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# Modeling the effects of education with artificial neural networks on anxiety level of coronary angiography patients: A randomized controlled trial

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## ABSTRACT

**Background:** It is thought that the education to be given before the angiography procedure decreases the patients' anxiety level and increases effectively their continuation and adaptation to the medical treatment. **Objective:** To evaluate the effects of education provided to coronary angiography patients on their state-trait anxiety level, the results of the studies obtained experimentally were processed with artificial neural networks (ANN). **Design**: This study was experimental research. **Setting:** The study was carried out at Angiography Unit, Heart Hospital of Erciyes University. **Participants:** Hundred patients were included in the study; 50 experimental and 50 control group. **Intervention:** It was trained that experimental groups' all the patients by researcher. **Measurements:** The data of the research were collected with a questionnaire form and state-trait anxiety inventory form. In addition to statistical analysis, a modeling system from obtained statistical results is implemented using ANN. **Results:** The average state-trait anxiety scores before the angiography procedure decreased after the angiography procedure for the experimental group, whereas those anxiety scores of the control group before the angiography procedure increased after the procedure. Furthermore, the estimation of results is performed very successful in the ratio of 99% by ANN system. **Conclusion:** It was seen that the education provided before the angiography procedure was effective on the state-trait anxiety levels after the angiography. This study presented that artificial intelligence algorithms based on an ANN could be used in systems that analyzed social and health problems.

**Key words:** Anxiety, artificial neural network, coronary angiography, state and trait anxiety

## INTRODUCTION

Nowadays, we do expect not only a long life but also a high life quality. Lifespan has been longer but chronic illnesses have become more prevalent. Furthermore, chronic illnesses have been regarded as main cause for death and physical disability.[1,2]

The data provided by the Ministry of Health of Republic of Turkey show that there is an increased incidence for the chronic illnesses such as cardiovascular disorders, diabetes, obesity, cancer, and respiratory tract disorders. 80% of the individuals over 65 has at least one of the chronic diseases.[1-3]

Cardiovascular disorders, which are among chronic illnesses, have become crucial since the incidence has increased and the death rate due to the cardiovascular disorder has become over 50% for both sexes. When compared the death caused by coronary disorders of the individuals between the ages of 45 and 74, Turkey has the highest death rate among the European countries. Our population is younger just like other developing countries, but it is odd that the death rate due to coronary disorders is as high as those death rates in the developed countries that have an older population. Coronary artery diseases are the most common one among the cardiovascular disorders.[4-6]

It is clear that medical treatment and catheterization procedures are used commonly for the general treatment of coronary artery disorders. The most commonly used method for the diagnosis and medical treatment is angiography. The prevalent heart disorders result in frequent angiography use as a medical treatment. In general, the patients have been subjected to angiography once or more than once. It is essential to prevent complications during the procedure, recurrence, and thus cost increase. For these reasons, it is also of high importance that the individual adaptation to the angiography procedure should be guaranteed and the high anxiety levels resulting from the procedure should be decreased.[7-10]

Health education, which is one of the important elements of nursing care, helps the individuals' adaptation to the consequences of the illnesses, the continuation of the therapy suggested and learning how to cope with the problems occurring as a result of their new situation. Furthermore, it decreases the anxiety level, pain, and hospitalization period of the individual.[6]

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In a study conducted by Balci and Enc on the evaluation of anxiety levels of the coronary angiography patients, they expressed their wish to have information about coronary angiography procedure because they experienced anxiety experienced during the procedure.

It is thought that the education to be given before the angiography procedure decreases the patients' anxiety level and increases effectively their continuation and adaptation to the medical treatment.[11]

The present study was conducted to evaluate the effects of the education to be given on anxiety levels of the coronary angiography patients and to emphasize the benefits of education on patient care.

## METHODS

### Setting and Study Design

The study was carried out at Heart Hospital of Erciyes University. The hospitalized patients who came to the hospital were included in the study during the angiography procedure and this operation continued until we had the aimed number of the study groups ($n$ = 100). The calculation was made with $\alpha = 0.05$ and $\beta = 0.10$ after discussing the data results before and after the angiography procedure from the study by Dereli[12] who surveyed "The evaluation of a programmed education on the patients' anxiety level, who had a permanent pacemaker for the first time." The minimum sample was thought to be 44 for each group and 100 patients were included in the study; 50 for experimental group and 50 for control group. First, the study started with the experimental group. Those who had the similar characteristics such as age, sex, and educational status were selected for control group.

### Questionnaires and Data Collection

The data of the research were collected with a questionnaire form that involved the sociodemographic characteristics and disease status of the patients. State-trait anxiety inventory (STAI) form that was invented by Spielberg[13] and adapted by Le Compte and Öner to the Turkish society with a validity and reliability test was used for data collection.[14]

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (revised October 2000). Before the questionnaire forms were distributed to the patients, formal permission from the Ethics Committee at Faculty of Medicine (Decision number: 04/275) and Management of Heart Hospital in University of Erciyes (Approval date and no: B.30.2.E RC.0.70.10.00.02/900-789) was taken. All patients who participated in the study were informed about the project for written consent.

When we were designing the education material, the following applications were made:

- Giving information about the angiography unit.
- Giving visual information (with photos) about the tools used for angiography and angiography procedures.
- Admittance of the patients to their beds after the angiography procedure.
- Giving visual information (with photos) about all the procedures to be made by the evening time of angiography procedure.

Together with the above applications, such helpful information as the symptoms of heart diseases, medical treatment methods, preparations before the angiography procedure, and arrangements about what to do during procedure and after procedure, decisions about medical treatment after the angiography were collected by the researcher and a visual educational material was designed. A planned education about angiography procedure was not provided at the hospital.

The questionnaire forms and STAI forms were distributed to the coronary angiography patients in the experimental group. They were asked to fill in the forms in the evening just before the angiography. Later, all the patients received an education from the researcher at the meeting hall of the hospital. The education finished at 25 min. The patients' questions were answered and it was seen that they relieved after the education. Following the angiography procedure, the patients had a personal interview in their room from the researcher in the evening on the same day and were asked to fill in the STAI forms. And also, the questionnaire forms and STAI forms were given to the coronary angiography patients in the control group and they were asked to fill in the forms in the evening just before the angiography. After the angiography procedure, the patients had a face-to-face interview in their room from the researcher in the evening on the same day and were asked to fill in the STAI forms, again. Meanwhile, control group, too, had an education about the medical treatment and the decisions after our research.

### Data Analysis

For the statistical evaluation, independent samples t-tests, paired samples t-test, and one-way ANOVA tests were made for the whole data collected during the study. The error threshold $\alpha$ for all comparisons was decided as 0.05. The results from the statistical study were accepted as train and test data for the designed ANN model as shown in Figure 1. The ANN model evaluated the data of the control and experimental group together. That is to say that it enables us to evaluate the both group's state and trait anxiety levels. The big part of results (70%) from the present study was used for the education of ANN structure. However, a remains part of data (30%) was used for the verification of the system performance during the test procedures. After the education, root-mean-square (rms) and mean square error (mse) were calculated. Epoch number of the algorithm and the system's learning condition were changed according to these error values (<0) during the education. After calculating the error values as zero "0," the data that the system did not use and process data were entered to the system and system's performance was tested. Here, rms and mse were regarded for the precision level of obtained results.

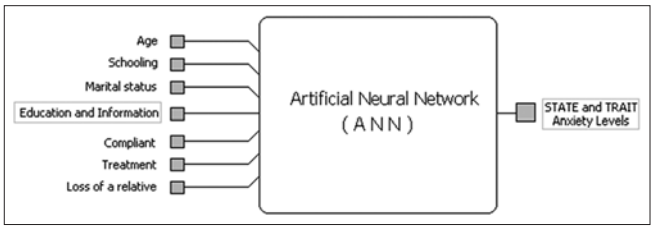


**Figure 1:** Block representation of proposed artificial neural networks structure for input/output variables

### *Artificial neural network*

Due to their nonlinear modeling capabilities, ANNs have been widely applied to nonlinear statistical modeling problems and are a natural choice for modeling large and complex databases of medical information. The goal of training an ANN is to adjust the weights of the network so as to optimize the performance of the network in estimating outcomes for a particular input space.[15]

An ANN, implemented in the MATLAB software package (MATLAB version 6.5 with neural network toolbox), and is composed of a Multilayer Perceptron (MLP) was employed and trained with Levenberg–Marquart (LM) learning algorithm. In the proposed ANN, the learning process is a supervised learning algorithm, which means that for all data of the training set a desired output are provided. The weighting values between processing elements (PEs) are attributed randomly at first and are continuously updated on the basis of the error calculated as the difference between the neural network output and desired output, and the learning process ends when the error reaches its value under the determined minimum error level.[16,17]

ANN training process is usually formulated as a nonlinear least squares problem. Essentially, the LM algorithm is a least squares estimation algorithm based on the maximum neighborhood idea. An MLP consists of three layers: An input layer, an output layer, and one or more hidden layers. Each layer is composed of a predefined number of neurons. The neurons in the input layer only act as buffers for distributing the input signals $\alpha_i$ to neurons in the hidden layer. Each neuron *j* in the hidden layer sums up its input signals $\alpha_i$ after weighting them with the strengths of the respective connections $w_{ij}$ from the input layer, θ is the bias term (or threshold) and computes its output value $y_j$ of the neuron as a function *f* of the sum:

$$y_j = f\left(\sum_i w_{ij}\alpha_i + \theta\right) \quad (1)$$

Where, *f* is the activation function that is necessary to transform the weighted sum of all signals affecting onto a neuron (whose structure is shown in Figure 2). The activation function *f* can be a simple threshold function, a sigmoidal, hyperbolic tangent, or radial basis function. The output of neurons in the output layer is similarly computed.[16-18]

Training a network consists of adjusting the network weights using the different learning algorithms. A learning algorithm gives the change $\Delta w_{ij}(t)$ in the weight of a connection between neurons *i* and *j* at time *t*. For the LM learning algorithm, the weights are updated according to the formulae:

$$w_{ij}(t+1)=w_{ij}(t)+\Delta w_{ij}(t) \quad (2)$$

and,

$$\Delta w_{ij}=[J^T(w)J(w)+\mu I]^{-1}J^T(w)E(w) \quad (3)$$

Where, *J* is the Jacobian matrix, μ is a constant, *I* is an identity matrix, and $E(w)$ is an error function.[19]

The ANN was designed in four layers: One input layer with eight inputs, and one output layer with two outputs as shown in Table 1. To make this classification, four-layered perceptron was employed and trained by the LM learning algorithm. The number of the PEs in two hidden layers was selected as 5 and 28 for optimum network output [Figure 2]. The tangent hyperbolic (*tanh*) function was selected as the transfer function that is used to determine the outputs according to the neuron inputs. The testing mse was obtained 7.11E-4 (i.e., $7.11 \times 10^{-4}$) from optimized multilayer perceptron feedforward network with training mse about 0.0001 at 203 epochs as shown in Figure 3.

**Table 1: Artificial neural network architecture and training/testing parameters**

| Architecture | | Training/testing parameters | | |
|---|---|---|---|---|
| | | Training algorithm | Levenberg–Marquardt | |
| The number of layers | 4 | | | |
| The number of processing elements on the layers | | | | |
| Input | 8 | mse | Training | 0.0001 |
| First hidden | 5 | | Testing | $7.11\times10^{-4}$ |
| Second hidden | 28 | rms for all data after testing | error_rms | $1.09\times10^{-4}$ |
| Output | 2 | | | |
| Activation function | | | | |
| Tanh (Tangent hyperbolic) | | Epoch number | 203 | |

mse: Mean square error, rms: Root-mean-square error

## RESULTS

Some patients (28.0%) in both experimental group and control group were in female and remain patients (72.0%) were men. It was seen that the patients were in the 50–59 age group (38.0%), whereas the remain patients were 60–69 (32.0%); and the ratio of an important amount (48.0%) has got a primary school education [Table 2].

When we investigated the patients' education history (whether they had an education or information about the health problem), almost all of experimental group (96.0%) and most of the control group (86.0%) expressed that they had not received an information about the health problem before.

In the study, it was observed that the average state-trait anxiety scores of the experimental group individuals that received an education before the procedure showed a decrease compared to the scores before the procedure. It was statistically significant ($P < 0.05$). However, the average state-trait anxiety scores of the control group individuals that did not receive an education before the procedure increased more than the scores before the procedure ($P > 0.05$) [Table 3]. The high values of anxiety levels are obtained in the informed patients that have got subprimary school education.

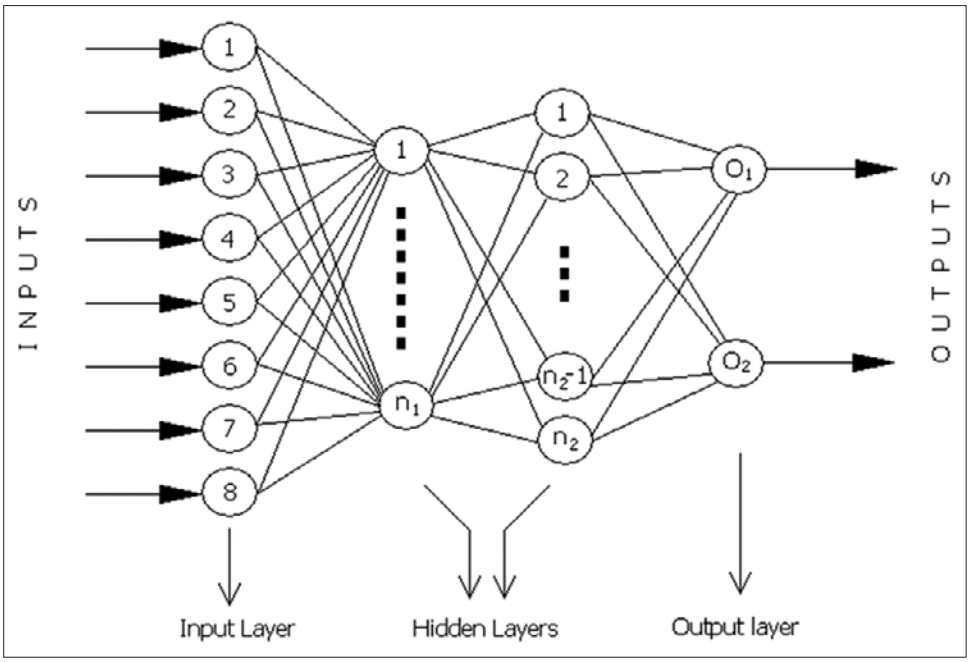


**Figure 2:** The structure of proposed artificial neural networks ($n_1$ and $n_2$ values in hidden layers are equal to 5 and 28, respectively)

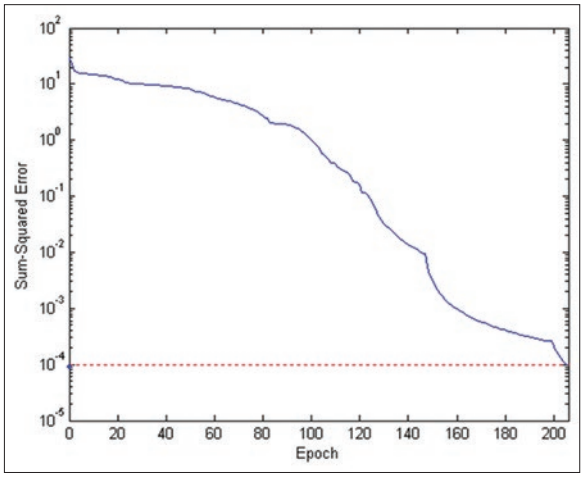


**Figure 3:** The error variations with respect to training epoch numbers (sum squared error and mean square error [mse] were selected 0.0001. If mse value is equal to 0.0001, training iterations is stopped)

It is found that trait anxiety score mean at after and before the operation was higher at women in experiment group, people whose education level is low, and have got coronary arterial disease. However, in control group, this mean high at women, people who were widow, and whose advised treatment decision is bypass ($P < 0.05$).

Average trait anxiety scores of the experimental group showed a decrease compared to those scores before the procedure, whereas in the control group there was a slight decrease compared to the scores before the procedure. The difference between the average trait anxiety scores before and after the procedure was of no statistical significance ($P > 0.05$) [Table 4]. The estimation of results is performed very successful in the ratio of 99% by ANN system [Table 5].

## DISCUSSION

### The Effects of Anxiety Level of Education

Anxiety may occur as a result of a physical disorder and also, any intervention made on the individuals is a cause of anxiety. Since anxiety is to affect the process and the course of the medical treatment, it must be dealt with care.[20-23] One of the effective methods to reduce anxiety is to provide the patient with a planned and organized education. In other studies too,[7,11,24-26] like the results of the present study; it is found out that education given to the patients before the medical process has reduced the stationary anxiety.

Since stationary anxiety score showed the anxiety about the process and the course of the medical treatment conducted, it was observed that there was a decrease in anxiety levels in experiment group, whereas a minimal increase in the control group after the medical process and courses was seen. The difference was due to the educational program provided to the experiment group before the medical process; therefore, we can say that education given to the patients is effective in reducing anxiety levels. The researchers[7,24-26] made on the current subject show that the patients who had a pre-operative education experienced a low level of anxiety and had a high level of self-care skills and were able to deal with the situation and this was possible only with a health education program.

A continual anxiety level is influenced not only by the present situation in which the individual is, but also by lifestyle, characteristic features. Views about stationary continual anxiety theories emphasize that stationary anxiety may change in a stressed atmosphere like angiography; however, continual anxiety, which is accepted as a characteristic feature, does not change. When the average scores of the continual anxiety were analyzed, the average scores for continual anxiety after the medical process decreased compared to the scores before

**Table 2: Characteristics of experimental and control groups**

| Characteristics | Groups | |
|---|---|---|
| | Experimental | Control |
| | Number (%) | Number (%) |
| Gender | | |
| Female | 14 (28.0) | 14 (28.0) |
| Male | 36 (72.0) | 36 (72.0) |
| Age | | |
| 40–49 | 11 (22.0) | 11 (22.0) |
| 50–59 | 19 (38.0) | 19 (38.0) |
| 60–69 | 16 (32.0) | 16 (32.0) |
| 70–79 | 4 (8.0) | 4 (8.0) |
| Marital status | | |
| Married | 42 (84.0) | 45 (90.0) |
| Widowed | 8 (16.0) | 5 (10.0) |
| Education level | | |
| Illiterate | 11 (22.0) | 11 (22.0) |
| Literate | 7 (14.0) | 7 (14.0) |
| Primary school | 24 (48.0) | 24 (48.0) |
| Middle school | 3 (6.0) | 3 (6.0) |
| High school | 3 (6.0) | 3 (6.0) |
| University | 2 (4.0) | 2 (4.0) |
| Occupation | | |
| Unemployed | 3 (6.0) | 2 (4.0) |
| Worker | 1 (2.0) | 2 (4.0) |
| Civil servant | 1 (2.0) | 2 (4.0) |
| Retired | 21 (42.0) | 27 (54.0) |
| Self-employed person | 5 (10.0) | 4 (8.0) |
| Farmer | 5 (10.0) | 0 (0.0) |
| Tradesman | 1 (2.0) | 0 (0.0) |
| Housewife | 13 (26.0) | 13 (26.0) |

**Table 3: State anxiety point means of people at experimental and control groups before and after**

| Groups | *n* | State anxiety | | *t* | *P* |
|---|---|---|---|---|---|
| | | Before operation (X±SD) | After operation (X±SD) | | |
| Experimental | 50 | 42.50±3.27 | 40.56±3.35 | 4.04 | <0.05 |
| Control | 50 | 40.04±3.68 | 40.78±2.79 | 1.69 | >0.05 |

SD: Standard deviation

the medical process in the experiment group. The differences between the scores of before the process and the after process were not statistically significant ($P > 0.05$) [Tables 4 and 5]. It was an expected result that there was not any change in continual anxiety level of the individual[11] because the education given to the experiment group was only about the medical process under consideration. It was thought that the minimal anxiety decrease in experiment group and control group might be due to the relief that occurred after the angiography procedure.

Like the present study, the studies made by Kölner and Berbard,[26] Steffenino *et al.*,[25] Ruffinengo *et al.*,[24] and Gürsoy[23] illustrated that the stationary anxiety levels decreased with education, whereas there was not any significant change in continual anxiety levels.

**Table 4: Trait anxiety point means of people at experimental and control groups before and after**

| Groups | *n* | Trait anxiety | | *t* | *P* |
|---|---|---|---|---|---|
| | | Before operation (X±SD) | After operation (X±SD) | | |
| Experimental | 50 | 47.22±6.30 | 46.74±5.62 | 1.28 | >0.05 |
| Control | 50 | 48.30±6.10 | 48.02±6.07 | 0.95 | >0.05 |

SD: Standard deviation

**Table 5: The testing performance of the system based on artificial neural networks**

| Group name | Patients number (*n*) | Recognition rates | |
|---|---|---|---|
| | | True (%) | False (%) |
| Train data (experimental and control groups) | 80 | 80 (100) | 0 (0) |
| Test data (experimental and control groups) | 20 | 19 (95) | 1 (5) |
| Total | | 99 (99) | 1 (1) |

## ANN

To evaluate the patients' state and trait anxiety levels before coronary angiography procedure, as input variables we decided to choose age, educational status (i.e., schooling), marital status, the cause to come to the hospital (i.e., compliant), recommended medical treatment (i.e., treatment), loss of a relative, and two state (bivalent variable) education variable that showed whether the patients had received an education before the procedure or not although there were many input parameters. Those variables representing state and trait anxiety levels were selected by these input variables. In Table 5, the data that displayed state and trait anxiety before the angiography procedure were employed in ANN and the results obtained were compared to those obtained by statistical methods. As seen in Table 5, the estimation of results is performed very successful in the ratio of 99% by ANN system. The system needs more and various data to provide closer results and to reduce the error value between them, thus leading a more extensive research. The consistency of the system was decided by Epoch number, rms, and mse error values during the education. When reached a certain value – for example: rms < 0.05 - the education procedure was abandoned and we made test procedures. In the test procedure, the data not used during the education were processed. The proper evaluations were carried out under the rms and mse error values just as in the education procedure.

## CONCLUSIONS

The present research was conducted with an ANN using the data that helped to estimate the state and trait anxiety levels of coronary angiography patients. The obtained results and the statistical results were highly closer. The aim of the present research was to demonstrate that the secondary special systems constructed by algorithms based on an ANN could be used in systems that analyzed social and health problems. In other words, the aim of the present research was to avoid many mathematical and statistical operations and to construct specialized system

models using some of the input and output of the system analyzed and the specialized experiences. Thus, time and efforts would be saved.

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