

MACHINE LEARNING THROUGH SOM NEURAL NETWORK ALGORITHM IN THE DOMAIN OF COGNITIVE NEUROPSYCHOLOGY

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Abstract:

Machine Learning through the application of Self-organizing Maps / Kohonen Self-Organizing Neural Network Algorithm in Cognitive Behavioral Therapy for Personality Disorders is one of its kinds Research Work. This pioneering effort is the amalgamation of the domain of Cognitive Neuropsychology with Artificial Neural Networks. This Research Work has five phases which are sequentially proceeded with. The first phase embodies Introduction as to what Machine Learning is and how pertinent it could be in the research domains. The second phase of the paper centers on the discussion of the fundamental terms such as Neuroscience, Cognitive psychology, Personality, and Personality Disorders. The discussion on Personality Disorders is kept to be candid and at the same time information-centric. Implications of Personality Disorder are being provided with its due significance. The third phase of this paper sheds light on Cognitive Behavioral Therapy (CBT) for personality disorders and the scope of Intelligent System for CBT. The fourth phase of the work commences by discussing SOM / Kohonen Self-Organizing Neural Network Algorithm for developing an Intelligent System for CBT in treating personality disorders. Sufficient information is provided about the Personality Inventory questionnaire with close-ended options. A thorough discussion is made on the Questionnaire being administered. This is followed by the induction of actual Questionnaire being prepared and administered for the purposes of this research work. Extraction of Inferences from the data obtained from the respondents is scientifically and systematically pursued. In the discussion under the topic, 'Saturation of Threshold Value', the rationale for the freezing of Threshold Value is being discussed. The crux of the fourth phase lies in the application of SOM / Kohonen Self-Organizing Neural Network Algorithm for treatment of Personality Disorders by fusing the CBT. The fifth phase of the paper lays foundation for the enrichment of this research attempt by spelling out other possible domains and recommended thrust areas. Thus, this paper will be a benchmark and an opportunity-provider, as a base-paper for further Research Works. Through this work, by fusing SOM / Kohonen Self-Organizing Neural Network Algorithm with CBT, attempt is made to cure the Personality Disorder of people, without any residual impact on their personalities.

Keywords:

Personality disorders, cognitive behavioral therapy (CBT), Kohonen self-organizing nets, winner take-all strategy.

1. INTRODUCTION

Machine learning is a subfield of computer science that evolved from the study of pattern recognition and computational learning theory in artificial intelligence. In 1959, Arthur Samuel defined machine learning as a "Field of study that gives computers the ability to learn without being explicitly programmed". Machine learning explores the study and construction of algorithms that can learn from and make predictions on data. Such algorithms operate by building a model from example inputs in order to make data-driven predictions or decisions, rather than following strictly static program instructions [1].

2. NEUROSCIENCE

Neuroscience, the study of the nervous system, advances the understanding of human thought, emotion, and behavior. Neuroscientists use tools ranging from computers to special dyes to examine molecules, nerve cells, networks, brain systems, and behavior. From these studies, they learn how the nervous system develops and functions normally and what goes wrong in neurological disorders.

Humans contain roughly 100 billion neurons, the functional units of the nervous system. Neurons communicate with each other by sending electrical signals long distances and then releasing chemicals called neurotransmitters which cross synapses -- small gaps between neurons.

2.1 COGNITIVE PSYCHOLOGY

Cognitive psychology studies cognition, the mental processes underlying behavior. It uses information processing as a framework for understanding the mind. Perception, learning, problem solving, memory, attention, language and emotion are all well researched areas. Cognitive psychology is associated with a school of thought known as cognitivism. On

a broader level, Cognitive science is a conjoined enterprise of cognitive psychologists, neurobiologists, researchers in artificial intelligence, logicians, linguists, and social scientists, and places a slightly greater emphasis on computational theory and formalization. Both areas can use computational models to simulate phenomena of interest. Because mental events cannot directly be observed, computational models provide a tool for studying the functional organization of the mind. Such models give cognitive psychologists a way to study the "software" of mental processes independent of the "hardware" it runs on.

2.2 PERSONALITY

Personality is defined as an individual's unique and relatively consistent patterns of thinking feeling and behaving. There are basically five dimension of Personality that is understood to be important in order that one may enjoy sound mental health. Those dimensions or traits are addressed as "Big Five" or "Five Factor" Model. The five factors are **Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism** (OCEAN, or CANOE if rearranged). The Neuroticism factor is sometimes referred to as Emotional Stability.

2.3 PERSONALITY DISORDERS [2]

Personality disorders, formerly referred to as character disorders, are a class of personality styles which deviate from the contemporary expectations of a society. Personality disorders are defined by the American Psychiatric Association (APA) as "an enduring pattern of inner experience and behavior that deviates markedly from the expectations of the culture of the individual who exhibits it". These patterns, as noted, are inflexible and pervasive across many situations, due in large part to the fact that such behavior is ego-syntonic and therefore, perceived to be appropriate by that individual. The onset of these patterns of behavior can typically be traced back to late adolescence and the beginning of adulthood, and, in rare instances, childhood.

2.3.1 ANTISOCIAL PERSONALITY DISORDER

Antisocial personality disorder (APD) is defined by the American Psychiatric Association's Diagnostic and Statistical Manual: "The essential feature for the diagnosis is a pervasive pattern of disregard for, and violation of, the rights of others that begins in childhood or early adolescence and continues into adulthood." Deceit and manipulation are considered essential features of the disorder.

2.3.2 AVOIDANT PERSONALITY DISORDER

Avoidant personality disorder (APD or AvPD) or Anxious personality disorder (APD) is a personality disorder characterized by a pervasive pattern of social inhibition, feelings of inadequacy, extreme sensitivity to negative evaluation and avoidance of social interaction. People with avoidant personality disorder often consider themselves to be socially inept or personally unappealing, and avoid social interaction for fear of being ridiculed, humiliated, rejected or disliked.

2.3.3 BORDERLINE PERSONALITY DISORDER

Borderline Personality Disorder (BPD) is a prolonged disturbance of personality function characterized by depth and variability of moods. The disorder typically involves unusual levels of instability in mood; "black and white" thinking, or "splitting"; chaotic and unstable interpersonal relationships, self-image, identity, and behavior; as well as a disturbance in the individual's sense of self. In extreme cases, this disturbance in the sense of self can lead to periods of dissociation.

2.3.4 DEPENDENT PERSONALITY DISORDER

Dependent personality disorder (DPD), formerly known as asthenic personality disorder is a personality disorder that is characterized by a pervasive psychological dependence on other people.

2.3.5 HISTRIONIC PERSONALITY DISORDER

Histrionic personality disorder (HPD) is defined by the American Psychiatric Association as a personality disorder characterized by a pattern of excessive emotionality and attention-seeking, including an excessive need for approval and inappropriate seductiveness, usually beginning in early adulthood.

2.3.6 NARCISSISTIC PERSONALITY DISORDER

Narcissistic personality disorder (NPD) refers to 'a pervasive pattern of grandiosity, need for admiration, and a lack of empathy'. The narcissist is described as turning inward for gratification rather than depending on others and as being excessively preoccupied with issues of personal adequacy, power and prestige. Narcissistic personality disorder is closely linked to self-centeredness.

2.3.7 OBSESSIVE-COMPULSIVE PERSONALITY DISORDER

People experiencing Obsessive-Compulsive Personality Disorder (OCPD) may feel anxious when they perceive that things are not "right." This can lead to routines and "rules" for ways of doing things, whether for themselves or their families. Rather than get something wrong, OCPD individuals will make lists of things to do and how to do them. Then they go on adding to the lists, or find new associated things to do, meaning they may never finish what they wanted to do in the first place.

2.3.8 PARANOID PERSONALITY DISORDER

Paranoid personality disorder is a psychiatric diagnosis characterized by paranoia and a pervasive, long-standing suspiciousness and generalized mistrust of others. For a person's personality to be considered a personality disorder, an enduring pattern of characteristic maladaptive behaviors, thinking and personality traits must be present from the onset of adolescence or early adulthood. Additionally, these behaviors, traits and thinking must be present to the extent that they cause significant difficulties in relationships, employment and other facets of functioning.

2.3.9 SCHIZOID PERSONALITY DISORDER

Schizoid personality disorder (SPD) is a personality disorder characterized by a lack of interest in social relationships, a tendency towards a solitary lifestyle, secretiveness, and emotional coldness. SPD is rare compared with other personality disorders. Its prevalence is estimated at less than 1% of the general population.

2.3.10 SCHIZOTYPAL PERSONALITY DISORDER

Schizotypal personality disorder, or simply schizotypal disorder, is a personality disorder that is characterized by a need for social isolation, odd behavior and thinking, and often unconventional beliefs. The schizotypal individual develops a fear of, strong objection to, or incapacity for social interaction, due to the sum of their past social experiences being negative in nature.

3. COGNITIVE BEHAVIORAL THERAPY (CBT)

Cognitive Behavioral Therapy (CBT) is a psychotherapeutic approach that aims to influence dysfunctional emotions, behaviors and cognitions through a goal-oriented, systematic procedure. CBT can be seen as an umbrella term for a number of psychological techniques that share a theoretical basis in behavioristic learning theory and cognitive psychology. Cognitive Behavioral Therapy (CBT) is a combination of behavior modification and cognitive therapy.

- **Cognitive** - Our thoughts, beliefs and assumptions. Our thoughts affect the way we feel and how we respond to events and challenges, both mentally and physically.
- **Behavioral** - Therapy aimed at changing behavior.

3.1 COGNITIVE BEHAVIOR THERAPY FOR PERSONALITY DISORDERS [3]

CBT is applied to many clinical and non-clinical conditions and has been successfully used as a treatment for many clinical disorders, personality conditions and behavioral problems. Whilst CBT is highly effective for a number of disorders it is important to note that cognitive behavioral therapy is unlikely to be effective in patients with substance dependence and/or abuse problems as cognitive behavioral therapy itself cannot change drug or alcohol induced mental health symptoms.

3.2 COMPUTERIZED CBT THROUGH THE APPLICATION OF SOM

There are cognitive behavioral therapy sessions in which the user interacts with computer software (either on a PC, or sometimes via a voice-activated phone service), instead of face to face with a therapist. This can provide an option for patients, especially in light of the fact that there are not always therapists available, or the cost can be prohibitive. For people who are feeling depressed and withdrawn, the prospect of having to speak to someone about their innermost problems can be off-putting. In this respect, computerized CBT / Intelligent System for CBT (especially if delivered online) can be a good option.

4 SOM / KOHONEN SELF-ORGANIZING NEURAL NETWORKS [4]

The term *self-organization* refers to the ability to learn and organize information without being given answers for input patterns. Thus, self-organizing networks perform unsupervised learning. This computational model may serve to explain some neurobiological phenomena such as how a baby learns since it does not know what is correct.

The self-organization model is effective for dealing with problems whose algorithms are too complicated to define, for example, modeling of irregular surfaces. In robotics, self-organization compensates for dealing with unexpected and changing situations which lack mathematical descriptions.

Kohonen identified two mechanisms for a network to self-organize spatially.

1. Locate the unit that responds best to the given input. This unit is called winning unit.
2. Modify the connections to the winning unit and connections to units in its neighborhood.

The Kohonen network (Kohonen 1988) consists of a single layer of nodes (plus an input layer). Each node receives inputs from the environment and from the other nodes within the layer. When we build a Kohonen network, it is important to properly initialize the weight vectors and input vectors are normalized to a constant (typically unit length). Each node computes by taking the dot product of its weights vector and the input vector. The result reflects their similarity (or distance). Symbolically,

$$O_j = X \cdot W_j$$

where O_j is the activation level of unit j , X is the input vector, and W_j is the weight vector of unit j . Suppose we place all weight vectors in a matrix called a matrix w , and let the vector O represent the activations of all nodes. Then we obtain

$$O = X W$$

Next, we examine the functionality of the Kohonen network: clustering, learning, statistical modeling, and topology preservation.

4.1 MACHINE LEARNING USING SOM FOR CBT, A DOMAIN OF COGNITIVE NEUROPSYCHOLOGY

In Kohonen's self-organizing feature maps, a network differentiates into multiple regions, each responsive to a specific stimulus pattern of feature (representing a personality disorder), just as in the auditory pathway, nerve cells and fibers are arranged anatomically in relation to the frequency response. If a specific input pattern requires a specific processing function, then this self-organizing heuristic may lead to a network with functionally differentiated regions (subnetworks).

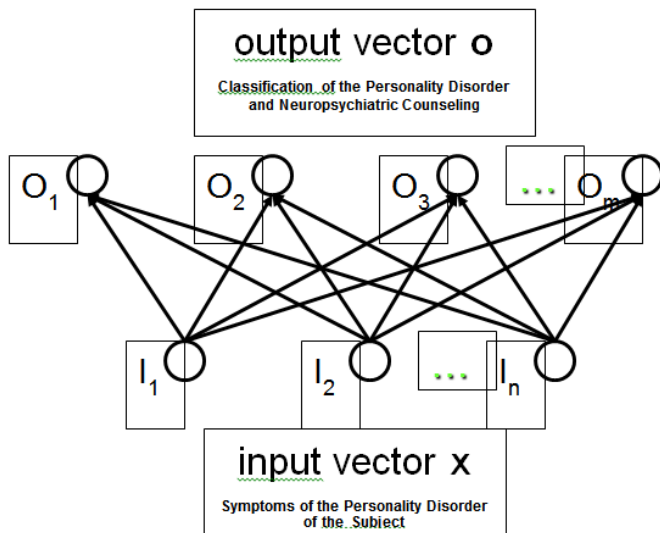


Figure 1. Machine Learning using SOM for CBT

SOM / Kohonen's Self-Organizing Network (adapted)

- **Weight Initialization**
 - Weights are initialized to small random values.
 - The initial radius of the neighborhood is set properly.
- **Calculation of Activation**
 1. The activation X_i of input unit i is determined by the instance presented to the network.
 2. The activation O_j of output unit j is calculated by

$$O_j = F_{\min}(d_j) = F_{\min}\left(\sum_i (X_i - W_{ji})^2\right)$$

where F_{\min} is the unity function (returning 1) if unit j is the output node with minimum d_j or its neighbor, and the zero function (returning 0) otherwise. (Note that if the weight vectors are normalized to constant length, then we may calculate the inner dot product of the input and the weights to find the node with a maximum value.)

- **Weight Training**
 1. Weight modification is given by

$$\Delta W_{ji} = O_j \eta (X_i - W_{ji})$$
 Where η is a gain term ($0 < \eta < 1$) that decreases over time. Note that the radius of the neighborhood also does so.
 2. Repeat by presenting a new instance, calculating activations, and modifying weights until $\eta = 0$.

4.2 PERSONALITY INVENTORY FOR SETTING THE THRESHOLD VAULE

4.2.1 Administering of Questionnaire

The administered Questionnaire for the development of Intelligent System for Personality Disorders CBT with Kohonen Neural Network Algorithm had the **Close-Ended Questions.**

Experimental Design using "Close-ended" Questionnaires with Seven Options such as 'Never', 'Very Rarely', 'Rarely, Sometimes', 'Frequently', 'Very Frequently', and 'Always'. The Seven Options as exercised by the Respondents indicate the Onset, Prevalence and Chronic State of the Personality Disorders and or Neuropsychiatric Disorders. The Questionnaire was administered to the Individuals who are adolescents and are in the adulthood.

4.2.2 PERSONALITY INVENTORY

Journey into Oneself.....

Name :
Age :
Gender :
Email id :

(The above details asked for, are optional)

1. Do you prefer to be alone always?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently g) Always
2. Can you comfortably receive love / warmth from other persons and reveal your feelings to others?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently g) Always
3. When you are being praised for a good-deed, do you acknowledge and give consideration to that?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently g) Always
4. Do you easily go ahead and express your warmth or love for friends, parents, and the dear-ones?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently g) Always
5. Do you find yourself in embarrassing situations?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently g) Always
6. Have you been rejected by your friends, while you were in your school or in college?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently g) Always
7. Do you often stop your vehicle after the stop line? Or do you think there is nothing wrong when you see others doing it?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently g) Always

8. When you need to purchase a ticket for a movie, would you wish to skip the queue for avoiding the physical strain?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
9. Do you think that there is nothing wrong in physically hurting someone when they do not listen to you; or someone who irritates you in a common place such as Cinema Hall, Hotel and such other places?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
10. Do you usually try to avoid staying alone and take all efforts to stay with someone whom you feel comfortable with?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
11. Do you find difficulty in identifying who you are with your own strengths and weaknesses?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
12. Have you thought that there is no meaning for you to be alive and felt like killing yourself?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
13. Do you want others to make important decisions that you need to take for yourself?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
14. Do you find yourself in situations where other people have made decisions about important areas in your life, e.g. what job to take?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
15. Do you ever volunteer to do unpleasant things for others so they will take care of you when you need it?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
16. Do you wish to be the center of attraction in a group so that many may want to relate to you?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
17. Do you use your physical appearance to draw others' attention to yourself so that you can develop relationship with them?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
18. Have your friends commented that your style of speech is very impressionistic but lacking in details?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
19. Do you often think, in a group that you are the most important person and wish to get all the attention of the members?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
20. Do you often do certain activities only to get excessively admired?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
21. Are you often envious of others or do you believe others are envious of you?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
22. Do you have your own way of doing things, whether it is arranging books on a shelf or cleaning home and insist on others that it is the right and best way of performing those actions?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
23. Do you always find that you are not able to finish many of the tasks in time as per your plan, by focusing excessively on only one task?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
24. Do you feel uncomfortable to ask someone else to do a task thinking that he / she may not do it as best as you would?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
25. Do you think you have been many a times exploited by your members of the family or friends?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
26. Do you often think that your friends / associates may not be loyal and deceive you?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always
27. Are you reluctant to confide in others because of unwarranted fear that the information will be used maliciously against you?
a) Never b) Very rarely c) Rarely
d) Sometimes e) Frequently f) Very Frequently
g) Always

28. When seeing two people laughing to themselves, do you often think that they are only talking about you and laughing at you?
- a) *Never* b) *Very rarely* c) *Rarely*
d) *Sometimes* e) *Frequently* f) *Very Frequently*
g) *Always*
29. Have you been having problems in interacting with your teachers, friends, and other relatives since your childhood?
- a) *Never* b) *Very rarely* c) *Rarely*
d) *Sometimes* e) *Frequently* f) *Very Frequently*
g) *Always*
30. Do you sometimes see strange images of people (illusions) moving around you when you are alone?
- a) *Never* b) *Very rarely* c) *Rarely*
d) *Sometimes* e) *Frequently* f) *Very Frequently*
g) *Always*

4.2.3 EXTRACTION OF INFERENCES

The Formulated Questionnaire contains 30 already-presented Close-ended Questions. All the 30 Questions have been segmented to probe into the presence / onset of 10 Personality Disorders. Each of the Three Questions in every segment embodies the pathological / diagnostic questions. Each of the question's options are being provided with an appropriate Weight such as the following:

- Do you prefer to be alone always?
a) *Never* b) *Very rarely* c) *Rarely*
d) *Sometimes* e) *Frequently* f) *Very Frequently*
g) *Always*

This question reveals the fundamental mood type of a subject / person who suffers from Schizoid Personality Disorder.

If the respondent has chosen the option "(g) Always" then a Weight of 10 is being awarded. The Weights are given to the options from "(a) Never" to "(f) Very Frequently" are being awarded with 0, 1, 2, 3, 5, 7 respectively.

Some Questions are constructed with reverse options. Such as the following:

- Do you easily go ahead and express your warmth or love for friends, parents, and the dear-ones?
a) *Never* b) *Very rarely* c) *Rarely*
d) *Sometimes* e) *Frequently* f) *Very Frequently*
g) *Always*

If the respondent has chosen the option "(a) Never" then a Weight of 10 is being awarded. The Weights are given to the options from "(b) Very rarely" to "(g) Always" are being awarded with 7, 5, 3, 2, 1, 0 respectively.

Thus, it will be concluded that if a person's / subject has the maximum total in any of the 10 segments (comprising of three questions, representing a Personality Disorder), then the subject could be suffering from that particular disorder. This signifies the "**Winner Take-All Strategy**" in the Kohonen Self-Organizing Neural Networks.

If a subject does not score maximum score in any of the 10 Segments and has scored equal total in few segments, then

those segments will be passing on their output level to the next closely associated personality disorder with the equal score. For example, if a subject has scored a total of 15 each for the segments (comprising of three questions) Narcissistic Personality Disorder and Antisocial Personality Disorder; the score for a particular question in the Narcissistic Personality Disorder which is very closely related to Antisocial Personality Disorder could be summed up with the already available total of 15 for the segment of three questions representing Antisocial Personality Disorder. This being done, the proposed Intelligent System for CBT could conclude that the subject may be suffering from Antisocial Personality Disorder. This establishes the concept of Kohonen's Self-Organizing Neural Networks, viz., the output of each node (questions segment for the personality disorder) can act as an inhibitory input to the other nodes. Thus, even though there is only one winner node, more than one node are allowed to change their weights (**Lateral inhibition**).

Similar as per Kohonen's recommendation, this inhibitory effect of node can also decrease, if the questions in one node (questions segment for the personality disorder), in no way related to any other node; that is no correlation with any other personality disorder. Thus, whatever segment having the maximum total emerges as the winner and prompts the personality disorder that the patient / subject may be suffering from, with all other nodes being suppressed to **Zero Activation Level**. Once the personality disorder with the subject being identified, appropriated CBT procedure can be initiated using the proposed Intelligent System for CBT.

4.2.4 ASSUMPTIONS OF THE RESEARCH ENDEAVORED

The following are the various Assumptions of this Research which can also be construed as the limitations

- It is assumed that the Questionnaire administered contains the right questions with which the symptoms of a Personality Disorder / Onset of a Personality Disorder can be traced effectively.
 - It is believed that the Respondents did not answer very casually or without realizing what information is being asked for.
 - The scoring method adopted has not been approved by any Clinical Psychiatrist, in which case after finding the symptoms, a through interaction and other pathological methods could be used to actually check whether the conclusion drawn holds good.
 - The CBT method proposed is the Comprehensive and the best-one. Furthermore, the CBT may not be effective with all the subjects (persons identified to have Personality Disorder), who can only be cured with medications.

5. CONCLUSIONS

The suggested Kohonen Self-Organizing Neural Network Algorithm can be extended to different facets of

Neuropsychology, especially with regard to the probing Cognitive capacities of a Person and his / her Behavioral Implications such as in selection of pupils for courses in any of specialized fields, in recruiting personnel in sensitive positions that require someone who is emotional stable and has a better outlook without any inclination to Personality Disorders(s), in forming Teams that require highly skilled and coordinated members who will be entrusted with mission critical projects both in the Private and Public Sector / State-owned enterprises. This Kohonen Self-Organizing Neural Network Algorithm has a wide-scope for application, analysis and exploration in various branches of psychology under various specialties viz., Health psychology, Occupational psychology, and Social psychology.

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