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How Metaphorical Thinking Influence Information Processing Ability: A Study using EEG Technique

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Abstract

Metaphorical thinking is a soft thinking technique connecting two different universes of meaning. The human mind tends to look for similarities. Human cognition is conscious as well as sub-conscious, concrete as well as abstract, intuitive enabling an individual to process knowledge, attention, memory, problem solving, decision making, reasoning, computation etc. through the senses they perceive. Hence, metaphorical thinking acts as a catalyst to promote all these processes mentioned. The present study is focused to find out the influence of metaphorical thinking amounting to neuronal activity in the prefrontal regions of the brain where most of the learning takes place. The present study is designed by recording the EEG data while the teachers were asked to read the metaphorical thinking statements incorporated in the lesson plan. Metaphorical thinking promotes active thinking in the subjects though thinking is always an integral activity of the living brain.

Keywords: Metaphorical thinking; Brain; Cognitive effect

Introduction

Metaphors are quite often used in language communication unconsciously throughout the world without any discrimination. The use of metaphors in language communication promotes semantic understanding of the context. For example, if a language teacher is explaining the concept of adjectives to his/her class by stating a sentence "Priya's skin is as soft as silk" here the students understands the adjective "soft" by linking skin with silk though they are completely different in their meaning. The main objective in the present research study is to establish the fact that thinking metaphorically could help an individual to build cognitive structures which in turn promote information processing ability. Therefore, the research study is designed in such a manner that the content to be taught is presented to the target group systematically planned implementing metaphorical statements so that the target group perceiving the content through their senses would direct their thinking metaphorically as the entire scenario is conditioned in a class room environment. Several researches mentioned that metaphors have deeper cognitive effect on individuals when explained to the learners in an appropriate way for example, when a Science teacher explaining the concept of the structure of the "atom", he/she should expose the learners with the metaphorical thinking statements namely: In what way Neil's Bohr theory of the structure of the atom similar to the planetary system. How do you explain the similarities as well as the dissimilar [1-12]. Taking into consideration several insights proposed by Lakoff and Núñez [6], the present research work intends to explain that the metaphorical thinking statements practiced by teachers on regular basis planning the content to be explained in the classroom could result in building cognitive structures as the metaphorical thinking statements are framed in such a manner that it initiates the thought process among students enabling them to understand the content in a better way. The above logic of sequential understanding was thought to have neuro biological correlation taking its root to the field of Neuro Science as suggested by Dehaene, Varela and Shear [13-15].

Research hypotheses

The following research hypotheses have been framed to support the research study

1. Practice of metaphorical thinking statements in the lesson plan promotes beta activity in the prefrontal region of the brain where most of the semantic learning occurs.

2. Increase of beta activity considered as one of the key indicators of active learning.

The main objective of the research study is to find out experimentally the regions of the brain actively involved in learning which in turn is attributed to the practice of metaphorical thinking. It is a well-known fact that the brain is always engaged in the process of thinking as long as an individual remain in his/her own consciousness. The most important question in the present situation is how to promote information processing ability among learners. Though there are several strategies available as well as proposed by several research studies from the past to present, the strategy applied in this study is to implement metaphorical thinking statements and metaphors. The usage of metaphorical thinking statements presented before the learners enables the learners to develop their own thinking which not only makes them to get involved in the present situation as their individual mind is engaged in thinking divergently relevant to the content presented to them by the teacher. In order for these processes to occur two conditions are imposed. The first one is it carried out in a class room situation. Secondly The teacher plays a pivotal role in setting up condition to initiate metaphorical thinking among his/her students. As we all know that learning is a complex phenomenon, till this date no one has accurately predicted a particular mechanism to the act of learning. Taking into consideration the above-mentioned facts an attempt has been made to propose a plausible theory how metaphorical thinking statements when practiced in the teaching /learning process enhances the information processing ability among the learners.

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Unlike in quantitative research study the normal practice is to train the students to think metaphorically and to find the effectiveness of training a "t" test is done to find the difference between pre and post academic test performance, the target group in the study are teachers. To find the effectiveness of the metaphorical thinking statements "EEG" signals are recorded on the teacher participants. The basic idea underlying the study when the brain is stimulated with the metaphorical thinking statements, active thinking is initiated among the subjects as every thinking is due to the neuronal firing, but in metaphorical thinking the intensity of neuronal firing is considered to be large as the result there would be immense beta activity in the prefrontal regions of the brain, the centre of active learning.

Influence of metaphorical thinking on EEG

EEG is a non-invasive measure of electrical brain activity. It is a record of electric field potentials, represented as changes in potential difference between different points on the scalp, which arise primarily from excitatory and inhibitory postsynaptic potentials. Though there were several studies related EEG in the literature the present study is designed to EEG recording by implementing metaphorical thinking statements in the lesson plan. According to Albert Einstein information given to an individual should be given as simple as possible. Therefore, metaphorical thinking statements comes to rescue enabling the learner to assimilate the given information more effectively. Metaphorical thinking helps an individual to develop abstract connection between two concepts in semantic memory. Recently conducted research on cognitive processes involved in producing conventional (i.e., familiar) and creative (i.e., novel) metaphors. The ability to produce creative metaphors was more strongly associated with fluid intelligence and verbal fluency, interpreting to the involvement of executive functions; in contrast, the ability to produce conventional metaphors was associated with general vocabulary knowledge. Recent Neuro imaging studies revealed solutions to long standing problems of how people come up with new ideas by associating it with increased activation in the left angular gyrus and decreased activation in the right temporoparietal junction. Bowdel and Gentner [16] found out how people quickly processed and understood information related to language similes and metaphors. One of earlier studies using EEG technique by Pynte et al. [17] examined participants electroencephalogram (EEG) recordings while they read sentences containing metaphors. Participants read sentences that either contained familiar metaphors, unfamiliar metaphors, or literal (control) sentences. During the presentation of the sentences, the researchers recorded electrical activity along the participant's scalp using an EEG system. As this was one of the first experiments to suggest that our brain is doing something quantifiably different when we read metaphoric sentences indicated neuronal activity associated with metaphors.

Methods

The research study was designed to analyze scalp EEG recordings on teacher sample as the subject. The investigator designed the lesson plan implementing metaphorical thinking statements for a particular content in the subject Chemistry relevant to 9th grade students studying in India following Central Board of Secondary Education curriculum. A sample of lesson plan implementing metaphorical thinking statements was shown as follows in Table 1.

While presenting the content to the students the teacher has to consciously mention metaphorical thinking statements in the class-room, as the result the learners would extend their thinking metaphorically and make an attempt to analyze the content. This way of presenting the content enable the student to relate the content with totally different domain which would initiate thinking among them, as the learners engage themselves in active thinking process which in turn increases neuronal activity determined by EEG recording.

Participants

The experiment was conducted on 20 teachers having more than five years of teaching experience in teaching Science with an average age 42 year (S. D=5.5 range from 30-55) working in Government, Government aided as well as private schools. They were recruited through paper advertisement in a leading Newspaper in India. Those who responded to the advertisement were invited to the Management studies department, Indian Institute of Technology, Madras for a presentation regarding the significance of implementing. Metaphorical thinking lesson plan. Those teachers willing to participate as volunteers were selected for the study. All the participants who took part in the study were asked to sign the consent form with full awareness regarding the procedure of the study. The experiment was carried out in the Neurology department of Sri Ramachandra Medical University and Research Centre, Porur, Chennai, Tamil Nadu, India after getting clearance from the Institutional Ethical Committee, Sri Ramachandra Medical University and Research Centre, Porur, Chennai. The study was approved by the Institutional Ethical Committee, REF: IEC-NI/16/JUN/53/30.

EEG Recording

To begin with the experiment the 20 teachers were divided into groups of 10 members in each as experimental and control group. The experimental group consisted of five teachers one female and four males and the control group consisted of three females and two males. The scalp EEG is recorded using Nihon Kohden EEG machine 1000 version 0.05, 81 using 10: 20 electrode systems as per international standards. Fp2, Fp1(pre-frontal), F4, F3 (Frontal), F8, F7(anterior temporal), T4, T3 (mid temporal), T6, T5 (Posterior temporal), O2, O1 (occipital), C4, C3 (Central), P4, P3 (Parietal), Fz, Cz, Pz (midline), A1, A2 (mastoid). The Nihon Kohden EEG-1200 offers many features that are ideal for a teaching and research setting. The recording was carried out using current < less than 20 microvolts and the frequency range of 500 Hz. The teachers were initially educated about how the recordings would be done by the well-trained technician who regularly record EEG for diagnostic purpose, as the recording was carried out in a hospital set up the machine was well standardized to record EEG wave form. In order to introduce well defined markers between passive thinking and active thinking that is to set a baseline the experimental group of teachers were asked to concentrate on letter "A" written on

Content	Metaphorical Thinking Statements
Laws of Chemical combination: According to the Laws of Chemical combination atoms of different elements combine to give a large number of compounds	In what way the existence of plant and animal species similar to the formation large number of chemical compounds from different elements.
According to the Law of constant proportion atoms of different elements combine in a definite proportion by weight what ever be the method by which they combine.	An excellent chef always maintains the same consistency how many times he repeats the recipe is it true?
	What connection the above-mentioned statements similar to the atom of elements always combine in a definite ratio?

Table 1: A sample of lesson plan implementing Metaphorical thinking statements.

a white sheet of paper and their scalp continuous EEG was recorded for 15 minutes. At the end of 15th minute, the teachers were given a sheet of paper consisting of metaphorical thinking statements relevant to the content and were instructed to read silently and were instructed to relate their thinking to what they were reading. As the sample were teachers having experience in teaching science they were able to relate their thinking to what they were reading. The remaining 15 minutes were used for recording continuous EEG with the intervention of metaphorical thinking. This experiment was repeated three times for each teacher in the interval of ten days belonging to the experimental group. A total of 15 recordings were done for experimental group. For the control group the experiment was carried out only once.

Analysis of the Data

The pre-recording was done showing the subjects the alphabet "A" to create a base line for 15 minutes and the intervention of reading the metaphorical thinking statements for another 15 minutes during the post- recording session. Therefore, the analysis was carried out for total 15 recordings with pre and post sessions. Analysis of the EEG data was carried out in two phases. The first phase consists of the analysis of the experimental group with fifteen recordings. The EEG data is analyzed using MATLAB version 2016b compatible with EEG lab version 15 with Sift software tool developed by Swartz centre for computational Neuroscience. The EEG LAB graphic user interface (gui) which could be used by the non-experienced MATLAB users to apply advanced signal processing techniques to their data. The ASCII text files containing continuous EEG data was imported via EEGLAB menu supported by MATLAB. The menu allows users to review, edit or transform the event and epoch information. Event information could be used to extract data epochs from continuous EEG data to create ERP image plots. In the present analysis the researcher focused to find beta wave activity (13 to 25 Hz) in the prefrontal region (Fp2, Fp1) for both the groups that is experimental and control. In the experimental group the data analysis was carried out by importing the raw data consisting

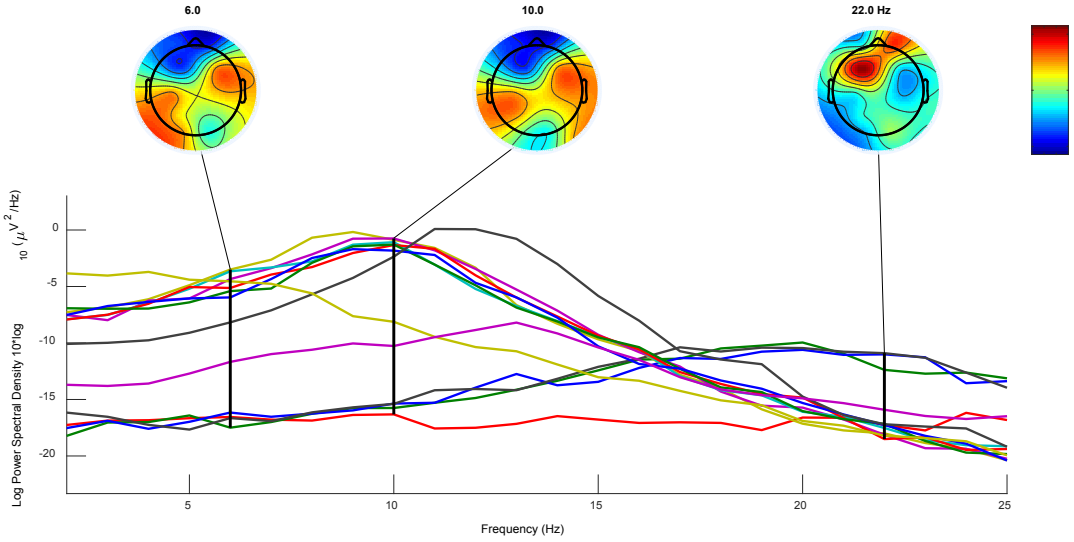

Figure 1: Represents channel spectral series depicting brain activity at three different frequencies.

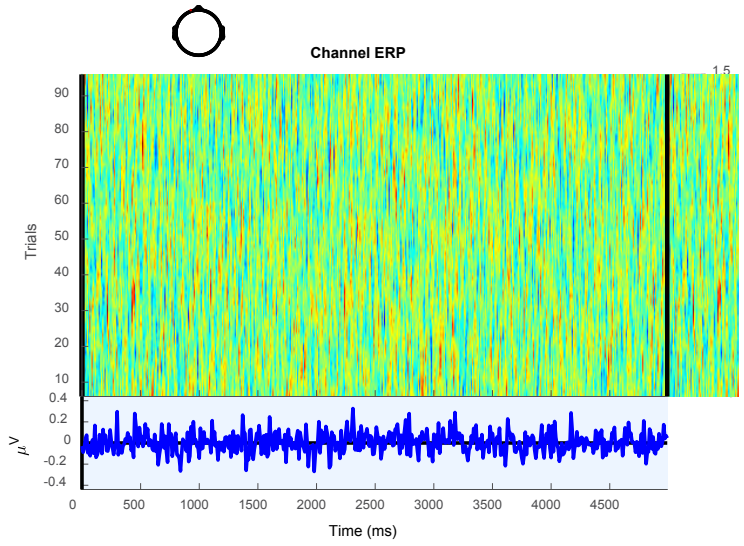

Figure 2: Channel ERP values plotted between time versus potential for the continuous EEG data.

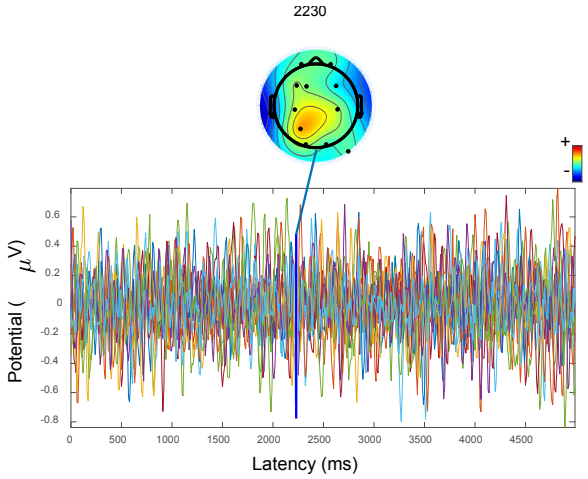

Figure 3: Shows the plot of potential versus time in milli seconds the latency was observed at 2230 (ms).

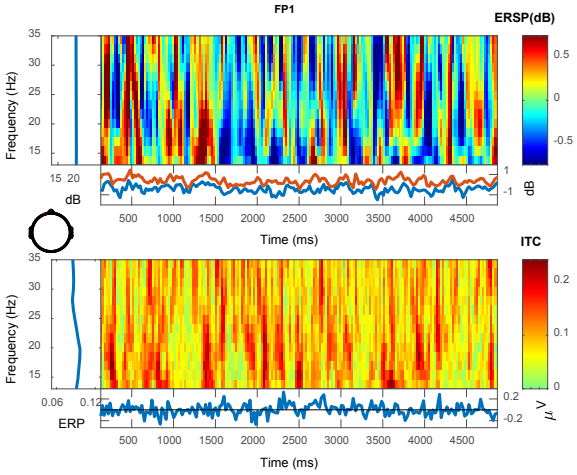

Figure 4: Shows brain activity in channel 1 between time (ms) and frequency in Hz indicating response that the subject reacts to stimulus.

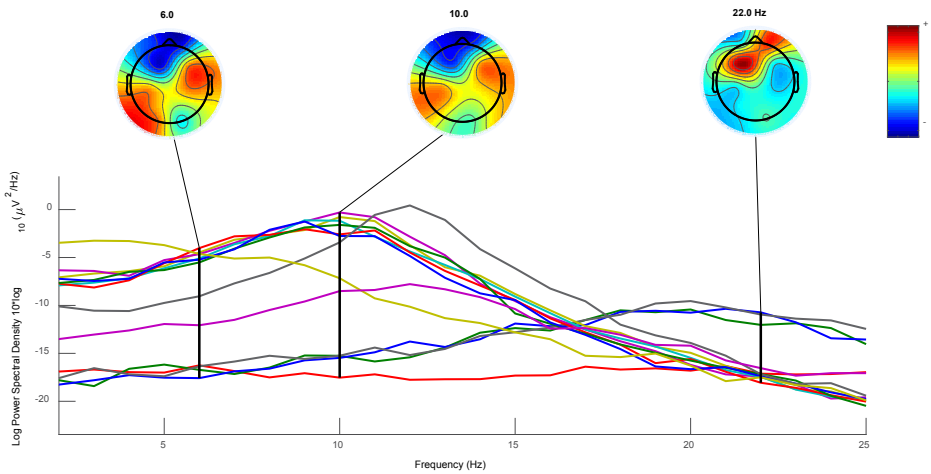

Figure 5: Depiction of channel spectral maps during intervention showing comparatively greater brain activity.

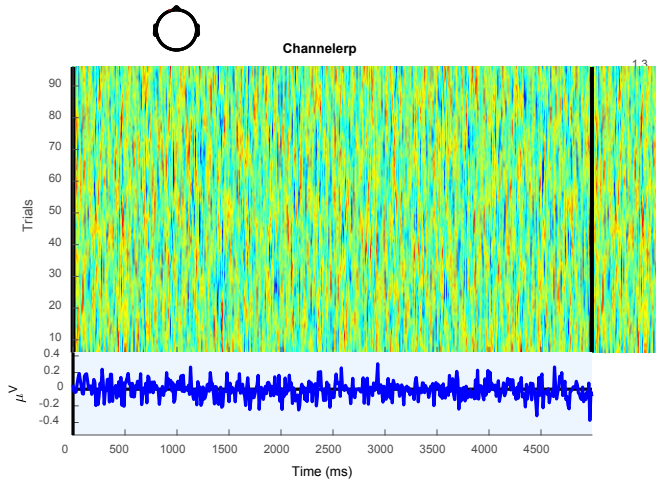

Figure 6: Channel ERP at various time intervals depicting comparatively more of beta activity.

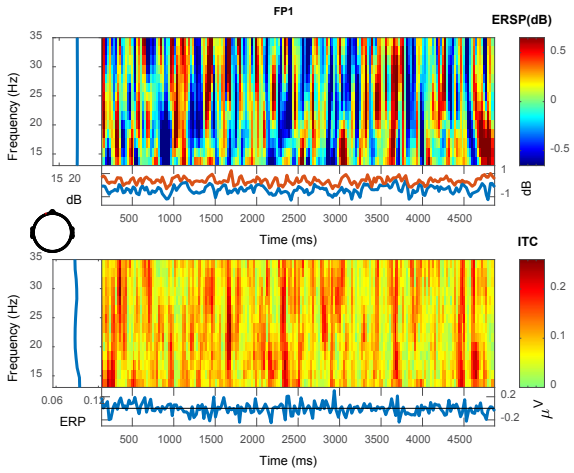

Figure 7: Response stimulus depiction as the result of implementing metaphorical thinking.

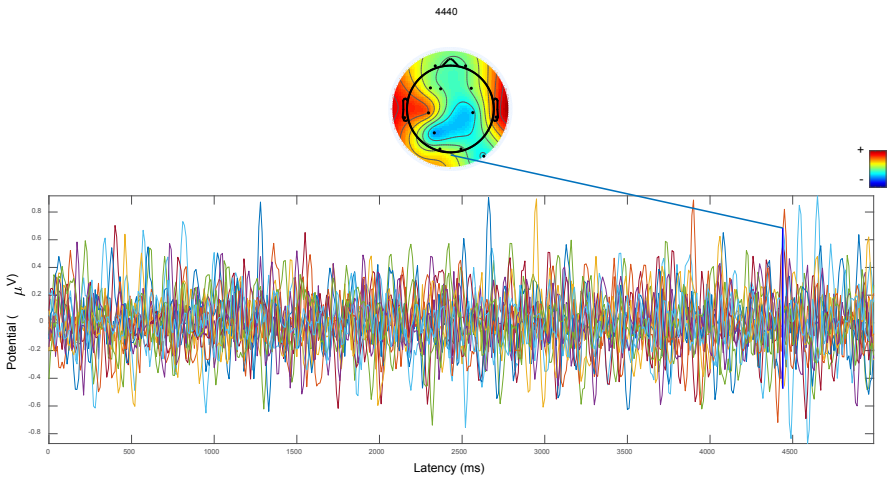

Figure 8: Channel latency shown in the time vs potential curve.

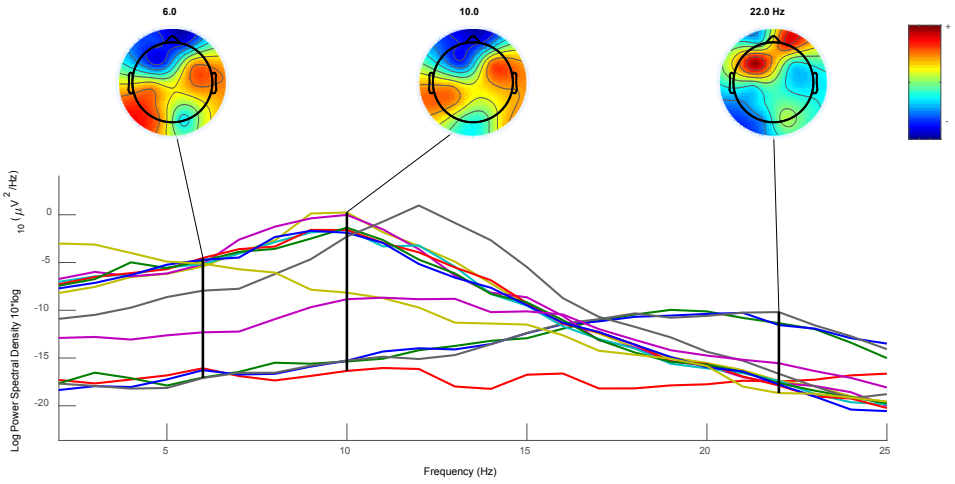

Figure 9: Spectral map for the trial 2 at different frequencies.

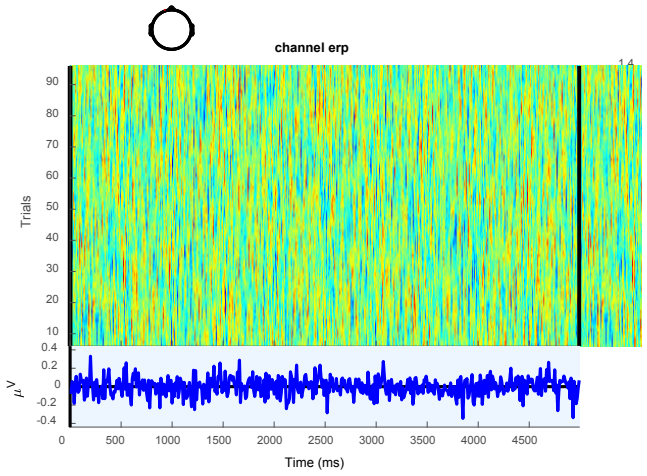

Figure 10: Channel ERP for trail 2 during pre- test session.

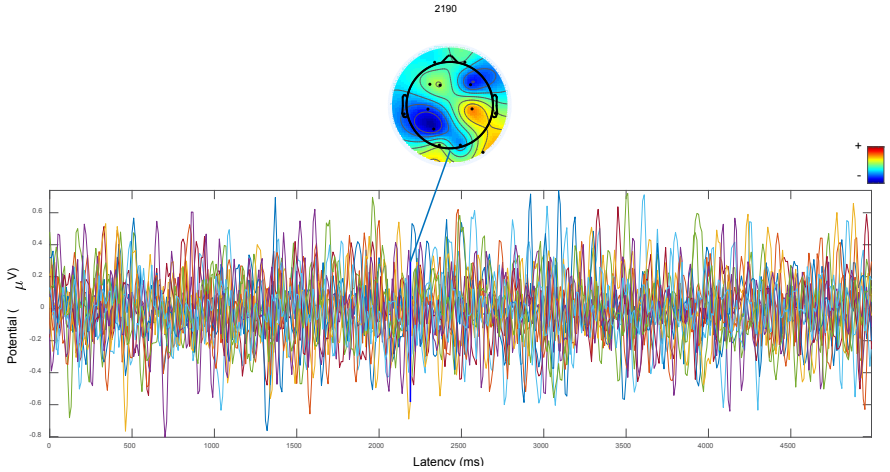

Figure 11: Time vs potential depiction for the channels showing the average latency in ms.

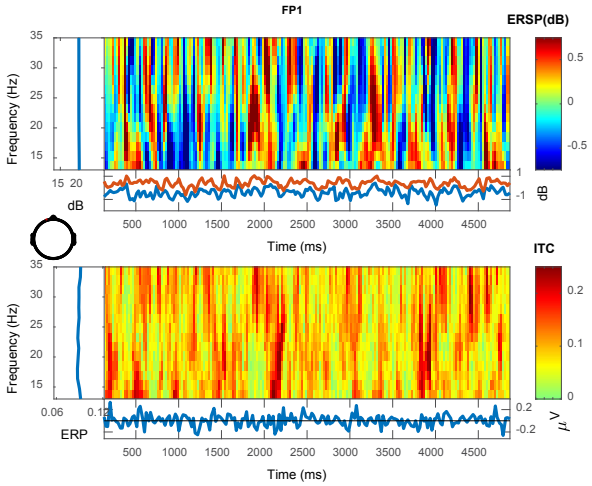

Figure 12: Response vs stimulus reaction shown in terms of ERP for channel Fp1.

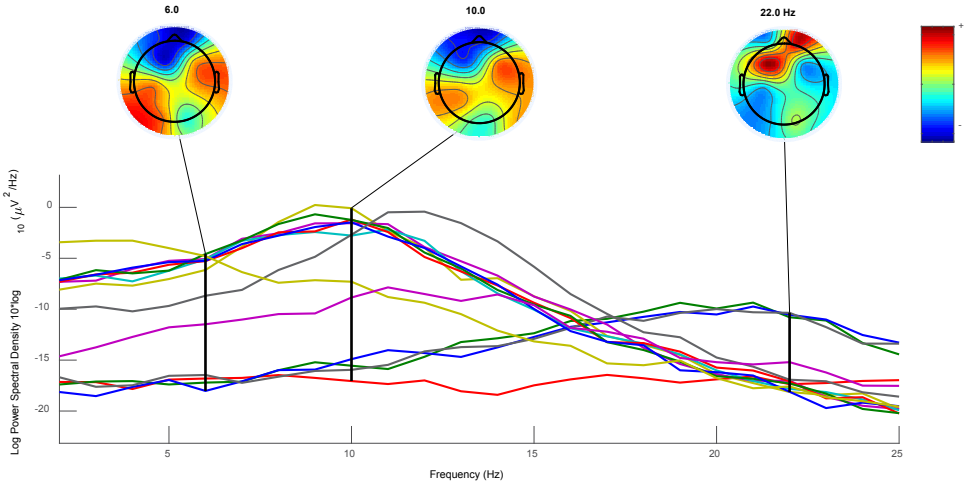

Figure 13: Post -test session showing the spectral maps.

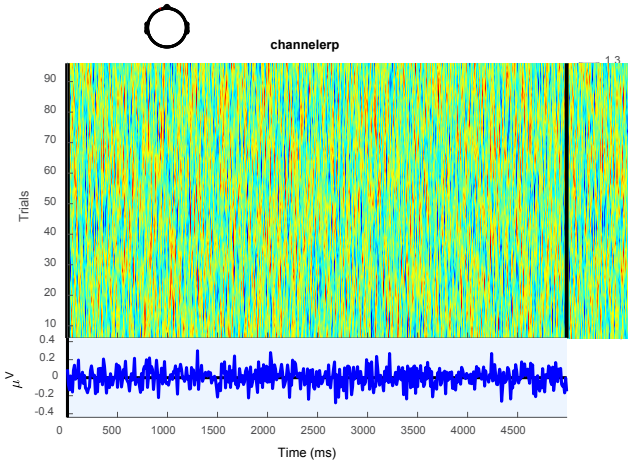

Figure 14: Post -test trial 2 showing channel ERP.

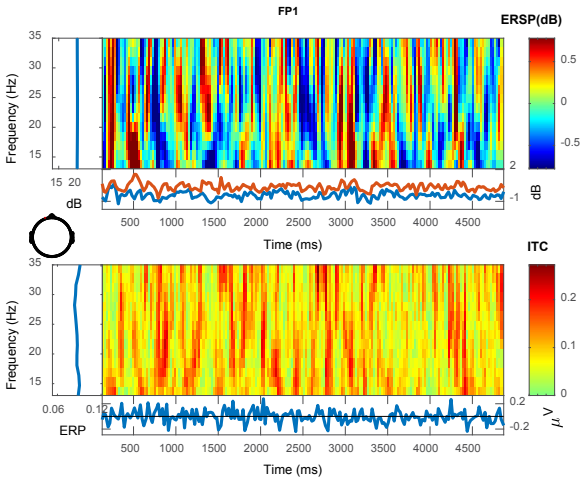

Figure 15: Post-test for trial 2 depicting response stimulus indicating ERP.

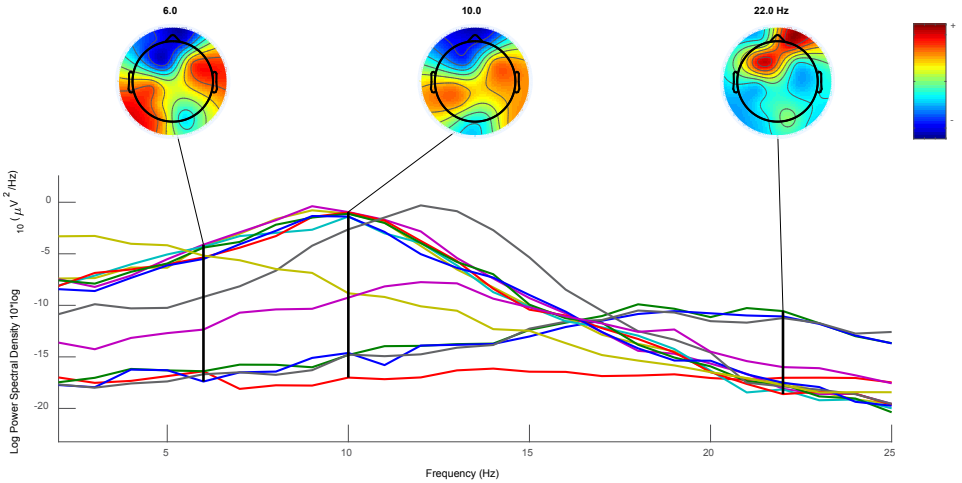

Figure 16: Shows spectral maps for pre-test trial 3.

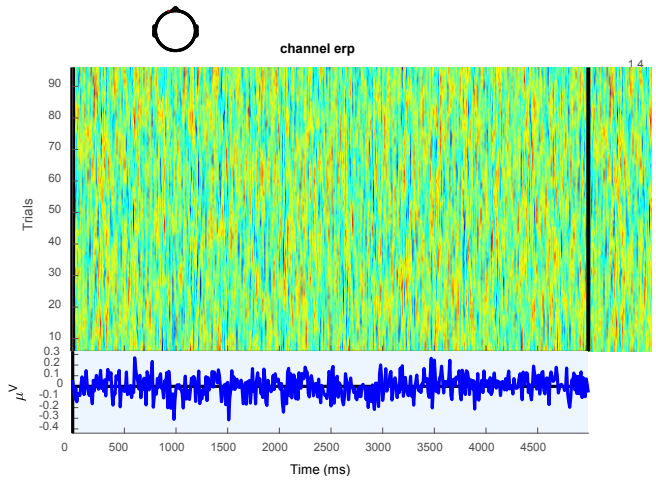

Figure 17: Channel ERP for the pre- test trial 3.

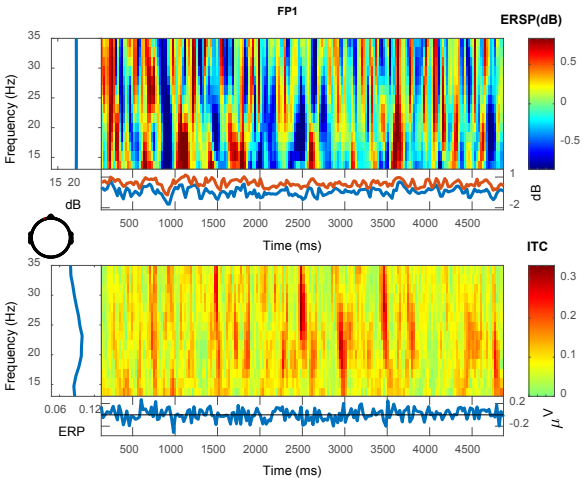

Figure 18: Shows response stimulus reaction for the pre-test trial 3.

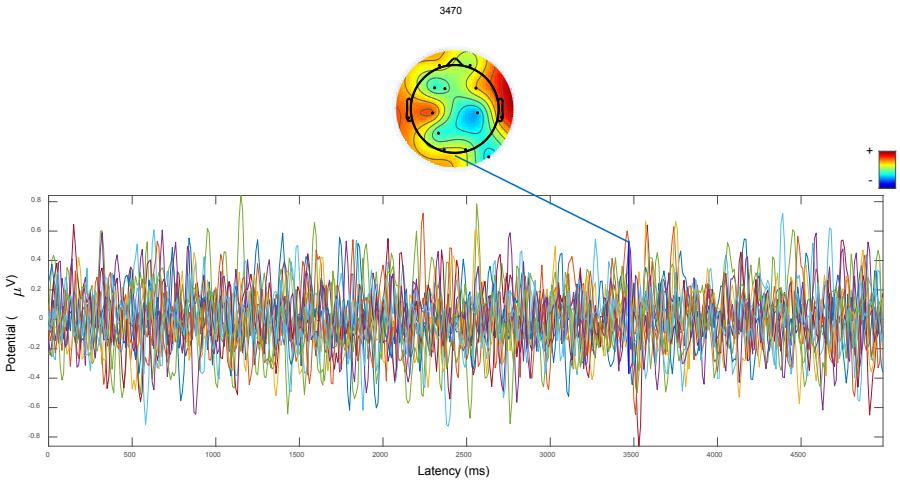

Figure 19: Potential vs time variation depicting average channel latency (ms).

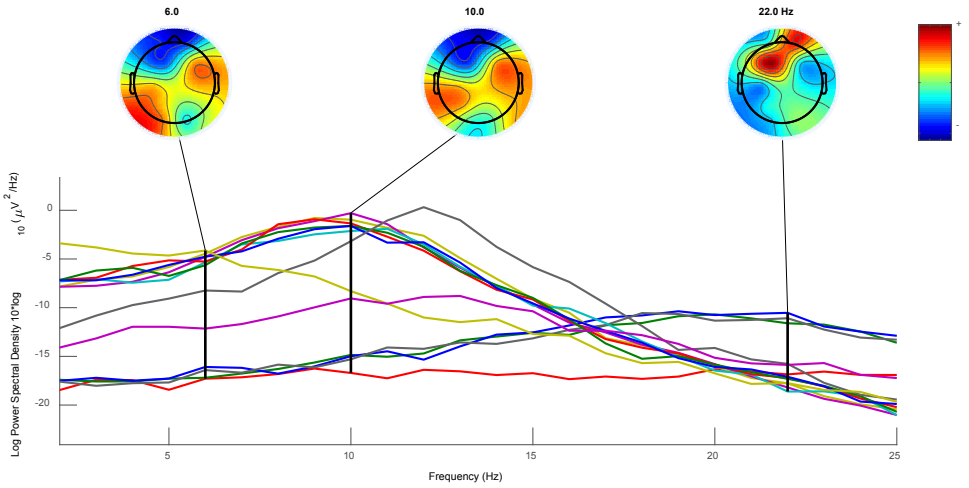

Figure 20: Spectral maps for post-test trial 3.

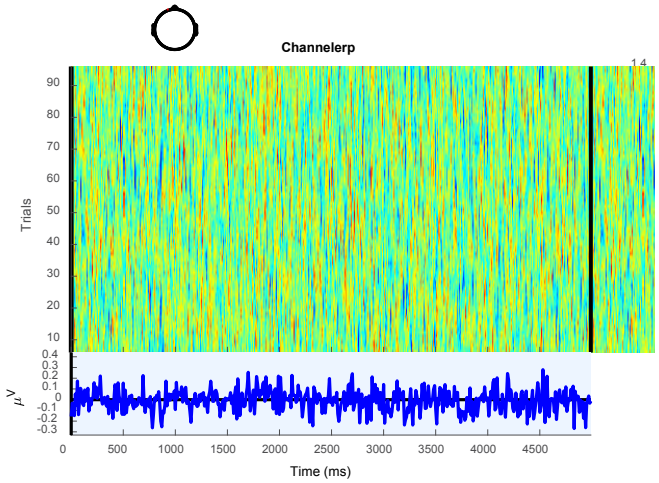

Figure 21: Channel ERP for post-test trial3.

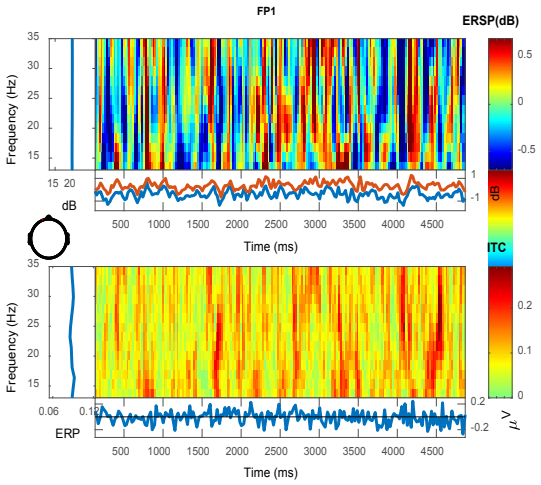

Figure 22: Stimulus response reaction depicting ERP for channel 1 during post -test session of trial 3.

of continuous EEG waveform recorded at 7 micro volts in the frequency range 0.53 to 256 Hz to the EEG LAB menu for prerecording as well as post recording respectively. The raw data was cleaned using short IIR filter in the frequency range 0.5 to 45 Hz. Removal of base line was done for the cleaned data using the appropriate option in EEGLAB tool box, similarly automatic continuous rejection option was selected to remove the artefacts due to muscular movements as well as eye blinks that occur during recordings. The processed data was further analyzed to compare ERP image plots as well as spectral maps at different frequency range. The brain dynamics related to ERP image plots as well as spectral maps for each subject during the pre and post session recordings were analyzed respectively. The spectral maps of one of the subjects during trial 1 shows enhanced beta activity during the post session recording compared to pre-test recordings. For the sake of simplifying the pre and post-test recordings are represented in the form of spectral maps of one subject is shown below. Pre-test recordings for subject one during trial 1 was shown below in Figures 1 and 2.

As the analysis was done depicting the figures conveying the brain dynamics during the pre and post sessions for three trials per subject repeated for five subjects would result in large special depiction. Therefore, restricted to one subject. From the pictorial representation it is clear that beta activation is much higher during post-test recording compared to pre-test recordings which clearly indicates that metaphorical thinking induces active thinking which would help the learners to build their own cognitive structures being innate quality of every individual though in the present experiment an individual consciously develops metaphorical thinking helping the individual to improve their information processing ability (Figures 3-24).

Results and Discussion

The above findings to certain extent supported by Coulson and Pan [18]. Both the studies used DVF and ERP methodologies, found no evidence for a special role for the RH in metaphor processing, unlike the present study was focused on role of metaphorical thinking in promoting information processing ability. However, both these studies conducted were different in their approach due to the fact that the study

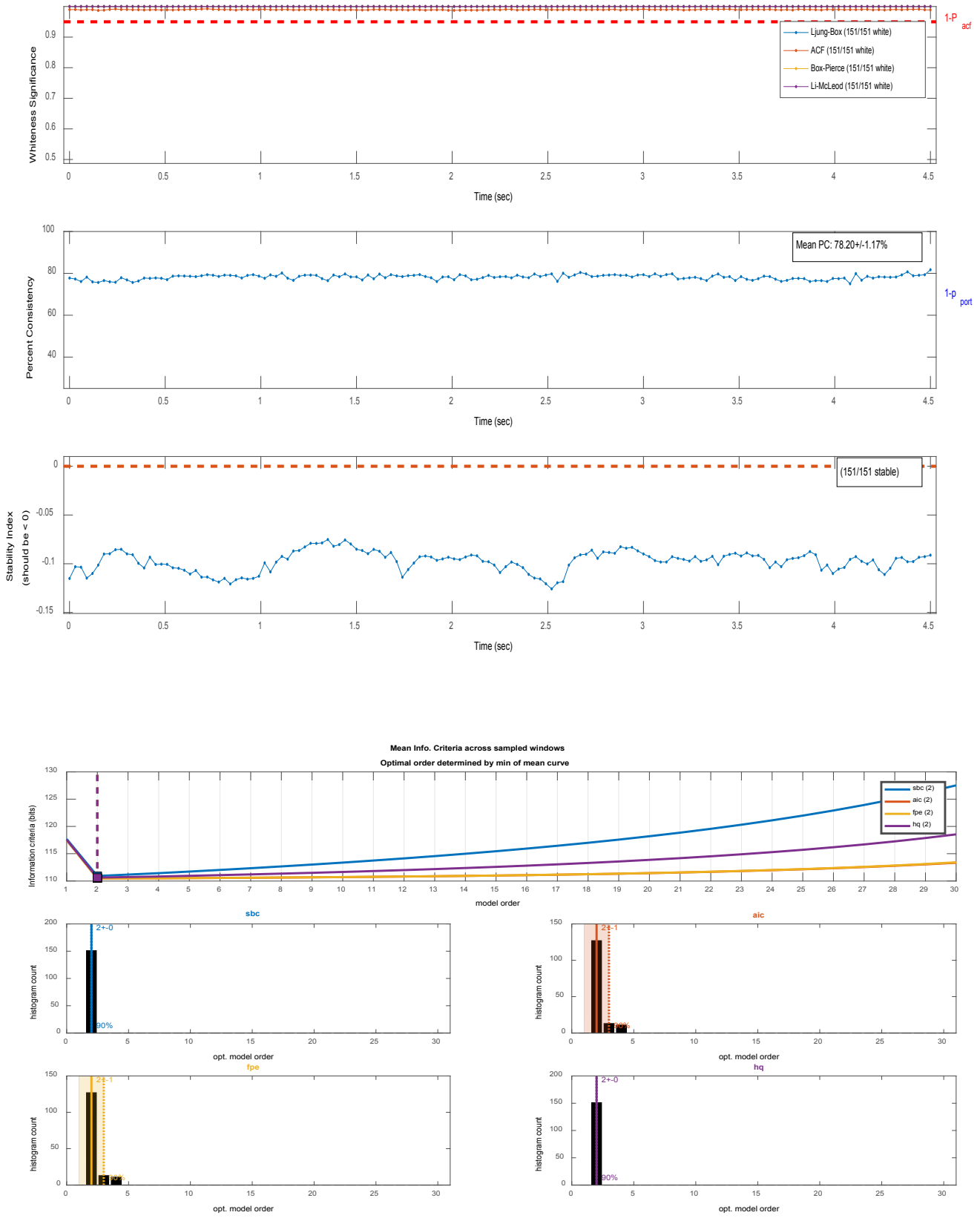

Figure 23: Depicts the average beta activity in time frequency domain for the pre-test of the sample.

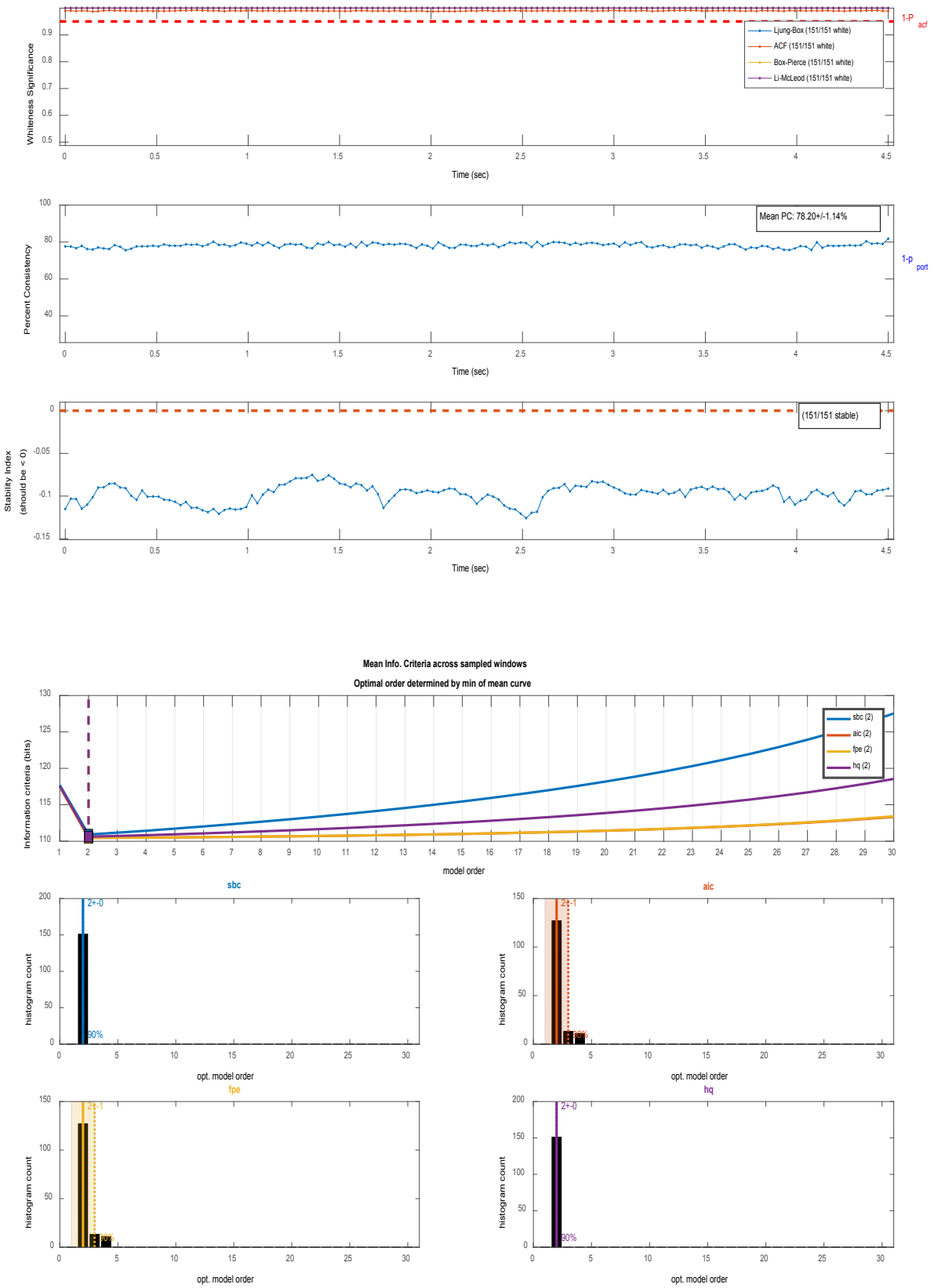

Figure 24: Represents increase in beta activity during post-test activity for the sample.

conducted by Coulson considered metaphorically ambiguous words in sentence contexts. Lexical ambiguity processing in sentence contexts can be considered to be fundamentally different from ambiguity resolution in single words, as the sentence provides a vastly richer meaning context and so introduces levels of processing not present in single word priming paradigms.

Conclusion

Metaphorical thinking is one of the learning techniques which could be practiced in its simplest way by teaching -learning community as it enhances beta activity considered to the brain wave responsible for active thinking though the brain is engaged in thinking as long the human being is breathing. It is also simplest technique to keep an individual engaged as it is similar to playing videogames or any other game where the person's concentration is fully immersed in the game. The most important drawback is the person implementing the technique should be able to think diversely.

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