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Brain signals classification for creative tasks

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Abstract. We tried to determine if emotive self-feedback from conscious assessment of artists' own works generates sufficient impetus for accomplishment of goals. Self-reports from participants of an 'experimental' group working independently and *without* external feedback on their work are examined. The performance of this group is compared to 'control' performers in tutored sessions (*with* external feedback). On the whole a two-fold analysis was carried out. First, *verbal* reports of the participants' feelings about their work in both experimental and control settings were analyzed. Second, a brainwave analysis of each participant was conducted while they were engaged in the same tasks so as to examine effects of concentration and energy output. The Hilbert-Huang transform was used to filter data frequency for brainwaves emitted at channels AF4, AF3, F6 and F7, all positioned along the pre-frontal cortex. Results of participants' brainwave behavior within frequency ranges of 14–16 Hz, as well as for higher ranges (above 60 Hz), do not show significant difference in the two groups. This indicates that brainwave activity is sustained in individuals who depend on self-feedback appraisals, at least within the domain of creativity investigated in this paper.

Keywords: Affect, creativity, external feedback, flow, motivation, self-feedback

1. Intrinsic resources of creativity

Studies on 'gifted' children show how psychological self-feedback about their work helps such persons in developing their skills and achieving mastery [1], [2, 3]. Although some studies showed how external feedback (and motivation) from other persons inspire creative behavior in organizations and studio productions [4, 5], it was Winner (1993) who suggested more concretely how a feedback psychology also inspires individuals, especially creative people.

For this paper we are not concerned exclusively with more talented individuals, but use Winner's model to predict how motivational self-feedback, based on retrospective appraisal of one's own working memory, could fuel and sustain interest for apprentice artists, especially in modern new media contexts. That artists have intrinsic resources of creativity is evident for creative artists like Van Gogh and Paul Gauguin who are famous in history for the dramatic obsession with their creative lives [1, 2, 6]. They went through depression and turmoil to come back and create artistic effects from deeply personal mental resources. The same is also perhaps true of students wanting to engage in creative professions [3, 8, 23, 58, 88, 89].

The idea of self-motivation could be cultivated for achievement of better results in digital design contexts as well. Whereas Bandura (1989) and Bandura and Zimmerman (1996; 2000; 2008) and later Pintrich (2000; 2004) have done pioneering research on self-motivation almost all such studies have been confined to learning environments devoid of artistic creativity. A proposal for art education was formally discussed by [48].

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2. Emotive self-feedback

Research has shown how emotions that artists feel while working impact creative behavior in both direct and mediated ways: but especially by *retrospective* appraisal of actions and by stimulating further actions in a conscious manner [51, 76].

Automatic and controlled behaviors are both impacted by emotive feedback, and specifically mood appraisals (Chaiken and Trope 1999; Wilson 2002). We chose to identify if self-induced mood appraisals are sufficient for maintaining or enhancing (or diminishing) creative performance, especially if the feedback was not derived externally. At least some influential thinkers like Langer (2007) and Terman (1954) have emphasized on creative intelligence and IQ [43, 78]. Facts show that individual creativity may be enhanced if the right environmental factors are available [28].

Giftedness may be a matter of potential [44] but on the whole mechanisms of acquisition and realization of creative performances have been discovered and studied [60], Schneiderman 2007; Sefton-Green 1999). What precisely are the results of an affective self-feedback mechanism that inspires creative people? How could self-assessment, conscious or otherwise, lead to increased levels of performance and satisfaction in creative performers? Following Levy's classic theory of free creativity [44] and the subsequent research of Golman (1995), Ryan and Deci (2000), and [10], subliminal (or intrinsic) feedback is now known to be a significant factor behind creativity. Mood feedback acts like a psychological rudder [1, 88, 89]. Hence, feedback for individual learners involves "self-regulation" [4, 18] Hattie.

A combination of emotional feedback and 'self-regulation' may generate sufficient drive for problem-solving moves and for finishing a task at hand.

3. Emotional intelligence

The research of proponents of emotional intelligence is relevant here [16, 63, 30, 73]. The role of *affective intuitions* is acknowledged to be of importance by Spendlove (2007), Boyer and Smith (2007), and Emmanouil (2015) in any learning process – and also we suggest, the digital creations in which working memory is constantly provoked and modified during complex problem solving process. Neurally, something like a short-cut may explain how creative patterns are generated.

Creative outputs may be conditioned by signals coming from the thalamus and impinging directly on the amygdala [65, 30, 73]. The research on affective aesthetic functions indicate this double activation method of the pre-frontal cortex and the paleo cortical hindbrain including the thalamus and the amygdala [43, 50], [Furst 2004]. If creative arts involve a certain degree of *cognitive* matching or 'copying', as an anticipation of skills which define how designs or representations are produced [24, 23], there is also a degree of involvement of empathy or emotive understanding of the object that is produced [40].

We use this theory here to further observe if brainwave formations prove heightened attention and motivation. Since brainwave activity, especially for pre-frontal cortex areas reports sensitivity, emotional valence and support we consider if there is any correlation between emotive feedback and brain activity, especially an unconscious yet organic, self-regulating feedback mechanism.

4. Self-Regulation from emotional feedback

In more market-situated contexts apprentices develop their own skills by monitoring what they are learning and by comparing it to existing models that offer aural or visual precepts [31, 81, 37]. Van Moer proposes so far as to evolve an *experience*-based visual arts learning process, like John Dewey's classic thesis that learning art should ideally depend on individual experience, rather than mandatory advisory intervention [81]. There is a growing consensus on the role of 'self-regulated' learning for students [60, 45, 18, 53, 3, 31] which lays emphasis on the way budding artists are inspired on their own to learn and improvise [45, 46, 57, 37]. There are contrary studies highlighting the facilitatory effect of advisor interactions on students' learning (Takano 1999). But a changing digital culture scenario implies more openness toward disinhibited factors of learning. Design learning based on self-feedback could be related to a student's inner experiences and may constitute a pillar of educative processes.

Consider the ideal scenario for a digital arts student. Any learner needs to be free, driven (or motivated), and creative but not uninformed or misguided. As one tries to evolve a certain design one gets to be receptive to pre-existing patterns and images. But that is not all. A learner's resolve is also bound in by her 'feelings', which include subliminal (intrinsic) resources of motivation. Informal freedom of spirit and self-initiated motivation should thus be a key ingredient for this course of simulations, as has been claimed [57]; Elliot and Dweck 2005'; [87].

5. Experiment flowchart

We however wished to study the probable success of self-feedback in context of self-regulated design, in untutored or minimally interventional training scenarios. One of our objectives was to find out if such contexts of creative expression eliminate external feedback and allow participants to rely on their own intuitions and sense of motivation associated with it. In the experiment conducted here we tried to analyze this for the digital arts education scenario. We draw a flowchart for a more self-motivation based studies conducted earlier by Rogers, Czikzentmihalyi and Spendlove.

The fact that emotive intelligence is involved in design strategies was thus adopted as a requisite for understanding the role of emotive feedback on creative practices (See Fig. 1). Let us say therefore that creative design involves multifunctional ingress beginning with what Thorburn and Jenkins calls 'immersion" in visual culture (Thorburn and Jenkins 2003). In the age of new media, a designer is prompted with prototypes of design that already exist in a given environment or milieu. Such prototypes create design-objectives or 'TASK' (Fig. 1) for a beginner. Visuals seen in commercials, internet, and media provide examples or prototypes which inspire and guide young artists and designers.

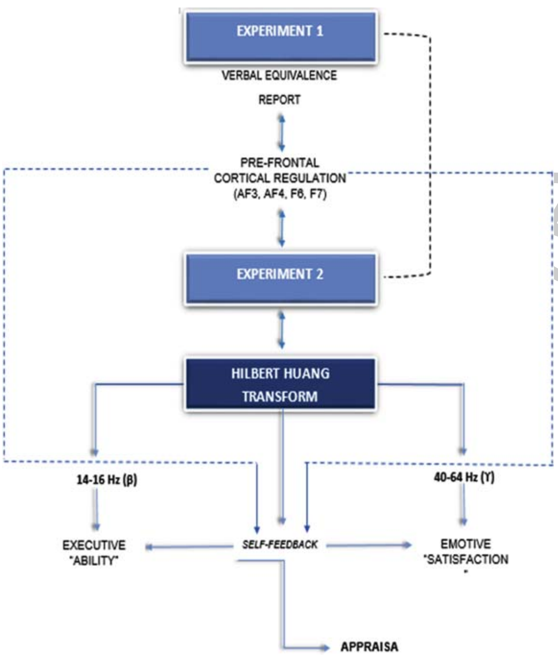

Fig. 1. Flowchart analysis for a dualistic emotive-cognitive creative task activity based on parallel verbal and neural processing.

Design activity would obviously involve matching of prototypes or improvisation on such prototypes. Yet, as research on design demonstrate, during given task-appraisal retinue students also fall back on the *sense* of success or emotive satisfaction for completion of the goal (Billet 2001; Potter 2002; Turnbull 2000; Silvia 2005; Huang and Liang 2001). We divide affect into dualistic 'emotive-cognitive" processes and recognize that this emotive-cognitive level either invites, or in case of mismatch, of expectation, lays or defers goal achievement.

6. Experiment

In this paper, self-feedback experiences are compared for two groups of participants, 'experimental' and 'control'. The 'experimental' group consists of participants who were set to finish an assignment on the basis of their self-assessment feedback. Control group consisted of participants for whom the assignment was accomplished with instructions from tutors. The purpose was to understand how emotional appraisals of one's performances caused direct behavioral changes in creative people, especially media artists [21], Schneiderman 2007).

A two-fold experiment was conducted: first, one in which student artists were asked to respond to a verbal questionnaire regarding their sense of emotional satisfaction with their own work. The responses were collected for each 5th to 6th minute interval in an assignment of half an hour. The responses were based on a Likert scale evaluation. Statistical analysis of responses yields tendencies of emotive feedback trajectories, which again were compared to expert evaluation of the work to understand if experimental or untutored participants performed better. In the second part of the experiment analysis was done on information from brainwave behavior collected with an EPOC-EEG BCI interface.

7. Participants

The experiment was conducted with aspiring artists, in the age group of 18 to 23. They were mostly students of digital arts and disciplines related

Table 1
Emotive satisfaction and self-regulated abilities

	No. of sample observations	Emotive Satisfaction Rating		Self-regulated Ability Rating	
		Mean	Variance	Mean	Variance
EXPERIMENT (Self-motivation)	9	$\mu_{expSatis} = 20.33$	$\sigma^2_{expSatis} = 18.00$	$\mu_{expAblt} = 19.64$	$\sigma^2_{expAblt} = 33.50$
CONTROL (External feedback)	11	$\mu_{ctrlSatis} = 18.89$	$\sigma^2_{ctrlSatis} = 5.43$	$\mu_{ctrlAblt} = 17.36$	$\sigma^2_{ctrlAblt} = 23.32$

to design ($n = 20$). For the experiment in both experimental and control groups participants were asked to execute an illustration using software skills that they already possessed.

8. Methodology

8.1. Experiment I. Semantic analysis of self-feedback effects

As we said a 'digital arts' arena was adopted to better understand creative decisions. Participants in the 'experimental' group were given a creative task of half-hour duration. They chose their preferred software's for the task appraisal. A visual or audio-visual project had to be completed in half an hour. Participants had to first state what they wished to accomplish. At every 5-minute interval they registered their level of emotive satisfaction (or motivation for task completion) on a Likert type scale ranging from 1–5. 1 represented 'abandoned" or extreme negative emotion. Maximum satisfaction level is represented by 5 which corresponds to extreme positive motivation and resolve for long term engagement.

A different set of "control" participants were studied ($n = 11$). For controls the responses were conditioned by external feedback, including instruction for participants. They received feedback from others and had to record their feelings of motivation and ability (self-regulatory control over media) at the same 5-minute interval.

8.1.2. Results of experiment I

Self-reports for both Experimental (self-feedback) and Control (External feedback) groups were studied to examine a trajectory of creativity based on self-motivation and, in contrast to external feedback motivation for creative task appraisal.

Duration-wise Histogram

Assuming n_x, μ_x and σ_x^2 to be the number of sample observations for random variables of 'emotive satisfaction' for experimental participants (denoted as *expSatis*) and for control groups (denoted as *ctrlSatis)* (see Table 1), and also further assuming *expAblt* and *ctrlAblt* for self-regulation or 'ability' for experimental group and control participants we obtain the following distribution.

The Bhattacharyya distance $(D_B(p, q))$ is used to measure similarity of two discrete or continuous probability distributions. $(D_B(p, q))$ is closely related to coefficient $(B_c(p, q))$ which is a measure of the amount of overlap between two statistical samples [15]. The Gaussian overlap of self-feedback 'ability' rating between Experiment and Control Groups is found to be little less than the overlap of 'emotive satisfaction' ratings between the two groups (see Histogram Fig. 2 (a) and (b) and 3). But, since $D_B$values

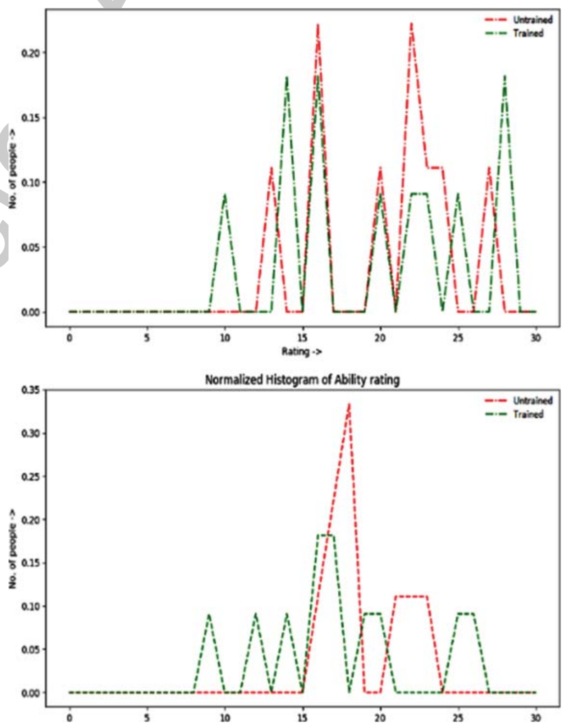

Fig. 2. a. (Top) Frequency of sample observations vs Total Satisfaction Rating from Tables 1 and 2b. (Bottom) Frequency of sample observations vs Total Ability Rating from Tables 1 and 2.

Table 2
Ratings for self-regulated and external feedback based understanding of 'emotive satisfaction' with one's own work

Total, Emotive Satisfaction Ratings		Total Emotive Satisfaction Rating		Ranks	
Self-	External	Self-	External	Self-	External
22	16		10		1
23	20	13		2	
22	25		14, 14		3.5, 3.5
20	10	16, 16	16, 16	6.5, 6.5	6.5, 6.5
16	14	20	20	9.5	9.5
13	28	22, 22	22	12, 12	12
27	16	23	23	14.5	14.5
24	14	23		16	
16	28		25		17
	23	27		18	
	22		28, 28		19.5, 19.5
Total				97	113

are high (according to the graph of natural logarithm) the distributions are less similar.

8.1.3. Discussion

Sample observations are collected from two separate populations of 'emotive satisfaction' for self-feedback and external feedback groups. We need to infer whether external feedback effects any significant change in goal achievement. Null hypothesis ($\mathbf{H}_0$) assumed is that external feedback does not effect any significant change (i.e. the means of two populations are equal). Considering $\mathbf{H}_0$ to be true, the probability of $\mathbf{H}_0$ being true in any two samples drawn from the populations is obtained. Value of α is taken as 0.05. If $\mathbf{H}_0$ denotes that Means of two distributions are equal then $\mathbf{H}_\mathrm{a}$ denotes that the Means are not equal.

Following are the important properties of the participants' *t*-distribution.

A. The participant *t*-distribution is different for different sample sizes.

The participant *t*-distribution is generally bell-shaped, but with smaller sample sizes it tends to show increased variability (being flatter). The distribution is less peaked than a normal distribution and is platykurtic. As the

B. sample size increases, the distribution approaches a normal distribution. differences are negligible for $n > 30$.
C. The Mean is zero (like standard normal distribution).
D. Distribution is symmetrical about the Mean (like standard normal distribution).
E. The variance is greater than one, but approaches one from above as the sample size
F. It takes into account the fact that the population's standard deviation is unknown.
G. The population is essentially normal (unimodal and basically symmetric)
H. increases ($\sigma^2 = 1$ for the standard normal distribution).

For a 2-sample *t*-test (as we are given in self-reports),

$$t\text{-value} = \frac{\mu_p - \mu_q}{\sigma_{p-q}} \tag{2}$$

where, $\sigma_{p-q} = \sqrt{\frac{\sigma_p^2}{n_p} + \frac{\sigma_q^2}{n_q}}$

Degree of freedom

$$(Df) = \frac{\sigma_{p-q}^4}{\left(\frac{\sigma_p^2}{n_p}\right)^2 / \left(n_p - 1\right) + \left(\frac{\sigma_q^2}{n_q}\right)^2 / \left(n_q - 1\right)} \tag{3.1}$$

for unequal variances

$$= n_p + n_q - 2 \tag{3.2}$$

for equal variances

From the given observations it may be said that $H0_{satis} \Rightarrow \mu_{expSatis} = \mu_{ctrlSatis}$ i.e. the Means of two random variables *expSatis and ctrlSatis* are same. Hence, external feedback is not absolutely required. $H0_{Ablt} \Rightarrow \mu_{expAblt} = \mu_{ctrlAblt}$ i.e. the Means of two random variables *expAblt and ctrlAblt* are same and hence again control type external feedback for performance is not required for creative performance. Variances of the random variables

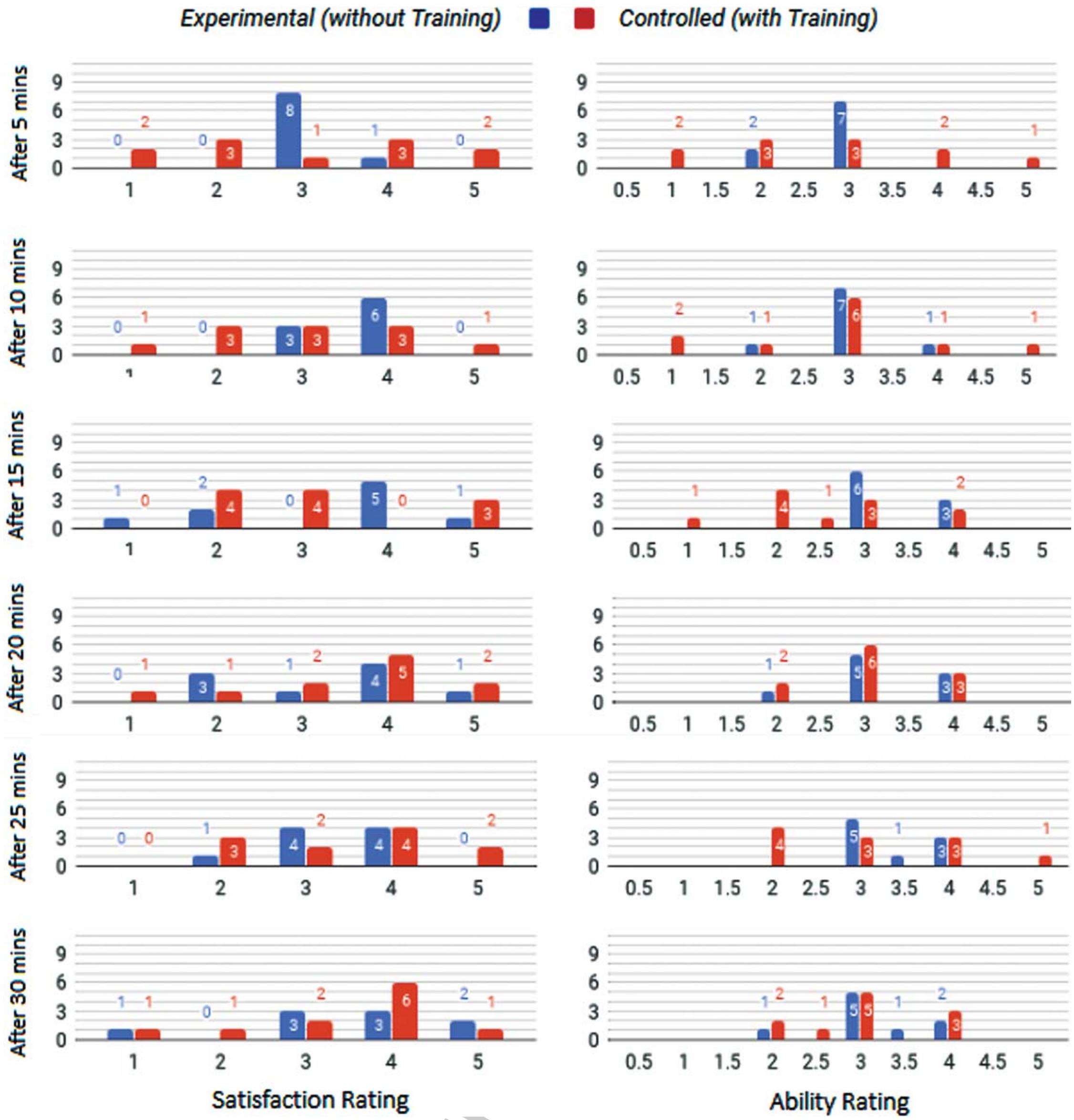

Fig. 3. Graphs of self-reports for emotive satisfaction and sense of ability for creative task recorded at 5 minutes' time interval.

expSatis & *ctrlSatis* and *expAblt* & *ctrlAblt* are respectively equal. So, Df is calculated using the Equation (3.1). Df = 9 + 11 - 2 = 18. *t*-value (*expSatis, ctrlSatis*) = 0.29, $p = 0.78$. *t*-value (*expAblt, ctrlAblt*) = 0.82, $p = 0.42$. $H0_{satis}$ and $H0_{Ablt}$ (the Means of two random variables) in both cases, cannot be rejected as significance level 0.05 is less that the *p*-values. So, external feedback is not essentially required.

The test statistic for the Mann Whitney U Test is denoted **U** and is the *smaller* of U_1 and U_2, defined below.

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

where R_1 = sum of the ranks for group 1 and R_2 = sum of the ranks for group 2.

$$U_{expSatis} = 9 * 11 + 9 * 10/2 - 97 = 47$$

$$U_{ctrlSatis} = 9 * 11 + 11 * 12/2 - 113 = 52$$

Table 3
Ratings for self-regulated and external feedback based understanding of abilities

Total Ability Ratings		Total Ability Rating (Ordered Smallest to Largest)		Ranks	
Self-motivated	External feedback	Self-motivated	External feedback	Self-motivated	External feedback
18	16		9		1
22	19		12		2
18	20		14		3
16	9	16	16, 16	5	5, 5
17	14	17, 17	17, 17	8.5, 8.5	8.5, 8.5
18	26	18, 18, 18		12, 12, 12	
23	12		19		14
21	16		20		15
17	25	21		16	
	17	22		17	
	17	23		18	
			25		19
			26		20
Total				109	101

$$U_{satis} = min\left(U_{expSatis}, U_{ctrlSatis}\right) = 47$$

p-value = 0.44

$$U_{expAblt} = 9*11 + 9*10/2 - 109 = 35$$

$$U_{ctrlAblt} = 9*11 + 11*12/2 - 101 = 64$$

$$U_{Ablt} = min\left(U_{expAblt}, U_{ctrlAblt}\right) = 35$$

p-value = 0.14

We can reject the null hypothesis and select the alternative hypothesis if $U < U_{critical}$. For sample observations equalling 9 and 11 and significance level = 0.05, the critical $U_{critical}$ value is 23. So, $H0_{satis}$ and $H0_{Ablt}$ (the Means of two random variables) in both cases cannot be rejected, since U_{satis}, $U_{Ablt} > U_{critical}$. We cannot say externally regulated creativity necessarily produces better results in a set up like in the given experiment.

8.2. Experiment 2. Brainwave analysis

Brainwave activity for the same participants (n = 20) were tested with the EPOC-EEG BCI hardware. Simultaneous brainwave graph was recorded during the performance of said tasks. Brainwave activity for the same participants were checked against findings based on conscious semantic responses to the level of 'emotive satisfaction' and the sense of self-regulated 'ability' experienced by participants.

Brain signals were captured with a Brain-Computer Interface (BCI) device during performance of tasks. The Emotiv-Epoc headset has 14 EEG channels (electrodes). The distribution of sensors (Fig. 4) in the headset is based on the international 10–20 electrode placement system. Four channels were used for the experiment. These are namely, AF3, F7, FC6 and AF4 (Fig. 4). These 4 channels were chosen for their recognized association with high concentration and activity for creative or problem-solving tasks (Sarnthein et al 1998; Wrobel 2000, [9] Jensen et al 2005; Herrington et al 2005; Gruzlier 2009), and for positive valence, (Aftanas and Golocheikine 2001; Herrington 2005; Gruzelier 2009).

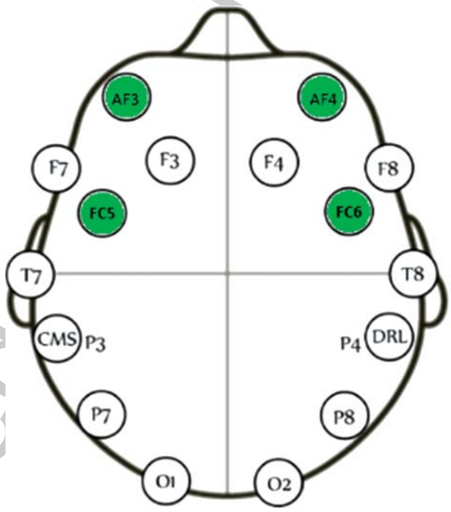

Fig. 4. Emotiv-Epoc headset electrode arrangement. Green indicates pre-frontal channels considered in detail for experiment.

8.2.1. Methodology

The idea was to examine brainwave activity for time-intervals in which participants also registered

Table 4

Figure 4 (a) and 4 (b) demonstrates average energy spectrum for all four individual channels normally considered for measuring creativity (Jensen et al 2005; Herrington et al 2005; Gruzlier 2009)

	AF4 + F7 + AF3 + F6	AF4 + F7 + AF3 + F6	SD		*t*-statistic		*P* value	
	Beta	Gamma	Beta	Gamma	Beta	Gamma	Beta	Gamma
Experimental	61.47	6.5566667	63.87	10.896	–0.50925	–0.66792	0.6185	0.5150
Control	87.344	16.92283	105.385	17.426				

self-satisfaction on the semantic workout-sheets for the experiment. The question is if activation from terminals AF3, AF4, FC6 and F7 supports the case for better verbal responses for self-feedback creativity in the experimental group against those recorded for control participants. A preponderance of a defined higher average beta and gamma wave range should indicate more concentration and involvement, and also potentially more creative activity (Watson et al 1979).

Electrical brain signals were obtained through non-invasive measures. Signal acquisition methods are generally employed to observe spontaneous brain activity based on the electrical activity of signals. When signals are acquired, generally, they are contaminated by noise and artifacts. Several techniques can be employed to remove these noises and artifacts, and identify the true signal. Feature extraction is done after noise is removed from the raw signal. Feature extraction techniques emphasize essential characteristics of the signal and its relation to biomedical events. For our case we used the Empirical Mode Decomposition (EMD) (Huang 2014). EMD again, is based on the fundamental principle of the Hilbert–Huang transform (HHT). The Hilbert Huang transform was carried out, so to speak, in 2 stages. First, we used the EMD algorithm: in the second stage the instantaneous frequency spectrum of the initial sequence is obtained by applying the Hilbert transform to the results of the previous step (Huang 2014). The HHT allows us to obtain the instantaneous frequency spectrum of nonlinear and non-stationary sequences.

These sequences can consequently also be dealt with by using EMD. The signal obtained is not continuous in time. 7680 discrete values are recorded per minute at a sampling frequency of 128 Hz. The signal is broken down into 22 signals (modes), which added together allow us to recover the original signal. This decomposition helps us calculate the energy in each time interval.

To separate the signals in the ranges of beta and gamma waves, the Hilbert frequencies are separated on the following basis: Beta 12 to 39 HZ, with an optimal ± 16 Hz ideal range for creativity (Watson et al 1979, [61]. Gamma Range is considered to manifest over 40 Hz (Watson et al 1979; Shiu et al 2011, [61]. The energies are added in each mode for beta and gamma in the corresponding time interval. Simultaneous presence of higher beta and gamma should indicate more emotive satisfaction (arousal) and creative flow. Higher energy output should be consistent with stress and concentration factors, higher gamma with more harmony. Supragamma levels of ±70 indicate emotive finésse in task execution, commonly associated with artistic competence [61]. The beta-gamma distribution for these channels are more significant in so far as they reflect typical creative focusing (Jensen et al 2005; Shiu 2011, [61].

8.2.1. Results

The study reveals that self- feedback is reflected in the Fourier spectrogram of at least 44% of experimental group participants as contrasted to only 36 % of control participants. Brainwave energy recorded for all participants are represented in the table below (Table 4). A sum of the average frequencies recorded for each candidate in each category was considered for statistical analysis. A distinctly high beta wave energy output in unconscious brainwave was evidently found to be the trend in both experimental and control participants. If the EEG records match the conscious registers of motivation in most cases of the experiment, we could safely say that there is correspondence between verbal claims made by participants on the trajectory of their feelings and brainwave activity.

The frequency data was adopted for both experimental and control groups involved in self-regulatory feedback and external tutored feedback for creative trajectories respectively. Of all channels AF4, AF3 F6 and F7 were considered for focus and creative, i.e. problem-solving task appraisals (Jansen 2005; Herrington et al 2005; Gruzlier 2009). Beta radiation studied for pre-frontal problem solving areas indicate activation and level of focus or absorption of participants in their work.

8.2.2. Discussion

At least, 44% of higher Beta and Gamma activity is recorded for the self-regulated experimental group. Participants 1, 2, 7 in the experimental group demonstrate high Gamma wave activity in all PFC terminals, notably AF4, F6 and F7 in the total 30-minute segment. Participant 2 reflects exclusively high peaks for AF4 and F7. Participant 5 demonstrates more sporadic creative peaks for both Beta and Gamma. In contrast to total average wave activity in the same 16 to 40 Hz range of self-motivated, self-regulated participants high peak activity is reflected in 36 % of wave functions in the external feedback group. Though individual performances are not significantly different ($p > .61$) for Beta and ($p > .51$) for Gamma (Table 4), there is no direct evidence of greater emotively driven self-regulated activity for experimental group in t-statistics predictions (after leaving out outliers in bad signals (Table 4)).

On the basis that brainwave behavior of the control and experimental groups is neurophysiologically similar (and assuming that high energy beta and gamma values would generally reflect the same values in contexts of self-feedback and external feedback) we observe that performance indicators for brainwave have no significant difference as far as brain activity in these two categories are concerned. Contrarily positive self-feedback could indicate towards better flow results for dedicated artists working on self-instruction reliance. There are preponderant high peak outputs, indicative of tranquility and flow for self-feedback creativity, though this may not be a universal rule in creative behavior. Design learning is definitely fostered by positive self–feedback. This is evident when brainwave patterns are compared to specific moments of conscious verbal self-feedback.

A general picture of brainwave energy output may be suggested for a larger time scale. We consider in some detail information on filtered brainwave behavior for beta and gamma wave activity generated for moments in which participants verbally recorded significant changes in their perception of emotional satisfaction with their own work, as well as their sense of competence or ability (Fig. 5 a–d).

We identify the peaks in changes in verbal report of satisfactions for both types of participants. We study brainwaves for each of the pre-frontal channels, but only for beta and gamma which are filtered following the Hilbert-Huang transform. For example, verbal report of change in levels of emotional satisfaction peaks for Participant 5 in the group of experimental participants. Interestingly, there is a drop of 3 negative points after 10 minutes, and a rise of 4 points positive on the Likert type scale. Interestingly, Participant 5 (Experimental) 10 to 11 minutes, for Channel F7 Gamma with distributing median of.013 SD ± 1.07 for a filtered Gamma distribution around the 50 HZ axis. We may say that there is a steady Gamma output for the time period. Similarly, for Control Participant (17), in the context of Participant 17 for example we notice a drop of 6 points on the Likert scale, between 20 and 21 minutes. However, for pre-frontal channels AF3, AF4 and F6 and F7 there is no significant difference in the behavior of brain waves for the same participant in the period between 15 and 21 minutes. However, the limitation here is that no inference can be made for all specific output signals between Control and Experimental participants.

9. Conclusion

We know how feedback strategies influence creative and meditative practices (Peper 2012). In this article however we have tried mainly to focus on self-feedback in learner-artists whose work requires imagination, freedom and emotional happiness or satisfaction for problem-solving. Whether brainwave activity reflects phases of better concentration and focus in the prefrotal channels is studied. There is no significant negative impact on pattern of wave behavior in case of self-feedback for participants in our experiment. This might mean that in any intelligent system self-feedback may be an efficacious alternative [19]. Similarly, following Boyatzis and colleagues' suggestion for more reseach on how neural functions are related to life and to all our other activities, we could say that a study of brainwaves for the frontal channels, especially for creative tasks, is a step in the right direction. The Hilbert Huang transform defines the range of frequencies studied and provides a useful tool for filtering a broad spectrum of wave activities. On the whole, both β and γ are found to reveal behaviors that are conistent with the findings in the literature for normative problem-solving capacities.

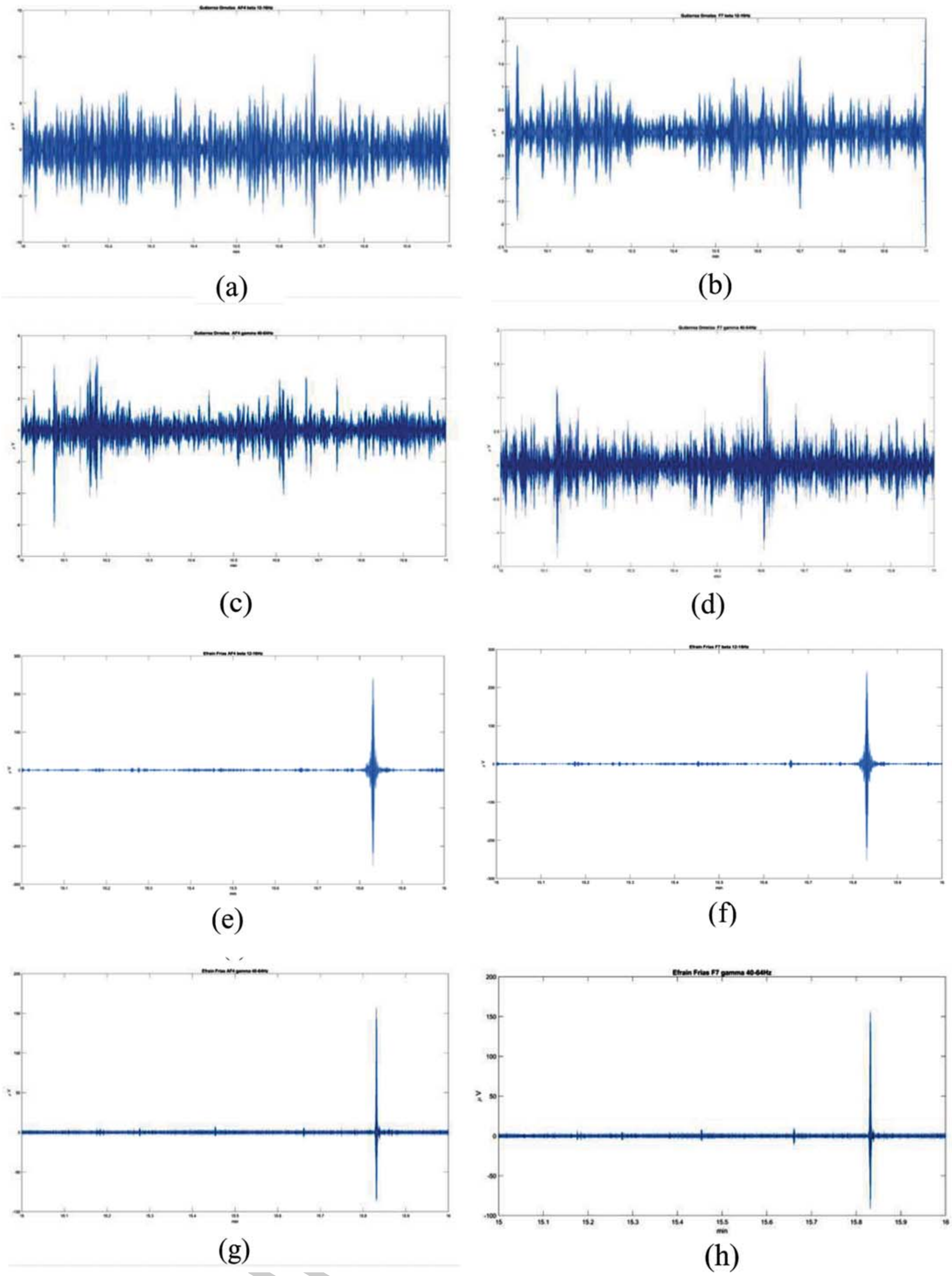

Fig. 5. (a) Filtered Beta wave trajectory for pre-frontal AF4 between 10 and 11th minute of task performance (Experimental category. Participant No.5) (b) Filtered Beta wave trajectory for pre-frontal F7 between 10 and 11th minute of task performance (Experimental category. Control category Participant No. 5) (c) Filtered Gamma wave trajectory for pre-frontal AF4 between 10 and 11th minute of task performance (Experimental category. Participant No.5) (d) Filtered Gamma wave trajectory for pre-frontal F7 between 10 and 11th minute of task performance (Experimental category. Participant No.5) (e) Filtered Beta wave trajectory for pre-frontal AF4 between 15th and 16th minute of task performance (Control category Participant No.17) (f) Filtered Gamma wave trajectory for pre-frontal F7 between 15th and 16th minute of task performance (Control category Participant No.17) (g) Filtered Gamma wave trajectory for pre-frontal F7 between 15th and 16th minute of task performance (Control category Participant No.17) (h) Filtered Gamma wave trajectory for pre-frontal F7 between 15th and 16th minute of task performance (Control category Participant No.17).

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