

CHAPTER – 7

RESULTS

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CHAPTER – 7 - RESULTS

7.0 RESULTS

In the first subsection data are presented describing between-groups differences based on demographic variables, in the second sub-section, inter-rater reliability procedures, statistical procedures and statistical analysis are presented. In the third subsection data are presented describing within and between group differences in scores on the ATTA i.e., Abbreviated Torrance Test for Adults. In the fourth sub-section EEG data is presented describing the neural activity in the regions of interests (ROI) based on the hypothesis i.e. frontal (F3, F4) and parietal (P3, P4). Here a two-way repeated measure ANOVA with post-hoc testing is presented showing within-group and between-group differences in task related gamma activity in the experimental group and delta activity in the control group. In the final subsection results from a partial correlation analysis are presented describing the relationship between neural activity occurring during performance in Creativity and cyclic meditation as mediated by the Abbreviated Torrance Test for Adults (ATTA) for Creative Cognition, based on the dimensions of fluency, flexibility, originality and elaboration.

The results section is divided into the following main sub-sections:

- (a) Demographic Differences between Groups,
- (b) Reliability Measures,
- (c) Creativity Tests – ATTA (Abbreviated Torrance Tests for Adults)
- (d) Electroencephalogram (EEG) and
- (f) Partial Correlations

7.1 DEMOGRAPHIC DIFFERENCES BETWEEN GROUPS

The data shows that there was homogeneity between the groups, experimental and controls in both the experiments. Experiment 1 had 120 subjects in each group, with 59 males aged 29.5 ± 8.1 years and 61 females aged 32.5 ± 6.7 years in CM group (av. 31.0 ± 7.5 yrs), and 59 males aged 34.0 ± 9.0 years and 61 females aged 29.5 ± 8.9 years as Controls (av. 31.8 ± 9.2 yrs).(Refer Table 7.1)

Table No.7.1 - Showing Mean and SDs - Experiment 1

	Nos	Experimental	Nos	Control	Nos
Total	120	30.97± 7.49	120	31.83 ±9.17	240
Male	59	29.47±8.06	61	32.97 ±9.03	120
Female	61	32.47±6.67	59	29.55 ±8.90	120

Table 7.1 displays the Ages of the Subjects in the two groups giving Means & SDs, in the experiment 1.

Experiment 2 completed assessments of 12 of the original 15 subjects in each group. It comprised 10 males aged 29.2 ± 6.9 yrs and 2 females aged 21.5 ± 0.7 yrs in the CM group (av. 27.9 ± 6.9 yrs), and 8 males aged 27.3 ± 9.4 yrs and 4 females aged 27.0 ± 6.9 yrs as controls (av. 27.2 ± 8.3 yrs). (Refer below Table No.7.2)

Table No.7.2 - Showing Mean and SDs – Experiment 2

	Nos	Experimental	Nos	Control	Total
Total	12	27.92± 6.94	12	27.17±8.3	24
Male	10	29.2± 6.92	8	27.25±9.38	18
Female	2	21.5±0.71	4	27±6.88	6

Table 7.2 displays the Ages of the Subjects in the two groups giving Means & SDs, in the experiment 2.

7.2 CREATIVITY SCORES - ATTA

Scores on the ATTA test before and after the interventions for Experiments 1 and 2 are given in Tables 7.1 and 7.2 respectively. Experiment 1, conducted in two phases for two groups of 120 with 60 in each group, experimental as compared and controls, and gave consistent results. (Refer below Table No.7.3 and Figure 7.1) below.

Table 7.3: ATTA Creativity Scores for Experiment – 1

Creativity Variables	CM			SH		
	Pre	Post	%	Pre	Post	%
Fluency	21.57 ±4.44	25.03 ± 3.07***	16.07	20.98±4.20	20.43±3.71*	2.621
Originality	16.37± 4.80	17.38 ± 5.43	6.21	15.28±4.87	14.80 ±4.73	3.162
Elaboration	19.60 ±4.98	20.53 ± 5.51	4.76	18.98±4.99	18.98 ±4.57	0.000
Flexibility	11.02±3.037	11.30 ± 4.16	2.57	10.70±2.86	10.73 ±2.95	0.312
Total Scores	67.75 ± 9.76	74.63 ± 3.84***	10.16	65.95±9.68	64.50±8.41*	2.199
Level	4.02 ± 1.28	4.92± 0.67***	22.41	3.65±1.29	3.68±1.27	0.913

Table No. 7.3, showing the pre post result of experiment 1, between the two groups i.e. experimental (CM) and control (SH), in the dimensions of fluency, originality, elaboration and flexibility.

Figure 7.1 – ATTA Creativity Scores for Experiment – 1

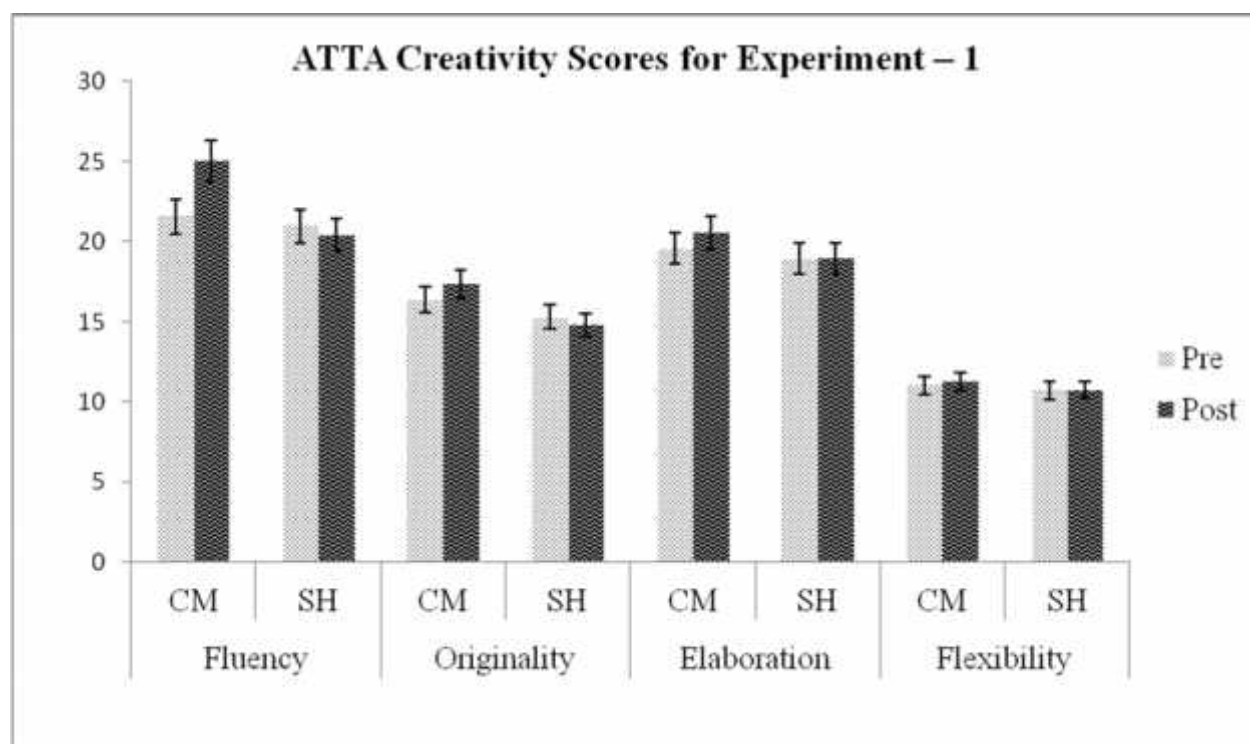


Figure No. 7.1, showing the pre post result of experiment 1, between the two groups i.e. experimental (CM) and control (SH), in the dimensions of fluency, originality, elaboration and flexibility.

The equivalent results for the second Experiment measuring Creativity and Brain Wave Synchronization in Frontal and Parietal lobes are set out in (Table 7.4 and Figure 7.2) below.

Table 7.4: ATTA Creativity Scores for Experiment - 2

Creativity Variables	CM			SH		
	Pre	Post	%	Pre	Post	%
Fluency	19.75±1.05	26.66 ± 1.43***	34.99	18.75 ± 2.53	18.25 ± 2.09	2.67
Originality	9.33 ± 1.72	16.83 ± 3.80***	80.39	13.17 ± 4.24	9.17 ± 1.40 *	-30.37
Elaboration	19.41 ± 2.19	25.25 ± 1.91***	30.09	18.50 ± 3.53	18.92 ± 2.97	2.16
Flexibility	8.66 ± 1.55	9.75 ± 2.34**	12.59	8.50 ± 1.00	12.08 ± 3.18 **	42.12
Total Scores	65.91 ± 5.26	77.66 ± 2.49***	17.83	60.42 ± 6.35	59.92 ± 8.17	-0.83
Level	3.58 ± 0.66	5.33 ± 0.49***	48.88	3.67 ± 1.30	2.58 ± 1.08 ***	29.70

Table No. 7.4 showing the pre post result of experiment 2, between the two groups i.e. experimental (CM) and control (SH), in the dimensions of fluency, originality, elaboration and flexibility.

Figure 7.2 – ATTA Creativity Scores for Experiment – 2

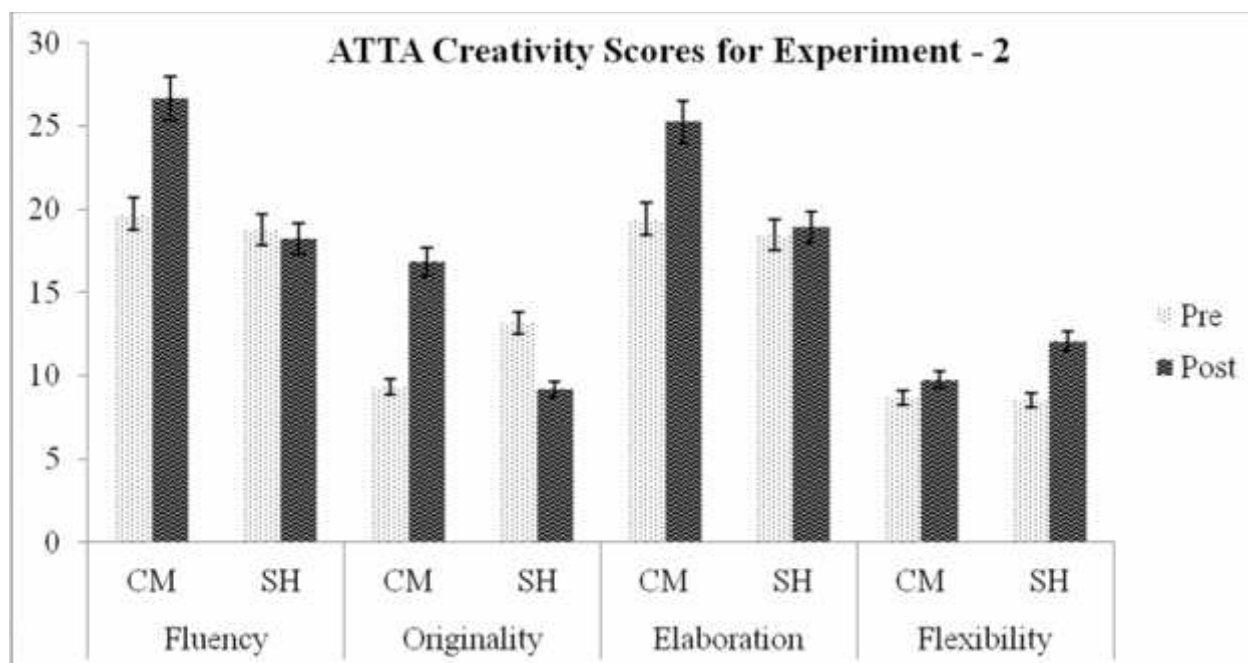


Figure No. 7.2 showing the pre post result of experiment 2, between the two groups i.e. experimental (CM) and control (SH), in the dimensions of fluency, originality, elaboration and flexibility.

Following section shows Table No. 7.5, and 7.6, the pre post result of experiment 1 and 2, with the % ge changes and p-value, between the two groups i.e. experimental (CM) and control (SH), in the

dimensions of fluency, originality, elaboration and flexibility, in the pre-post testing sessions, in both the experiments.

Table 7.5: ATTA Creativity Scores for Experiment – 1 (% change & p-value)

Creativity Variables	Cyclic Meditation		CM		Shavasana Controls		SH	
	Pre	Post	% change	p value	Pre	Post	% change	p value
Fluency	21.57 ± 4.44	25.03 ± 3.07***	16.07	0.000	20.98 ± 4.20	20.43 ± 3.71*	-2.621	0.042
Originality	16.37 ± 4.80	17.38 ± 5.43**	6.21	0.008	15.28 ± 4.87	14.80 ± 4.73	-3.162	0.355
Elaboration	19.60 ± 4.98	20.53 ± 5.51*	4.76	0.015	18.98 ± 4.99	18.98 ± 4.57	0.000	1.000
Flexibility	11.02 ± 3.037	11.30 ± 4.16	2.57	0.919	10.70 ± 2.86	10.73 ± 2.95	0.312	0.912
Total Scores	67.75 ± 9.76	74.63 ± 3.84***	10.16	0.000	65.95 ± 9.68	64.50 ± 8.41*	-2.199	0.019
Level	4.02 ± 1.28	4.92 ± 0.67***	22.41	0.000	3.65 ± 1.29	3.68 ± 1.27	0.913	0.755

Table No. 7.5, showing the pre post result of experiment 1, with the % ge change and p-value, between the two groups i.e. experimental (CM) and control (SH), in the dimensions of fluency, originality, elaboration and flexibility, in the pre-post testing sessions.

Table 7.6: ATTA Creativity Scores for Experiment – 2 (% change & p-value)

Creativity Variables	Cyclic Meditation		CM		Shavasana Controls		SH	
	Pre	Post	% change	p value	Pre	Post	% change	p value
Fluency	19.75 ± 1.05	26.66 ± 1.43***	34.99	0.000	18.75 ± 2.53	18.25 ± 2.09	2.67	0.352
Originality	9.33 ± 1.72	16.83 ± 3.80***	80.39	0.000	13.17 ± 4.24	9.17 ± 1.40*	-30.37	0.02
Elaboration	19.41 ± 2.19	25.25 ± 1.91***	30.09	0.000	18.50 ± 3.53	18.92 ± 2.97	2.16	0.664
Flexibility	8.66 ± 1.55	9.75 ± 2.34**	12.59	0.02	8.50 ± 1.00	12.08 ± 3.18**	42.12	0.006
Total Scores	65.91 ± 5.26	77.66 ± 2.49***	17.83	0.000	60.42 ± 6.35	59.92 ± 8.17	-0.83	0.768
Level	3.58 ± 0.66	5.33 ± 0.49***	48.88	0.000	3.67 ± 1.30	2.58 ± 1.08***	29.70	0.000

Table No. 7.6, showing the pre post result of experiment 2, with the % ge change and p-value, between the two groups i.e. experimental (CM) and control (SH), in the dimensions of fluency, originality, elaboration and flexibility, in the pre-post testing sessions.

7.3 SYNCHRONY AND ASYMMETRY – EEG

An asymmetry scores for the power frequency was used to investigate relationship between CM and Creative Cognition. The asymmetry matrix computed using methods following work by Fink and Carlsson^{215,331}, as explained in detail in chapter 2, and provides a measure of degree of the left or right brain activation. Separate anterior and posterior analyses were computed for comparison by aggregating homologous leads in each regions of interest (F3-F4, P3-P4). Positive power scores are indicative of greater power shift at the right compared to the left aggregated electrodes sites, which is

assumed to reflect greater left-sided to right brain activation. Conversely, negative scores are indicative of greater right-sided brain activation and positive scores indicate left sided activation. In our study we correlated right sided asymmetry, correlated to gamma indicating heightened awareness, temporal-spatial binding, and salience, in the CM group as compared to that with the shavasana group. (Refer Table 7.8)

To estimate the degree of asymmetry in brain regions of interest (ROI), we analyzed the data in within-subject design. For each subject, estimates of the power were computed and averaged across the trails of each categorized session. Electrodes were collapsed into electrodes clusters as shown in refer back Figure 6.4, resulting in frontal and parietal means for each hemisphere. Asymmetry indices were then computed by subtracting the natural logarithm of left-sided power scores from natural logarithm of left-sided power and Asymmetry Index = $\ln[\text{right power}] - \ln[\text{left power}]$. Assuming an inverse relationship between the dominant power and cortical activation, a more positive asymmetry index reflects a greater relative left hemisphere activity and vice versa. Finally, asymmetry indices for control vs. Experimental subjects were subjected to paired t-tests for the frontal and the parietal regions, respectively.^{266,348, 350}

Table 7.7: EEG Data Asymmetry between the frontal (F3, F4) & parietal (P3, P4) & Synchrony Scores

Creativity Dimensions	Brain Regions, Electrodes	CM Mean ± SD	SH Mean ± SD	Independent ‘t’ test p value
Fluency	F3, F4	85.67 ± 2.54	18.50 ± 2.29	0.001
	P3, P4	71.33 ± 5.82	10.17 ± 2.34	0.001
Originality	F3, F4	62.67 ± 2.80	10.33 ± 1.77	0.001
	P3, P4	72.83 ± 2.08	8.33 ± 1.30	0.001
Elaboration	F3, F4	74.63 ± 3.25	46.33 ± 3.07	0.004
	P3, P4	66.50 ± 3.312	16.33 ± 1.17	0.025

Table 7.7 showing - F3,F4 – Frontal Regions left and right Electrodes, P3, P4 – Parietal Regions left and right electrodes. CM – Cyclic Meditation, SH –Shavasana.

Figure – 7.3 EEG Asymmetry and Synchrony

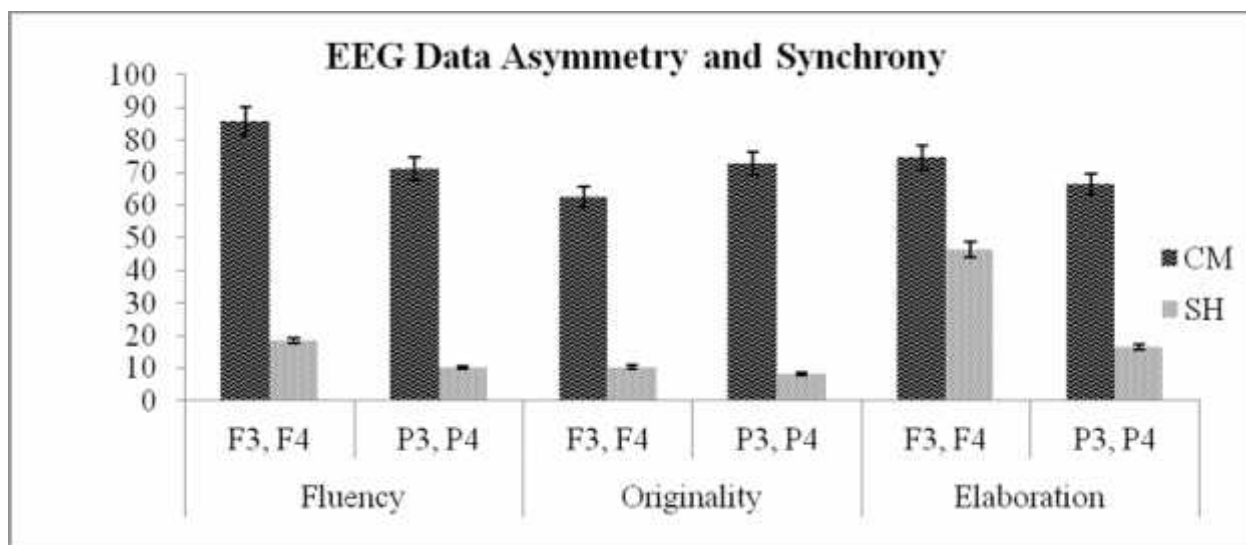


Figure-7.3 depicts the EEG result of asymmetry and synchrony, in experiment 2, in the dimensions of fluency, originality and elaboration, where pre-dominantly gamma electrical activity was observed in CM as compared to the control group with SH training.

7.4 RELIABILITY MEASURES

Creativity dimensions scores such as i. Fluency, ii. Flexibility, iii. Originality and iv. Elaboration, were calculated by summing the number of ideas per participant, after eliminating redundancies. The rater's scores were averaged to calculate a final (mean) score for each participant. Originality scores were assessed by assigning values for each idea as per the standard in the manual. These values were between one and five, with a score of five indicating high originality and a score of one indicating low originality.

7.5 CREATIVITY CORRELATION AND EEG GAMMA ACTIVITY

Frontal gamma synchronization in the left and right hemispheres during the baseline, creativity task and cyclic meditation phases reported as task-related power (TRP) values. To calculate task-related power at a given electrode site, power during the reference interval is subtracted from power during the activation interval. Pearson product-moment correlations were run to determine the relationship between frontal and parietal gamma activity during the tasks in both the groups. In shavasana group there were no significant correlations between frontal gamma synchronization in the left and right hemisphere for any tasks in the three series.

Conversely, in the CM group there was a strong positive co-relations between frontal and parietal gamma synchronization in the left and right hemisphere following post intervention for CM and CR tasks, and even for the post baseline, i.e. CM, $r(8) = 0.831$, $p = .001$, Baseline Post $r(8) = .847$, $p = .001$ and CR $r(8) = .747$, $p = .006$. The findings show that in the CM group synchronization increased simultaneously across hemispheres during the three tasks / phases. Given that gamma activity influences creative cognition and processing in the frontal and parietal regions of the brain^{39,252,267} findings that showed gamma synchronization occurring in the frontal parietal regions, influences the creativity dimensions of fluency, elaboration and originality, that occurred in the CM group, assumed to signify internally oriented attention, suspension of external bottom-up stimulation and to-down processing⁸

Therefore, I interpret that top-down processing and internal focus of attention likely characterized by the creative mental state that occurred while participants in the current study. In order to gain further insights into this latter interpretation, further research is needed. The asymmetry scores significant and substantially reported frontal gamma synchronization in the right hemisphere. A pattern has emerged in the creativity literature that may indicate a special role for the right hemisphere as related to creative cognition and ideation. Furthermore, several EEG studies showed increased activity in the right hemisphere and increased right hemispheric synchrony in other frequency bands.

7.6 CORRELATION OF THE STRENGTH BETWEEN FRONTAL AND PARIETAL REGIONS OF INTEREST (F3, F4 & P3, P4)

I examined areas showing an association between the divergent thinking in the ATTA test of creativity and the dimensions such as fluency, flexibility, elaboration and originality within both the groups, Cyclic Meditation and Shavasana. Creativity was correlated with the frontal and parietal cortex, nodes of the DMN. It should be noted that current study involved college cohorts mainly the post graduate level students, and therefore psychometric measures of intelligence and cognition were concentrated at a rather high level, which might have substantially weakened the sensitivity of the analysis because of the resulting lower variability in general levels of Creative intelligence or cognition. Focusing attention during the CM and during the Creativity tasks might have resulted in significant source-power changes in gamma in the frontal and parietal regions such as F3, F4 and P3, P4 where the specialized knowledge is stored. There were no significant changes of such kind in the Control Shavasana group in both phases. The pattern of enhancement and synchrony was mainly in the right hemisphere in gamma band over parietal and frontal areas. The statistical gamma activity (25-60 Hz) exhibited both significant during CM and Creativity.

It is noteworthy that activation in areas sub-serving basic spatial attention and focus areas in parietal lobe manifested specifically as an increase in power in the gamma band. This supports previous observations of sustained EEG gamma oscillations during high-level mental activities, such as reading, learning, emotions and problem solving.³⁴³ Our finding is consistent with evidence demonstrating that activation of cortical regions induced by attention, focus and cognitive process; as such Creative Cognition followed by innovation generally translates into synchronization of rhythmic neural activity at frequencies above 40 Hz, the so called gamma synchronization (Lachaux et al., 2008)

7.7 LATERALIZATION OF CREATIVITY

Asymmetry results shown above confirms the involvement of both hemispheres in the CM as well as Creativity phases, giving pre dominant association of the right hemisphere in the focused attentional processing and creativity task. A possible explanation for the right hemisphere laterality of the gamma source-power changes in the current study may be based on the retrieval and memory.³⁴⁴⁻³⁴⁶ Neuropsychological reports suggests a predominant right hemisphere involvement of frontal and parietal regions in association with the fluency, flexibility and the elaboration dimensions of creativity, as found in the current study on the fact of the specialised knowledge and domain knowledge store and its retrieval.^{6,34,36,46}

7.8 SUMMARY

The results and findings of this study should be interpreted in the context of brain regions associations particularly frontal (F3, F4) and parietal areas (P3.P4) areas during the creativity and CM practice and their co-relates to gamma band activity. Moreover, our results suggest that parietal and frontal associations enable better synchrony and enhanced performance in the creation cognition. The main contribution of the current study is the identification of gamma wave band as underlying neural activity of the frontal and parietal regions as the source activity. Moreover gamma band occurred in the right lateral frontal cortex during performance of the ATTA creativity task, likely representing a mechanism to interrupt transiently local neural communication in cortical regions not relevant to the ongoing cognitive task. Overall analysis determine the cortical network of the sources related to focus and attention and creativity underlying the executive and default mode network and its neural activity, with the EEG signatures in the gamma activity bands.