

Prediction of Patient's Response to Cognitive-Behavior Therapy by Artificial Neural Network

Ebrahim Rezaei Dogaheh ^{1,2*}

1. Substance Abuse & Dependence Research Center, University of Social Welfare & Rehabilitation Sciences, Tehran, Iran.

2. Department of Clinical Psychology, University of Social Welfare & Rehabilitation Sciences, Tehran, Iran.

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ABSTRACT

Objective: Social anxiety disorder (SAD) is defined as a constant fear of being embarrassed or negatively evaluated in social situations or while doing activities in the presence of others. Several studies have examined the role of certain variables that might predict response to treatment and may affect treatment outcome. The purpose of this study was to identify predictive variables of change and improvement.

Methods: The English version of the SPIN (Connor et al., 2000) was translated into Farsi and used in this study. In addition to SPIN, the measures including Clinical Interviews with the DSM-IV (Spitzer, Williams and Gibbons, 1994); and Depression, Anxiety and Stress Scale-21 (DASS-21) (Lovibond et al., 1995), the Credibility/Expectancy scale (Davilly & Borkovec, 2000) and Homework Compliance scale (Primakoff, Epstein, & Covi, 1986) were administered to a sample of 59 participants with SAD ranging from 18 to 40 years of age.

Results: Among the variables studied with the neural network model, logical sense in the Credibility/Expectancy scale (CEQ), depression in DASS, fear and avoidance in SPIN, and the compliance with homework (HCS) were significant in prediction of recovery rate.

Conclusion: The artificial neural network is capable in predicting SAD patients' respond to cognitive-behavioral therapy.

1. Introduction

Social anxiety disorder (SAD) is defined by intense and persistent fear of social situations in which the person is exposed to unfamiliar people or to possible scrutiny by others. Cognitive-behavioral approach has been recognized as efficient and effective in treating SAD (Rezaei Dogaheh, Mohammadkhani, & Dolatshahi, 2011), but for different reasons, some clients are not capable of significant or substantial improvement following the course of treatment. Several studies have addressed the role of specific factors that may predict response to treatment and affect the overall outcome. Studying such predictor and intermediate outcome variables can ultimately facilitate the provi-

sion of modified treatments and increase the effectiveness of interventions.

Some studies have focused on factors specific to the patient and the therapist. The examples include (1) demographic characteristics, (2) functional damage (intensity/disturbance, duration of symptoms, and interpersonal problems), psychopathology and personality disorders, and (3) expectations.

The effect of demographic characteristics including age of onset on treatment outcome of SAD has been investigated in several studies. Van Ameringen, Oakman, Mancini, Pipe, & Chung (2004) reported that in a study of 204 patients treated with sertraline and placebo, patients whose disease was late-onset (after age

* Corresponding Author:

Ebrahim Rezaei Dogaheh, PhD

Address: Substance Abuse & Dependence Research Center, University of Social Welfare & Rehabilitation Sciences, Tehran, Iran.

E-mail: ebrahim_rezaee@yahoo.com

19 years) responded better to treatment with were sertraline. Darimle, Herbert et al. (2007) and Borge, Hoffart & Sexton (2010) demonstrated that the early incidence of symptoms can be considered as an index of poor response to treatment. Chen et al. (2010) found that of the male gender is associated with a poorer response to Sertraline treatment.

However, the studies on the effect of disease duration on treatment outcome variables were almost equivocal. For example, Chen and colleagues (2007) showed that the duration of SAD is not associated with poorer health outcomes while Van American, Masini, Chang, Batzar and Yang (2002) showed that duration of generalized SAD is a significant predictor for poor response to therapy (with sertraline). The effect of SAD severity on treatment outcome has also been examined in some recent studies. Stein, Pitts, Kumar and Hunter (2002) on a study of 76 patients who were referred for individual and group CBT found that more symptoms can predict negative responses to therapy.

Another variable is the subtype of SAD. Several studies (Slapp et al., 1996; Chen et al., 2007; Turner et al., 1996) have drawn no significant difference between the generalized and non-generalized subtype of SAD while using Fluvoxamine, or application of CBGT and exposure. However, in other studies in which the CBGT were implemented (for example, Lincoln et al., 2005), the generalized subtype of SAD showed poorer response compared with generalized subtype patients.

The Effect of affective disorders on treatment outcome of patients with comorbid SAD had mixed results. Shoeling and Emel Gamp (1999) and Lincoln et al. (2005) have reported that the presence of major depression in SAD patients treated with group CBT is associated with poor treatment outcome while Marom, Giboa - Shichmen, Derka, Weisman and Hermesh (2009) indicated no differences between the two groups in the posttest results.

As can be seen, the effect of psychological (or demographic) variables on the outcome results seems equivocal and ambiguous. Undoubtedly, one of the important factors that may affect the accuracy of the findings is the research process (from data collection to analysis and conclusion). One of the most common methods for estimation of treatment response is based on the multiple regression models.

However, recent years witnessed a growing tendency to use intelligent systems of prediction such as Artificial Neural Network (ANN) to solve multivariate issues.

This study intended to predict to recovery rate of patients with social anxiety disorder using artificial neural network model. ANN consists of simple processors that is developed by inspiring from the human brain function and based on psychological theories. Using computer simulations of neurons, researchers formed a model that is able to learn, remember and optimize itself to correct their errors (the same way a human brain does). There are different types of ANNs based on three characteristics of the neuron models employed, the network structure and learning rules. A special type of ANN named Multilayer Perceptrons (MLP) seems to be a powerful tool for finding non-linear relationships between input and output space.

Every neural network consists of layers of simple processing elements connected together, called neurons. Generally, the smallest unit of neuronal information processing makes up the network performance. All neural networks have three input, hidden and output layers. The output layer would be the desired response. The layers are recognized by their weights indicating the effect of two neurons on each other. Each neuron has a threshold that is a function of their role in the training process. The learning process in MLP networks takes place by minimizing the mean squared error of the output and using back-propagation learning algorithm using numerically iterative methods.

In present study, a three-layer network was used for training. First layer (input layer) included input variables. The second layer was hidden and the third layer was determined by the type of response variable including two neurons i.e. the recovery of patients with SAD. To analyze and test the neural network model, the maximum estimated errors based on sum of squares of experimental error were considered.

2. Methods

This study was a comparative and correlational research. The sample included the patients who were referred to the outpatient clinics of University of Social Welfare and Rehabilitation Sciences, Tehran and Islamic Azad University. The sample consisted of 59 patients diagnosed with SAD who were selected by purposive sampling. The inclusion criteria were (1) Age (the age of participants ranged between 18 to 39 years), and (2) Education (minimum education level of participants was diploma). Exclusion criteria were (1) any report of having a history of psychotic symptoms (hallucinations, delusions, confusion, disorganized speech, and behavior

and negative symptoms such as lack of speech or passivity) by the patient or organic disorders such as Epilepsy.

Measures

Demographic questionnaire

It was included the information on age, gender, educational level and history of psychiatric disorders. Clinical Interviews with the DSM-IV (Spitzer, Williams, & Gibbons, 1994): The semi-structured clinical interview assesses psychiatric disorders of Axis I DSM-IV disorders. Sharifi et al. (1994) have reported acceptable diagnostic reliability of the Persian version of this tool in Iranian population.

Social Phobia Inventory (SPIN); (Connor et al., 2000)

SPIN is a self-report inventory with 17 items developed to assess symptoms of SAD. Rezaei Dogahneh (2013) has reported the psychometric properties of SPIN in Iranian population. The reliability in clinical and non-clinical sample were both reported as good ($\alpha=0.66$ and 0.87 respectively) with a cut-off score of 29 and acceptable convergent and discriminant validity. Depression, Anxiety and Stress Scale-21 (DASS-21) (Lovibond et al., 1995): DASS is made up of 21 self-report items, on a four-point Likert scale of frequency or severity of the participants' experiences over the last week.

The main purpose of the DASS is to identify aspects of emotional disturbance; for example, to assess the degree of severity of the core symptoms of depression, anxiety or stress. Henry & Crawford (2005) and Anthony et al. (1998) have reported the reliability and validity of DASS-21 in non-clinical ($n=1794$) and clinical samples ($n=258$) respectively. In Iran, Asghari, Saed, & Dibaji (2008) examined the factor structure, reliability, concurrent and discriminative validity of Persian version of the DASS-21 in a non-clinical sample ($n=378$). The results confirmed the reliability and validity of the scale was appropriate.

Beck Depression Inventory-2 (BDI-II)

It is a self-report 21 item tool to measure cognitive, affective, motivational, and vegetative symptoms of depression. The internal consistency of BDI-II was 0.91 (Beck, Steer and Brown, 1996) and its test-retest reliability was 0.93 . In Iran, Dobson & MohammadKhani (2007) reported 0.91 and 0.94 for coefficient alpha and test-retest reliability of BDI-II.

The Credibility/Expectancy scale (CEQ) (Devilley & Borkovec, 2000)

This 6-item scale is completed by patients, assesses the logic and credibility of therapy and calibrates their expectations of health care. It consists of two sets of words, items 1 to 4 (set 1) and items 5 and 6 (set 2). The first part is about the beliefs and the second part is on feelings of

Table 1. Mean and standard deviation of patients with SAD in on HCS, CEQ, SPIN and DASS-21.

Variable	Mean	SD
Compliance/adherence in homework	3.53	1.01
Question 1 (to be reasonable) in CEQ scale	7.02	1.42
Question 2 (success rate) in CEQ	6.68	1.21
Question 3 (recommend to others) in CEQ	8.05	0.99
CEQ total score	21.75	2.67
Question 4 (predicted improvement) in CEQ	5.31	0.70
Question 5 (the feeling of symptom reduction) in CEQ	5.12	0.72
Question 6 (feeling better) in CEQ	4.39	0.81
The total score of expectancy in CEQ	14.81	1.43
Fear subscale score in SPIN	12.97	2.94
Avoidance subscale score in SPIN	14.78	3.42
Physiologic subscale score in SPIN	10.68	3.30
SPIN total score	38.47	6.80
Depression subscale score in DASS	17.46	8.40

Table 2. Results of the different ANN models with different hidden nodes based on online training.

Number of nodes in the middle layer	Sum of squares of training error	Relative error	Sum of squares of experimental error	Relative error
14	4.425	0.206	1.714	0.327
27	6.782	0.301	3.538	0.381
29	6.626	0.308	0.891	0.306
33	3.469	0.151	0.586	0.353
55	0.627	0.028	3.234	0.450

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the patients about their therapy. Devilly and Borkovec (2000) noticed that the items 1 to 3 of the first set and item 4 of second set load respectively on credibility and expectancy factors. They reported 19.28 and 15.95 as the mean scores of expectancy and credibility scale. The one-week test-retest reliability for expectancy and credibility were 0.82 and 0.75.

Homework Compliance scale (Primakoff, Epstein, & Covi, 1986): This clinician rated scale is designed for the assessment of compliance with homework on a 6-point scale from 1 ("patient was trying to do homework") to 6 ("the patient has tried over the task demands"). However, this measure does not assess the quality of the work performed. One can determine the patient's compliance by calculating his/her performance in multiple sessions and the scores achieved. In a study by Woody and Adasky (2002) on 53 patients with SAD, the average score on the scale of compliance at baseline was 4.64 (SD=0.74). When treatment continued, the post-test mean and SD scores decreased to 4.25 and 1.22. The inter-subject reliability of this scale was $r=0.88$.

3. Results

About half of clinical group (27 patients; 8.45%) were male and the rest (32 patients) were female. Most participants (46 patients; 0.78%) were married. In terms of employment, 9.72% of them were unemployed. The age of onset for 59.3% of patients was after 18 years that among them 79.7% of patients had a history of receiving and attending psychotherapy sessions. The mean age of patients participating in the study was 23.75 ± 4.99 years. The average recovery rate for these patients was 0.37 ± 0.14 . The mean scores on HCS, CEQ, SPIN and DASS-21 have been presented in Table 1.

Accordingly, 50 models were fitted to find the best network topology. Thee results of the different models to find the best network structure are shown in Table 2. Finally, a network with 29 nodes in the middle layer was

selected as the best model for prediction. Coefficient penetration (influence) table were applied for finding significant and effective variables. The results are presented in Tables 2 and 3.

The characteristics of online training topology

The characteristics of online training topology included following ten items:

1. The size of the training set was almost 70% of the data randomly;
2. The size of the experimental set was nearly 30% of the data randomly;
3. The number of input variables: 24;
4. The number of intermediate nodes: 10-60;
5. The number of Outputs Nodes: 1;
6. The activation function in middle layer: hyperbolic tangent;
7. The activation function in output layer: same;
8. The error function: sum of squares;
9. Teaching method: online;
10. Operations on quantitative independent variables: standardization.

4. Discussion

In recent years some research has been performed using ANN models. In these studies the numerous abilities of ANN has been employed to predict and explain behavioral and psychological phenomena. For example, Paluti et al. (2005) showed that the ANN is capable to assist the therapist in decision making and selection of appropriate treatment. Sereti et al. (2007) also believed that ANN can be a useful tool in the diagnosis of mental disorders. They studied a group of patients with mood-disorders using ANN model for prediction and diagnosis of patients with depression.

In psychotherapy, the homework between sessions is frequently used to move the patients toward treatment goals (Dean, Glasser, Audz, & Kazantzis, 2005) and

Table 3. Analysis of penetration coefficients of the variables in predicting the recovery rate of patients with SAD by ANN (online training and 29 hidden nodes).

	Importance	Normalized Importance
Marital status.g	0.014	11.5
Prior treatment_exp	0.014	11.6
Employment status.g	0.015	12.8
Duration of disorder.g	0.019	15.9
Gender	0.020	16.5
Family income	0.020	16.6
Generalized subtype of SAD	0.023	19.1
DASS (anxiety subscale)	0.023	19.6
History of psychotropic medication	0.028	23.4
Age	0.028	23.6
Educational level	0.029	24.4
Credibility_6_feel_improve	0.029	24.5
Age of onset	0.030	25.5
Credibility (item 4: improvement)	0.031	26.2
Credibility (item 3: recommend)	0.035	29.0
SPIN (physiological arousal)	0.035	29.0
Credibility (item 2: success)	0.041	34.1
DASS (Stress subscale)	0.042	35.2
Credibility (item 5: feeling reduced symptom)	0.056	46.5
DASS (depression subscale)	0.064	53.7
SPIN (fear subscale)	0.086	72.5
Credibility (item 1: logical)	0.093	78.0
Homework compliance scale	0.106	88.9
SPIN (avoidance subscale)	0.119	100.0

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the assigning homework to patients in clinical practice is common. Kazantzys, Lampropoulos and Dean (2005) in a large survey (N=827) on a sample of the American Psychological Association (APA) members with different theoretical perspectives found that 68% of these individuals verify using homework in their clinical practice. Assigning homework is often considered as the successful experience of CBT sessions. Detweiler and Wishman (1999) believed that the role of homework in CBT is to reinforce the material learned in therapy and facilitate the maintenance of newly learned skills to real life situations. At the other hand, doing homework helps positive health outcomes through increasing self efficacy. Bandura (1998) believed that homework can help improve

the self-efficacy by preparing the chances of achieving certain goals.

In present study, considering the maximum prediction error, the power of ANN to predict the response of SAD patients in CBT based on sum of squares of experimental error was 0.115. Depending on the type of research needed in future research, it seems that ANN compared with other conventional statistical methods may lead researchers to better predict the change-related variables in CBT.