ORIGINAL ARTICLE

EVALUATION OF ELECTROCARDIOGRAM SIGNALS OF FEMALE AND MALE IN CREATIVITY BASED ON CLASSIFICATION APPROACHES

Sahar Zakeri[1,*], Ataollah Abbasi[2], Ateke Goshvarpour[3]

1- M.Sc. Student, Computational Neuroscience Laboratory, Department of Biomedical Engineering, Faculty of Electrical Engineering, Sahand University of Technology, Tabriz, Iran. s_zakeri@sut.ac.ir
2- Assistant professor, Computational Neuroscience Laboratory, Department of Biomedical Engineering, Faculty of Electrical Engineering, Sahand University of Technology, Tabriz, Iran. ata.abbasi@sut.ac.ir
3- Ph.D. Student, Computational Neuroscience Laboratory, Department of Biomedical Engineering, Faculty of Electrical Engineering, Sahand University of Technology, Tabriz, Iran. ak_goshvarpour@sut.ac.ir

Abstract: As Electrocardiogram (ECG) analysis is often used to detect cognitive behavior, this paper presents a novel approach for distinction between male/female and normal/creativity states from ECG signals. The goal of this article is to indicate the heart mechanisms that mediate creativity, and how detect the creative men or women subjects. For these purposes, a nonlinear feature of the ECG signal was extracted to detect creativity states. Doing three tasks of Torrance Tests of Creative Thinking (TTCT- Figural B), ECG signals of 52 participants (26 men, 26 women and 19-24 years) were recorded. Then, the performance of Support Vector Machine (SVM) classification was evaluated. The results showed that the best accuracy between male/female is 91.74% and normal/creativity states is 91.36% with this classifier.
Keywords: Creativity, Electrocardiogram, Gender, Fractal Dimession, Support Vector Machine,

1. INTRODUCTION

Extensive research has been done on the heart beat rhythm and is now in progress. Researchers records the electrical activity of the heart from the start and eventually reached the digital signal processing systems [1]. Myogenic rhythm of the heart that works with the ability to beat regularly without neural input. Potential to regulate the heartbeat in the right atrium of the heart rate produced by the system and the heart muscle moving along [2]. A considerable overlap in time between the action potential and contraction of the heart compared to skeletal muscle there [3]. Increased rate of stimulation of sympathetic nerves and parasympathetic nervous activity decreases [4]. The autonomic nervous system on cardiac action potential duration and conduction velocity of impact [5, 6].
Dynamic heart, nonlinear and non-stationary and continuous performance and swinging beat and stimulate the inner and outer coexisting. Given these definitions and assumptions, the linear analysis of all aspects of cardiac function may be especially delicate and subtle interactions between the regulatory mechanisms controlling the function does not include the heart [7]. As a result of nonlinear dynamical systems techniques to determine cardiac system created a multi-dimensional processes. In mathematics, a nonlinear system is defined as a system of degree 2 or higher.

Psychological research on creativity began in 1950, which included responses were vague [8]. There are several theories to explain creativity in their place enlightening explanation of the needs and demands of family situation arises. Others, such as Torrance Harrington (1974) [9, 10], believe that creativity is a means to effect personal factors such as motivation, emotion, emotions, feelings, experiences and personal learning depends. Some researchers, such as Guilford (1950) proposed that creativity and cognitive dimension depend on higher mental processes such as thinking, intelligence, imagination, and associated information processing. Like Sternberg (1996) showed that creativity is a multivariate phenomenon [9, 13]. This means that factors such as community, family, personality and cognitive abilities that affect simultaneously.
Dr. Paul Torrance demonstrated that creativity is the combination of four factors: flexibility, fluency, originality, elaboration. He is "The Father of Creativity," with the development of the Torrance Test of Creative Thinking (TTCT) is known. TTCT was developed by Torrance in 1966. Reformed four times: in 1974, 1984, 1990, and 1998.TTCT been translated into more than 35 languages. General information on these tests are widely used. Torrance Test of Creative Thinking Form B

(figural) has three distinct tasks and carry out any task that takes 10 minutes and it will be a total of 30 minutes. It is scored with four scale: originality, elaboration, flexibility and fluency [10].

Already, Electroencephalography (EEG) signals were used in the detection of creativity levels [14]. Although, these studies have been done statistically, but detailed analysis based on feature extraction has not been done. In addition, the role of physiological signals such as ECG has not been studied.

In this paper, investigated effect of creativity state on ECG signal. We used nonlinear feature to separate creativity steps and female from male. Some researchers showed that many women had transcend in creativity [15] and all of them studied on EEG signals or MRI [16-19]. In this research, we used ECG signal and extract its features to separate creative subjects on gender. The resulted feature vector is fed to kernel based Support Vector Machine (SVM) system for classification. Until this time, there is no study on classification creativity with nonlinear features of ECG.

2. METHODS
2.1. ECG RECORDING

In this research, the ECG signal 52 students of biomedical engineering, material engineering, and control engineering were collected (26 female and 26 male). The subjects were asked to not drink coffee for 5 hours and have enough sleep. All tasks were explained before recording. They sit on

$$D^{katz} = \frac{\log(L)}{\log(d)}$$

Where L is the total length of the curve or sum of distances between successive points, and d is the diameter estimated as the distance between the

$$d = \max \|x(1) - x(i)\|$$

Considering the distance between each point of the sequence and the first, point *i* is the one that maximizes the distance with respect to the first point. The FD compares the actual number of units that compose a curve with the minimum number of units needed to reproduce a pattern of the same spatial extent. FDs calculated in this fashion

comfort chair and electrodes were connected on their wrist. They were present in the lab half-hour before. Observer had a conversation with subjects to be relax and didn't have stress. ECG signals recorded from lead II, 2-minutes of rest states and 30 minutes in creativity states, while the TTCT is done. Sampling frequency was 1000 Hz. The ECG signals were filtered between 0.4 Hz and 350 Hz with Chebyshev 2; an additional 50 Hz notch filter was applied to avoid power line contamination. Electrode impedances were kept below 5 kΩ. The ECG signals were recorded in the Computational Neuroscience Laboratory of Sahand University of Technology.

2.2. FEATURE EXTRACTION: FRACTAL DIMENSION

A fractal is a set of points that when looked at smaller scales, resembles the whole set. An essential characteristic of a fractal is self-similarity. This means that its details at a certain scale are similar, but not necessarily identical, to those of the structure seen at larger or smaller scales. The FD of a waveform represents a powerful tool for transient detection. This feature has been used in the analysis of ECG to identify and distinguish specific states of physiological function. Several algorithms are available to determine the FD of the waveform, among others the algorithms proposed by Higuchi and Katz [20]. According to the method of Katz, the FD of a curve can be defined as:

(1)

first point of the sequence and the most distal point of the sequence. Mathematically, d can be expressed as:

(2)

depend on the measurement units used. If the units are different, then so are the FDs. Katz approach solves this problem by creating a general unit or yardstick: the average step or average distance between successive points, a. Normalizing the distances, D^{katz} is then given by:

$$FD = \frac{\log(L/a)}{\log(d/a)} \tag{5}$$

2.3. CLASSIFIER: SUPPORT VECTOR MACHINE

Support Vector Machine (SVM) approach in the automatic classification of electrocardiogram (ECG) beats [21]. Since an SVM is known to have the advantage of offering solid performance of classification with even smaller learning data, we can expect the proposed algorithm, with rather small learning data, would prove better performance than other classifiers. SVM classification whit Kernel function was used in this paper to classify ECG signal data [22].

3. RESULTS
3.1. GENDER

Comparisons between males and females, indicate level of creativity of women is higher than men in all 4 TTCT scales (Table 1). Task 1 of TTCT has two parameters to scoring (originality and elaboration) but task 2 and task 3 has four parameters to scoring (originality, elaboration, flexibility and fluency). After extraction TTCT scores norms technical and z transform were applied. Then all scores were in the range from zero to 100 point.

Table 1, The mean scores ± standard deviation of the three tasks of TTCT for men and women.

	Orginality	Elaburation	flexibility	fluency
Women	53.44±30.90	54.16±24.64	52.96±22.60	56.30±24.12
Men	46.03±21.54	42.21±25.78	46.23±16.82	46.02±22.77

Alteration of FD showed in Figure 1. This feature was clinically significant ($p<0.05$). The features were ranked using Wilcoxon ranking method. It can be seen from Figure 1 that FD show lower values at the end of the test as compared to the normal. After three tasks, the amount of each of these parameters is less than the initial value.
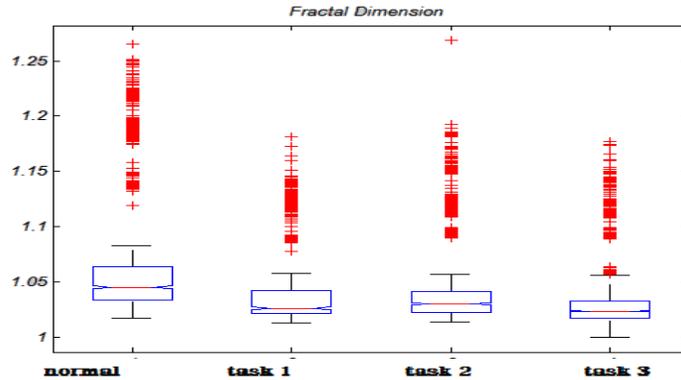

Figure 1. Nonlinear parameters distribution diagram for creativity tasks and normal states.

3.2. SVM CLASSIFIER RESULTS

Three measures namely accuracy, sensitivity and specificity were used to assess the performance of the SVM classifier. Accuracy indicates overall detection accuracy, sensitivity is defined as the ability of the classifier to accurately recognize a true case whereas specificity would indicate the classifier's ability not to generate a false negative (normal subject, false apnea case). These measures are defined as follows.

$$Accuracy = \frac{TP+TN}{n} * 100$$

$$Sensitivity = \frac{TP}{TP+FN} * 100$$

$$Specificity = \frac{TN}{TN+FP} 100$$

where n, T, TN, FP and FN are the number of input samples, the number of correct recognition with negative label, the number of false recognition with positive label and the number of false recognition with negative label, respectively. It

was discovered that replacing all the dot products by nonlinear kernel functions, like polynomial, quadratic and radial basis function (RBF), made the whole algorithm nonlinear. Table 1, shows the difference between male and female in creativity tasks.

Table 2. SVM classification results using nonlinear parameters between male-female groups in three task of TTCT.

	accuracy	sensitivity	specificity	error
Task 1	91.74	91.69	91.75	0.08
Task 2	88.77	89.78	87.74	0.11
Task 3	89.22	88.89	89.54	0.11

According to Table 2, the best performance of SVM classifier reached in task 1. So, maximum accuracy 91.74% was seen on task 1 between two groups.

Six class created according to six states; class A: normal vs. task 1, class B: normal vs. task 2, class C: normal vs. task 3, class D: task 1 vs. task 2, class E: task 1 vs. task 3, class F: task 3 vs. task 3. Table 3, shows SVM results of creativity states on six different states. Table 3, shows the maximum accuracy in "A" group.

Table 3. SVM classification results using nonlinear parameters between normal and creativity states.

	accuracy	sensitivity	specificity	Error
A	91.36	90.00	92.71	0.9
B	84.77	85.05	85.08	0.15
C	88.90	93.13	85.51	0.11
D	85.41	88.22	82.72	0.15
E	86.55	89.32	84.27	0.14
F	69.05	77.79	62.86	0.31

5. CONCLUSION

Nonlinear methods have proven to be more useful for the analysis of non-stationary and nonlinear methods. They can capture subtle changes in the signals. Hence, we have used nonlinear methods to extract the features in the ECG signals. Since, no study has been done in this field, so the results cannot be compared with the work of others.

It reports the summary of accuracy percentage classification of three classifier on men and women groups using ECG signals. The error diversity of SVM classifier is demonstrated that task 1 was less than others. Therefor the SVM performances, in this task is better than the other tasks to separate two groups of men and women.

ECG signals are useful in the detection of cognitive behavior. Study of the ECG signals using nonlinear parameters method will greatly aid in the understanding of the inner dynamics of the system. Classification of creativity/normal states and male/female groups with ECG signals was not done using a classifier, but for the first time, it was done in this article.

Whole ECG recording for creativity and normal subject are obtained from Sahand University of Technology. Finally proposed feature set achieved an accuracy of 91.74%, sensivity of 91.69% and specificity of 91.75% with SVM network.

In this paper we present a novel solution to deal with the shortcomings of creative classification of the ECG signal. It shows that the proposed *SVM* performs in task 1 better than any other tasks.

REFERENCE

[1] Poungponsri, S., Yu, X. H. (2013). An adaptive filtering approach for electrocardiogram (ECG) signal noise reduction using neural networks. *Journal of Neurocomputing, 117,* 206-213.

[2] Wolf, S. (1956). The End of the Rope: The Role of the Brain in Cardiac Death. *Journal of Canadian Medical Association, 97(17),* 1022–1025.

[3] Szilágyi, S. M. (2007). Dynamic Modeling of the Human Heart. Ph.D thesis, Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics, Department of Control

Engineering and Information Technology, (pp. 1-114).

[4] Ozbay, Y., Ceylan, R., Karlik. B. (2011). Integration of type-2 fuzzy clustering and wavelet transform in a neural network based ECG classifier. *Journal of Expert Systems with Applications, 38,* 1004–1010.

[5] Ansari, A. Q., Gupta. N. K. (2011). Automated Diagnosis of Coronary Heart Disease Using Neuro-Fuzzy Integrated System. *World Congress on Information and Communication Technologies,* 1379-1384.

[6] Imanishi, A. Higa, M. O. (2007). On the Largest Lyapunov Exponents of Finger Plethysmogram and Heart Rate under Anxiety, Fear, and Relief States. *IEEE, International Conference on Systems, Man and Cybernetics,* 3119-3123.

[7] Nguyen, T. A., Zeng, Y. (2014). A physiological study of relationship between designer's mental effort and mental stress during conceptual design. *Computer-Aided Design, 54,* 3–18.

[8] Ghacibeh, G. A., Shenker, J. I., Shenal, B., Uthman, B. M., Heilman, K. M. (2006). Effect of vagus nerve stimulation on creativity and cognitive flexibility. *Epilepsy & Behavior, 8,* 720–725.

[9] Rad, I. S., Karimi, L., Ramezani, V., Ahmadi, M., Heshmatic, R., Jafar, E. (2010). Psychometric properties of Torrance test (Persian version) of creative thinking (A form). *Procedia Social and Behavioral Sciences, 5,* 1429–1433.

[10] Kim, K. H. (2006). Can We Trust Creativity Tests? A Review of the Torrance Tests of Creative Thinking (TTCT). *Creativity Research Journal, 18,* 3–14.

[11] Almeida, L. S., Prietob, L. P., Ferrando, M., Oliveira, E., Andiz, C. F. (2008). Torrance Test of Creative Thinking: The question of its construct validity. *Thinking Skills and Creativity, 3,* 53–58.

[12] Ayob, A., Hussain, A., Mustaffa, M. M., Majid, R. A. (2011). Assessment of Creativity in Electrical Engineering. *UKM Teaching and Learning Congress, 60,* 463–467.

[13] Higuchi, T., Miyata, K. (2012). Creativity Improvement by Idea-Marathon Training, Measured by Torrance Tests of Creative Thinking (TTCT) and Its Applications to Laboratories. *Seventh International Conference on Knowledge, Information and Creativity Support Systems, 22,* 66-72.

[14] Fink, A., Grabner, R. H., Gebauer, D., Reishofer, G., Koschutnig, K., Ebner, F. (2010). Enhancing creativity by means of cognitive stimulation: Evidence from an fMRI study. *NeuroImage Journal, 52,* 1687–1695.

[15] B. Cramond. Women and Creativity". Encyclopedia of Creativity (Second Edition)**.** 2011, Pages 521–524.

[16] N. Srinivasan. Cognitive neuroscience of creativity: EEG based approaches". Methods**,** Volume 42, Issue 1, May 2007, Pages 109–116. Neurocognitive Mechanisms of Creativity: A Toolkit.

[17] M. G. Starchenko. "Brain maintenance of verbal creativity". NeuroImage, <u>Volume 47, Supplement 1</u>, July 2009, Pages S88, Organization for Human Brain Mapping 2009 Annual Meeting.

[18] O. M. Bazanova, D. Vernon, "Interpreting EEG alpha activity". Neuroscience & Biobehavioral Reviews**,** Volume 44, July 2014, Pages 94–110, Applied Neuroscience: Models, methods, theories, reviews. A Society of Applied Neuroscience (SAN) special issue.

[19] A. Fink. "fMRI/EEG". Neuroscience Letters**,** Volume 500, Supplement, July 2011, Pages e15.

[20] Ayyoob, J. "Sleep apnoea detection from ECG using features extracted from reconstructed phase space and frequency domain". Biomedical Signal Processing and Control, Volume 8 (2013), pp. 551–558.

[21] Melgani, F., Bazi, Y. (2008). Classification of electrocardiogram signals with support vector machines and particle swarm optimization. *IEEE, Trans INF Technol Biomed.*

[22] Zhu, Y., 2012, SVM Classification Algorithm in ECG Classification. *Communications in Computer and Information Science, 308,* 797-803.