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Current methodology and methods in psychophysiological studies of creative thinking

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Abstract

Important points on methodology and detailed description of methods used in polymodal psychophysiological studies of human verbal creative thinking are presented. The psychophysiological studies were conducted with healthy volunteers during implementations of specially developed and adapted psychological tests aimed to bring the subjects into states of verbal creative thinking. Four different task sets (''story composition'', ''associative chains'', ''original definitions'', ''proverb sense flipping'') were developed and applied. Positron emission tomography of regional cerebral blood flow (rCBF) and state-related quantitative electroencephalography (power and coherence evaluated) were used. The effectiveness of the methods is illustrated with figures.

Keywords: Psychophysiology; Creativity; Creative thinking; Methods; Tests of creative thinking; Regional cerebral brain flow; Quantitative electroencephalography

1. Introduction

Contemporary methodologies in cognitive neuroscience allow us to answer questions about the psychophysiology of mental performance in the normal and diseased brain. Scientific work today provide us with ample evidence that there is rapid progress in studying the highest form of human mental activity–creative activity. The complexity of the subject under investigation and the different experimental paradigms used account for the fact that the data currently available do not always agree well. As such psychological tests and physiological methods should be deliberately varied according to the aims of the study and the phenomena investigated for the simple reason that no single method is the only one for solving a problem of such complexity. For the same reason, close cooperation of several research groups is not only highly desirable but is ''a must'' in order to achieve genuine progress. Furthermore, clarity in the methods is a necessary condition for such cooperation and the publication of the present volume ''Models for the study of creativity in animals and man'' is a timely and valuable contribution to the field in this regard.

In the present paper we explain some essential aspects of our methodology. We also provide a detailed description of the methods used in our psychophysiological studies of human verbal creative thinking. All studies were conducted with healthy volunteers, using psychological tests specially designed to bring the subjects into states of verbal creative thinking. Positron emission tomography (PET) measuring regional cerebral blood flow (rCBF) and state-related quantitative electroencephalography (EEG) were our main tools. The effectiveness of the methods is illustrated in various figures.

2. Methodology, general considerations

Studies of creativity are considered a higher level of research into brain and mentality, its further progress and evolution. Due to the integration of cognitive psychol-

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ogy, neuropsychology and cognitive neurophysiology achieved during the last decade, it has become possible to attack this problem. The latest advancements in technology, especially rCBF investigations using PET and fMRI, play a particularly important role here.

As a science, the psychophysiology of creative thinking is still in its infancy. There is but a small number of publication on the topic, most on either EEG [1–11] or PET [12–17], which is due mainly to the complexity of the problem. But even this relatively modest number of studies on the brain's creative mechanisms has been of great importance to elucidating a wide range of problems, be they philosophical, medical, pedagogical or technical.

The current psychophysiological literature [18] contains more than 60 different definitions of creativity. Thus, creativity cannot be considered as being rigorously defined, but there is a certain consensus that creativity yields something partly or entirely new; gives existing objects new properties or characteristics; allows one to imagine new potentialities not conceived of before and to see or perform something in a manner different from what was thought possible or normal previously. These concepts also guided our research and the selection and design of our psychological tests.

A distinction between the creative person, the creative product, the creative process, and the creative influence of the environment has been outlined by Rhodes [19]. Each of these factors is an important component of creative activity. In our studies, we have concentrated on the creative process (creative thinking in particular), assuming that creativity is a common trait of people and, as such, more or less inherent in any healthy human being.

Tests designed to study the living brain with a conventional contrast analysis, are the main obstacles in this regard. This is due to the intimate link between the creative process and on-going brain activity. One should seek to differentiate between the effects caused by a creative process and on-going activity on the one hand, and those caused by stress factors of mental and emotional loads. This is necessary so that the research can distinguish between the effects of quantitative brain resource mobilization and those of system dynamics inherent in the activities. The psychologist faces a challenge here that is like that of Scilla and Haribda, (When sailing through a strait Odisseus had to choose between two evils, the Scilla rock on one side of the strait and the storming Haribda waters on the other).

This makes it very difficult to study brain correlates of creative thinking. In terms of methodology, this situation demands, that "double tests" be introduced. That is, at least two variants of creativity and control tasks should be applied in the same experiment. These variations have to allow the analysis of unavoidable factors, primarily those intimately tied to the complexity of the task. The mechanisms that are potentially important in the implementation and optimization of creative thinking must be considered as early as possible.

A wide scope of psychophysiological investigations , explicating underlining brain mechanisms reveal the expediency and necessity of polymethodical (polymodal) physiological description/analysis of local and global brain dynamics. Studies combining brain hemodynamics (PET/fMRI) and electrodynamics (EEG/MEG) data are currently considered to be the best approach to deal with the challenge [20]. Polymethodical results have to be treated as complementary ones. Any divergence in the data between these methods can be even more informative than the convergence because of the principal differences in the correlations of the measurable values in synaptic activities [21–23]. This is why we attempt to utilize both PET and EEG within the same psychological paradigms.

There is a pressing demand for psychological tests of creativity that are compatible with these techniques in several parameters, such as time formats, presentation of stimuli and control, as well as fundamental ideology.

All this makes the psychophysiology of creativity and creative thinking extremely difficult to study.

3. Psychological aspects of methodology and psychological tests used

It is noteworthy that psychological approaches vary widely in different laboratories, which makes the investigations hard if not impossible to compare.

Psychological tests (tasks) for our studies were designed on certain premises.

There was enough psychological evidence to assume that fast cognitive leaps or intuitive insight are essentials for creative thinking [24]. But we do not share the view that only the above mentioned transitory brain processes condition for a creative thinking as different from a non-creative one. A search for brain correlates of creative thinking compatible with temporal resolution of state-oriented physiological measurements (PET and state-oriented EEG) seemed justified to us, too. Proper psychological tests here should provide more or less uniform sustained creative processes in subjects in time intervals long enough for sufficient data acquisition.

Psychophysiological investigations in humans are mostly based on comparisons (contrasts) between situations and a within-subject comparison design in the group under study. Comparisons between good performers and poor performers are possible and used. The method, however, is less sensitive (group comparisons) and demands a substantially larger number of participants because of the high inter-individual scatter in data. In initial psychophysiological studies of creative thinking it is reasonable to stay within the frames of the within-subjects design and divide tasks into more creative, less creative and non-creative.

We cannot precisely estimate all cognitive and emotional factors influencing the human brain during creative activities. Here along with multifactor contrasts in a certain experiment, one should be able to compare the results obtained from the tasks which belong to the same type, e.g. verbal creative tasks, but are somewhat different ("story composition", "associative chains", "original defi-