those of a lower ability of the kind. That expectation is based on the assumption that a larger difference between two successive numbers means that they are more distant in their representational network. On the other hand, a more evenly distributed connectedness in such a network would mean a lower degree of predictability of pair sequences of numbers (in other words, more of the possible pair combinations between two numbers of the given set will be generated as associations between two consecutive numbers). Another characteristic would be that fewer stereotyped numeric sequences based on the counting skill should occur for those of a greater conceptual fluidity, due to weakened connections (greater fluidity) in the number representation network. Implicitly, the three above mentioned characteristics should lead to an increased variability in the generated numeric series (at least, on its lower scales) by those of greater conceptual fluidity, and possibly greater creativity, as it was expressed in the general hypothesis formulated above.

Gabora's[47] suggestion that creativity implies defocused attention, which would create conditions for a mental state placed at the edge of chaos and, implicitly, for a representational flow characterized by self-similarity, could support another hypothesis. It could be expected that the generated number series of those participants of a higher creative performance should be characterized by the self-similarity property (the fluctuation pattern on various scales –in this case sequences length – is similar, but not identical). This implicitly means that they should have long distance positive correlations. That is, the number generated at a given moment will depend on a number generated many moments ago. Such long-time correlations could be associated with a superior ability to integrate information over longer time intervals, as a consequence of a more distant influence in time of the activation of an element on that of others with which it is connected.

To test the above mentioned hypotheses I used for the free number generation task a version in which the given interval of numbers was of the natural numbers between 1 and 99 and the required length of the generated number series was of 200. The present study continues a previous similar research of mine (in Faiciuc[48]).

[47] *Ibidem.*

[48] L. Faiciuc, *op. cit.*, p. 73-85.

In that research, in the free number generation task the given numeric interval was of the natural numbers between 1 and 9, and the generated series were of a 500 number-length. Then, the participants had to write down the generated numbers on paper, by themselves. In the present study the numbers were dictated to a colleague. Another (perhaps) relevant difference was that the participants were students in mathematics, possibly having a more complex representation for natural numbers than other people. Also, in that research, besides the literary composition task another task was used to assess the creative performance of the participants. It 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 could, with the explicit requirement that those rules had 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 small numeric interval (of only nine numbers) made unlikely the generation of series with long range positive correlations. As a consequence, it was not possible to investigate the hypothesis regarding the association between the generation of such number series and their level of creative performance. In addition, in the case of a small set of given numbers, all of them could be held in the short term memory and accessed directly from there. By contrast, in the case of a large set of given numbers, as in the present study, their generation is made by a supposedly different process than by directly accessing them in the short term memory. It can be hypothesized that such a process could imply direct access to a long term memory representation of a number and/or that it could presuppose a combinatorial process. In that case, the units and decimals of a two digits number digits are completed with the ciphers held in the short term memory. Having a larger numeric interval, another hypothesis would be better tested. The participants of a higher creative performance in the word synthesis task would be expected to cover, in generating a number series, more of the given numeric interval. That would mean a greater percentage of the natural numbers between 1 and 99 to be generated and smaller differences between the frequencies of each of them (in other words, a more even distribution). It could then be said, as shown above, that considered in its randomness aspect the generated number series has a higher level of variability.

Summarizing, the creative performance in the literary composition task is expected to be associated positively with:

– the frequency of large differences between two consecutive numbers, that is of distant associations (due to a defocused attention that allows for a more rapid crossing over of the representational network);

– the frequency of negative and null differences between two consecutive numbers (due to a presumed tendency of resistance to counting skill stereotypes, perhaps, also, to the effect of a defocused attention enabling a more evenly distributed connectedness);

– the occurrence of long range positive correlations (due to an intermediary level of connectivity in the representational network) and negatively with;
– small differences between two consecutive numbers (see above why);
– positive differences between two consecutive numbers (see above why);
– the probability of predicting a sequence of two consecutive numbers.

More specific predictions will be made after a more detailed presentation of some descriptive indices for the generated number series which could be considered measures for its variability.

2. METHOD

The present research is, generally, 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 large number of variables.

Participants. 26 first year history students (20 girls and 6 boys) participated in the research.

Tasks, material and scoring procedures. Participants were required to carry out two tasks in a collective session.

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

Although there are no studies on the validity or the reliability of such a task as a creativity probe, some arguments 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[49] (1968) Word Rearrangement Test, which in his research had the highest linear correlations with two other originality measures used by him: T.A.T. Originality (r = .41) and Anagrams (r = .33). Interestingly, it did 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 had one of the highest correlation 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's[50] research, a significant relationship between the performance in the same literary composition task, especially that concerning the stylistic achievement, and the performance in the numeric sequence completion task was found, which, supposedly, required creativity for its execution.

[49] F. Barron, *op. cit.*
[50] L. Faiciuc, *op. cit.*, p. 73-85.

The second task was that of a free number generation. The free number generation task is one in which I asked participants to report whatever number (from a given numeric interval) was in their mind, successively, that is to say (or write) those numbers that freely passed through their minds until a number series of a given length was completed. That task differs from the random number generation task used by other researchers (for example, Towse[51]) in order to study working memory. In that case, there was the constraint to generate random number series, that is series that have the randomness property.

As shown above, in the present research, 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 recorded them on paper.

In my first research[52], there was a significant stability regarding 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 values of the indices obtained for number series generated by the same subjects at a month interval. The linear correlation coefficients had values higher than 0.5, significant at a $p < .001$ level. So, it could be said that there are reasons to suspect that the values obtained for descriptive indices are associated with some individual constants of the processes involved in the generation of the numeric series.

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

The first of them, RgCalc, was designed by Towse and Neil[53] 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, indicating no redundancy, that is perfect equality of response alternative frequencies, and 1, indicating complete redundancy, when the same response choice is used for the entire series);

– *The response frequency* for each alternative response (number from the given interval);

– *Random number generation (RNG)*, which describes the distribution of the response pairs or, in other words, the dependency between one choice and the next, 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

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[51] J. N. Towse, *On random generation and the central executive of working memory*, in „The British Journal of Psychology", 1998, 89, p. 77-101.

[52] L. Faiciuc, *op. cit.*, p. 73-85.

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

of the possible responses that were repeatedly used, 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 Diagrams (RNG2)*, which 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 (of numbers separated only by the minimal 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) and another for the percentage of descendent adjacent pairs of numbers (when the first value is higher than the second);

– *Turning point index (TPI)*, which 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 accordance with Azouvi et al[54] (1996) who showed that patients with closed head injuries produced a lower TPI than did controls, it could be said that TPI indicates the run/strategy, where individuals produce an arithmetic chain of responses (based on counting skills);

– *Phase length*, which 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*, which describes the variability in the phase length;

– *The first-order differences*, which indicate the frequencies of the arithmetic differences 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, based on them, like in my previous research, other descriptive indices: the percentage of large, or small first-order positive, negative or absolute differences (higher or lower than 20 as an absolute value as well as higher or lower than 10 as an absolute value), the percentage of null differences between two successive numbers. The values of 20 and, respectively, 10 were chosen after a survey of the graphical representation of the mean frequency for each possible difference and after statistically analysing by means of Mann-Whitney test the significance of the difference between two mean frequencies. Those values proved to be closer to two thresholds associated with marked changes in the mean frequency of the difference between two consecutive numbers. Beyond a difference of approximately 20 the mean

[54] *Ibidem.*

frequency is extremely low, rarely surpassing a value of 1. Differences smaller than 10 had mean frequencies in the interval between 4 and 8.

It should 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 Goldberger[55], on the ground what they called the Detrended Fluctuation Analysis method. It computes a fractal scaling exponent α, which provides a measure of the "roughness" of a time series. The larger its value, the smoother its time series. At the same time, it can be said that it is a measure of the level of the self-similarity and, implicitly, it indicates the occurrence of long time correlations in the series. In other words, it shows the relationship between the fluctuation on smaller and that 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, persistent long-range power-law correlations in the series occur, where relatively large observations tend to be followed after some interval by additional larger observations. When α is 1, we have a special case, named the 1/f noise (or pink noise), a kind of noise that is frequently met in the time series obtained by measuring natural phenomena, inclusively neuropsychological ones. It indicates the properties of a time series generated by fractal processes, which result in irregular fluctuations across multiple scales, characteristic for the self-similarity property. It is the case of a series possessing dependencies at many, or all, examined time scales. When α is lower 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 ones 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, on 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 by using several evaluative dimensions: the number of the given words integrated in composition, the number of the given 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 (the level of thematization) that supports the integration of

[55] 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.

the given dissimilar words (which means employing a strategy different from that of a simple description or narration that reach the integration only by spatio-temporal contiguity), and global originality. Theoretical arguments for the meaning and the importance of a thematic thinking (or of an ability to thematize) for the creativity assessment could be found in Faiciuc[56]. By using some of these dimensions, I tried to improve the quantification in the assessment of the originality, beyond a subjective global score. The last three dimensions were evaluated on a scale of seven points (from 0 which means lack of the considered attribute to 7 which means the highest level for the assessed dimension). In general, some of the above mentioned dimensions correspond to those criteria considered necessary for the assessment of a creative product by Bessemer and Treffinger[57] (1981) when they elaborated the Creative Product Analysis Model. The first criterion refers to novelty (surprise, originality). The second criterion was named by them resolution (meant to show how logical, useful, valuable and meaningful a creative product can be). The third is the level of elaboration and synthesis, that is how well distant elements are integrated into a coherent whole, resulting in an organic, refined and elegant product.

The data obtained from the literary composition task by evaluation on the above mentioned scales were synthesized by factorial analysis, employing the principal components method with a Varimax rotated solution. Three factors were retained that had eigenvalues higher than 1. The first factor explained 50% of the variance in the results and could be linked with an associational variation generation aspect of creativity (manifested in stylistic, metaphorical and original thinking). It correlated the most with the assessed dimensions for global originality, figurative meanings of the words, stylistic figures and original images. The second factor covered 21% of the total variance and it can be associated with a synthetic aspect (janusian and homospatial thinking) of the creative performance (the ability to integrate disparate elements in a coherent whole). It correlated the most with the 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 each of the above mentioned factors.

Two independent evaluators rated the literary composition for each participant on the seven dimensions mentioned above. One was the author, the other one was a literature teacher. However, in the data processing only the scores obtained from the author were taken into account.

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[56] L. Faiciuc, *Rolul organizării tematice a cunoştinţelor în performanţa creativă*, „Studii şi cercetări din domeniul ştiinţelor socio-umane", Cluj-Napoca, Edit. Argonaut, 2001, p. 73-85.

[57] S. P. Besemer, K. O'Quin, *Confirming the Three Factor Creative Product Analysis Matrix Model in an American Sample*, "Creativity Research Journal", 1998, 12 (4), p. 105-109.

3. RESULTS

The main specific hypothesis of the present study was that there should be an association between the above presented descriptive indices for the variability in the generated series, computed with RgCalc and DFA programmes, and the level of the creative performance in the literary composition task.

A positive correlation was expected between the creative performance and the mean frequency of occurrence of large positive, negative or absolute 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 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, phase length, the mean difference between two successive numbers (expressing the ratio between the negative and positive differences), the mean frequency of negative, positive, absolute differences smaller than 10, or smaller than 20. As in our previous study, there was an association between some DFA indices (indicating the characteristic fluctuation at a given window size) and creative performance, it was expected that they should occur also in the present research.

Considering the small volume of our sample and the fact that some variables had an asymmetric distribution, it was preferred to compute nonparametric correlation coefficients in order to estimate the association between the investigated variables. 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, level of coherence, presence of a theme, the global originality) with all the above mentioned descriptive indices for the generated number series were computed with RgCalc and DFA.

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

Table 1

Spearman and Kendall's tau-b 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

Spearman correlation coefficients for the stylistic factor score

	DFA6	DFA7	DFA8	Mean frequency of the null differences
Stylistic factor score	**ρ = 0.348** p = .04	**ρ = 0.374** p = .03	**ρ = 0.361** p = .03	**ρ = 0.378** p = .028

Table 3

Spearman 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	**ρ = - 0.329** p = .05	**ρ = - 0.395** p = .023	**ρ = - 0.383** p = .027

Table 4

Kendall's tau-b correlation coefficients for the number of original images score

	Mean frequency of null differences	Mean frequency of ascendening pairs of successive numbers
Number of original images score	**τ = 0.318** p =.03	**τ = - 0.279** p =.036

Table 5

Kendall's tau-b correlation coefficients for the coherence score

	DFA10	DFA11	DFA12	Mean frequency of negative differences smaller than 20	Mean frequency of null differences	Mean repetition length
Coherence score	**τ = -0.263** p = .036	**τ = -0.257** p = .04	τ = -0.237 p = .053	**τ = -0.291** p = .025	**τ = -0.293** p = .024	τ = -0.228 p = .063

Table 6

Kendall's tau-b correlation coefficients for the global originality score

	Mean frequency of the null differences	Mean of the differences between two successive numbers
Global originality score	**τ = 0.308** p = .032	**τ = - 0.284** p = .029

In order to appreciate the level of agreement between the two evaluators that rated the creative performance at the literary composition task (the inter-rater reliability), the nonparametic correlation coefficients Kendall tau-b between the scores assigned for each evaluative dimension to each participant by the two raters were computed. All of them indicated a significant positive association between the ratings of the two evaluators. The values obtained for each dimension are reported in the *Table 7*.

Table 7

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

The number of words from the given set integrated in composition	The number of the words from the given set used with a figurative meaning	The number of stylistic figures	The number of original images	The level of logical coherence and integration	The level of thematization	Global originality
τ =0.756 $p < .001$	**τ =0.854** $p < .001$	**τ = 0.848** $p < .001$	**τ =0.712** $p < .001$	**τ =0.598** $p < .001$	**τ =0.848** $p < .001$	**τ =0.814** $p < .001$

4. DISCUSSION AND CONCLUSIONS

the specific hypothesis, Data supported only a few of the specific hypotheses. As expected, there was a negative association between a global score for the creative performance in 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, at least partially, 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 of a higher creative performance. Another possible explanation is the one based on a higher level of defocused attention for those with greater creative performance, which enables them to generate more distant elements.

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 in the given set and since in our case this set was rather large and the

series length rather short, the redundancy index was not quite informative regarding the series randomness. A similar reason could be invoked to explain the missing association with the phase length. As there were many numbers to choose, the shorter phases were less likely to occur than in our previous study. Maybe a similar explanation would hold in case of the absence of any association with the ascending pairs of successive numbers, less likely to occur in the case of a large set of given numbers. However, with ascending pairs the expected negative association was found, but only in the case of the score for the number of original images.

No negative association was found, 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 that 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 positive associations 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 were found, though 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 higher than 20 or 10 in absolute value, frequency of the peaks and troughs, mean frequency of the negative differences or of the self-similarity α coefficient. The first three of the missing expected associations could perhaps be explained, as above by considering the large set of the given numbers. When the given number interval is large some combinatorial operations could be expected to be 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 only occur on the ground of activation spreading for differences lively to range as 20, or somewhere around. Several answer could be provided 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. The first of them is based on the fact that for differences higher than 20 in an absolute value, the incidence was so low, 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 of $p = .05$). A second answer is concerned with a tendency of the general population to prefer positive differences (a significant difference was found by comparing with the mean frequencies for positive and negative differences higher than 20 in absolute value: $t(25) = -7.225$, $p<.001$, the mean frequency for the positive ones being twice higher the mean frequency for the negative ones). So, for higher levels of creative performance, at least with regard to coherence factor we could have expected, that tendency to be manifest to a lesser extent (by avoiding this general stereotype), to

counting in the opposite direction being harder (data support this view by a result that tends to be close to the significance threshold of $p = .05$). But it seems to me that such a preference for generating negative differences, tends to occur rather to the benefit of the much larger absolute negative difference, at the expense of the smaller ones, which would tend to have a lower incidence.

In the case of a large number set, the frequency of the turning points is also likely to be low, 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 the respective association was hard to be render evident due to a reason opposed to the invoked for the first study. There are only a few of the subjects (three of them) had values higher than 0.5 for the self-similarity coefficient, the majority of them generating series characterized by anti-correlation (with an α coefficient lower than 0.5). By changing the free number generation task to one with a larger set of given numbers, almost all participants had series with an α coefficient higher 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 on the ground of their 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 of 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 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 extant in a number series.

By comparison with our previous study, in the present one a positive association with some DFA indices occured, separately, for the coherence and the stylistic factor and not for the entire composite score. Another difference is that the association refers to windows of different sizes. Whereas in the previous study positive associations for window sizes of 5 or 6 numbers were found, in the present one there is 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 to the DFA6, DFA7 and DFA8 indices). The change might also be related to the larger set of alternative responses given for choice, which does not facilitate obtaining fluctuation differences on the shortest sequences. By contrast, there was a negative association 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) as well as 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 with regard to 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 of highest creative performance, that would presumable have both the above mentioned abilities, should present in a free associative task 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 longer ones. It has been said that the α coefficient indicates how "rough" a temporal or numeric series is on its various scales. Following our results, there is reason to believe that for people of higher creative performance the generated series is "rougher" only for some of the smaller scales. 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. There is a possible explanation for the differences between the two studies regarding the positive association of the fluctuations on smaller window sizes with the global score for composition, in one case, and the stylistic factor, in the other. It could be based on the observation that for window sizes of 5 or 6 numbers (for which in this study there was an association with the global score) there no correlation was found between the coherence score and DFA indices for those window sizes. But, 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 would in the end have no association with those indices. Such contradicting results regarding the characteristics of the generated series on different scales 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. A theoretical speculative support for such an hypothesis would be the following idea. In order to synthesize disparate ideas, a rapid alternation between generated opposing representations would be required. In terms of the results obtained in my study, that would mean that variation

generation measures (the stylistic factor) should be positively associated with higher level of fluctuations (variability) on short time scales. An additional requirement for a synthesis of disparate elements would be the presence of a global structure (a theme, for example), developed at a higher level of organization, in which the elements placed on lower level of organization could be integrated. That would mean that coherence measures should be negatively associated with variability (fluctuations) on longer time scales.

By comparing the results of the two studies, one can observe that there are both similarities and differences between them.

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 are 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 pairs of numbers (in the first study they correlated with the coherence factor, in the present one with the frequency of the original images). It can therefore be observed 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 (for example TPI and the phase length) and other indices for those generated with larger sets of given numbers (for example RNG and RNG2).

There are several explanations for the most constant result of the two studies, the one referring to null differences. 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 has been revealed in several studies (for example, Towse[58]). A more speculative explanation would be that people able

[58] J. N. Towse, *On random generation and the central executive of working memory*, "British Journal of Psychology", 1998, 89, p. 77-101.

to reach for those that had a higher level of creative performance display a tendency toward a more intensive activation of a number representation, or to one that persists longer so that the corresponding number will continue to be generated several times consecutively, until its activation fades away, and a sudden transition to a very distant number can possibly occurs

A general conclusion would be that there are some signs of an association between the creative performance (operationally defined as a word synthesis ability) in the literary composition task and the variability of the series resulted from a free number generation task. But there are only signs, and not very clear results. The expected associations were not manifested with the anticipated power and for all the computed variability indices. Multiple reasons could explain the obtained results.

The first of them would be that the volume of the sample was rather small and there are reasons to suspect that the participants were rather homogeneous in their performance, being of a rather medium level of creativity (there were extremely few cases – one or two – that had a somewhat more remarkable creative performance). So, it was difficult to reveal all the expected differences. An argument in that direction would be the fact that many of the envisioned differences were close to the statistical significance threshold of $p = .05$.

Another possible reason would be that the scores obtained in the literary composition task could not be considered a valid and reliable measure of the creative performance, especially for that aspect of creativity which refers to the ability to integrate disparate elements into a coherent whole. Or, they are a reliable and valid measure only in the case of verbal creativity and not in general. The traditional dispute between general and specific creativity is relevant in this case. A general creativity, which is supposedly more associated with some characteristics of the free associative thinking, would be hard to be made evident with specific creativity tasks, in which that kind of creativity could be the dominant factor in performance. As pointed out in the introductory part of the study, conceptual fluidity (the ability to generate distant variations) is not sufficient for a creative performance. A dense conceptual network, acquired by learning the specific knowledge of a domain, would also be required.

In addition, another general explanation would be that defocused attention, supposedly manifest in some of the features of the series produced by free number generation by the most creative participants, may not be a permanent or constant property of the psychic activity of an individual of higher creativity. As shown by Martindale[59], such a defocused attention would occur predominantly when one is in a creative state, some time before and during a creativity task. So, it would be rather hard for anyone to leave marked traces in the performance of a free number generation task when (s)he is not in a state of "inspiration".

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[59] 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.

The attitudinal aspect of creativity may also have played a role in the obtained results. As it was shown in the Wallach's et al.[60] research, presented in the introductory part of the paper, there are people who, despite their 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 generation task, in case that some conscious attitudes matter in performing the task, such people would 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 would have a similar creative performance with those that are additionally creative from an attitudinal point of view. A distinction made by Guilford[61] between spontaneous and adaptive flexibility is relevant with regard to this issue. In the case of spontaneous flexibility, 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 solutions of a most unusual kind and which might seem soluble by more conventional methods[62].

The above-made considerations may be 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, a 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 possible. 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 and strategies that would lead to some preferential choices. But it would also be true, that it is less likely that such "strategic" choices (which would consider the frequency of the previous responses) to be made systematically, due to that length of a generated series (which makes difficult the monitoring of the previous responses or sequences of responses).

In conclusion, the obtained results did not offer a clear answer to the questions advanced at the beginning of the paper. But they may seem encouraging for an extension of the research, with a sounder methodological design. They offer some hope because, still, there were found 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 manner, as they come to their mind, (when no regularity would be expected by many observers).

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[60] M. A. Wallach, N. Kogan, *op. cit.*

[61] 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, p. 235-257.

[62] *Ibidem.*