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Expert system for determining the level of stress before pediatric dental treatment

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Abstract

The paper is focused on finding a solution based on an expert system designed to ease the dentist's treatment decision by evaluating the patient's anxiety and stress status.

To identify the requirements and functionalities of this system there was performed an extensive research based on psychological questionnaires and the use of a powerful device made to determine body energy and stress variables.

The experimental results were summarized and conclusions related to the proposed solution were discussed.

Then we presented the software specially designed to establish the opportunity of clinical intervention considering the patient's stress and anxiety.

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Keywords: expert system; medical decision support system for dentists; anxiety; dental treatment.

1. Introduction

Before initiating any dental treatment it is relevant to evaluate the clinical cooperation of the patients [1]. Getting a successful result in pediatric dentistry needs a good communication with the young patient. This is not possible when fear intervenes in the confrontation with the doctor [2].

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Less compliance could be easily associated to the person's fear. Any dentist could expect a certain anxiety or fear from the young patient but these become a problem when they are exaggerated [1, 2]. Many patients faced with unpleasant or painful past experiences consequently manifest an unjustified fear when confronted with the doctor, the dental equipment, different smells of the dental office or sounds produced by dental drills. Exaggerated fear can lead to poor collaboration with the dentist, a difficult treatment, bad results and undesirable events [3, 4].

The goal of the study was to determine the exact anxiety level in patients using a computer program specially designed for this purpose. This software establishes the opportunity of medical intervention considering the patient's anxiety and related symptoms.

2. Theoretical background

Anxiety includes state anxiety which is defined as "a transitory emotional condition that varies in intensity and fluctuates over time" whereas "trait anxiety is a personality trait that remains relatively stable" [5]. It refers to the tendency to be anxious without external stress. First, we determined the patient's anxiety level by using a psychological questionnaire, Spielberger's State-Trait Anxiety Inventory - STAI - which has been approved and validated in many studies [6]. We have adapted this questionnaire in order to better match our study. The Romanian translation of the questionnaire was used.

STAI is composed of two scales, A-state and A-trait, measuring distinct anxiety concepts: state anxiety (how someone is feeling in a certain condition) and trait anxiety (common fear of someone). "Both scales consist of twenty items for which a person rates anxiety on a scale from one (almost never) to four (very much so)" [5].

It has been shown that A-state scores increase after various kinds of stress and decrease after relaxation training [7]. Therefore, this scale can be used to measure changes in the intensity of the anxious condition occurring in certain situations.

Generally, those who score high in A-trait will show increases in A-state more frequently than individuals who score low in A-trait because they tend to react to a large number of cases, judging them dangerous or threatening [8].

State anxiety is a transitory emotional state or condition of the body characterized by subjective feelings, consciously perceived tension and fear and increased activity of ANS-Autonomic Nervous System [9].

This nervous system controls vital functions such as heart activity, blood pressure, digestion, salivation, perspiration and exchanges between body and environment [10].

The sympathetic nervous system plays a role in stress situations with all aspects of increased secretion of adrenaline: peripheral vasodilatation, acceleration of heart rate, rise in blood pressure, sweating, hyper salivation; skeletal muscles are well supplied with blood at the expense of internal organs, the pupil of the eye is increased, the whole body being in a state of alarm.

The second step of the study was to determine the stress status of the patient with a powerful device used in traditional Chinese medicine and homeopathy [11] approved in E.U. Over the last decades scientists have shown that electromagnetic fields govern biological systems.

The device measures the energy level of the whole body shown by Energy parameter which is the average of energy values determined in 24 energy points located on the skin surface of hands and feet, corresponding to various organs and systems.

It also evaluates the stress status of the autonomic nervous system associated with symptoms and gives us indications of potential risks for the body health when these values are increased [12].

3. Research methodology

In order to investigate the correspondence between the values given by anxiety questionnaires and those shown by device's parameters we formulated the following hypotheses:

Research hypotheses:

- We assume that changes in the normal values of trait anxiety can lower the body energy shown by Energy parameter of the device and lead to diseases;

- We suppose that high values of state anxiety are related with high values of the ANS parameter which is shown in a strong relation with stress symptoms by the device we used.

3.1. Research variables

In the present research we established an independent variable and dependent variables measured with digital and nominal scales, thus:

Age of the patients was the independent variable

Dependent variables were:

- State anxiety expressed by A-state score
- Trait anxiety expressed by A-trait score
- Energy parameter which shows the energetic level of the body; we called it E for ease of expression.
- ANS parameter which reveals the stress at a certain moment; we called it ANS for ease of expression because it's related to the autonomic nervous system activity.

3.2. Methods

To undergo this study, we used the following methods:

1. Psychometric methods

- STAI questionnaire where we adapted A-scale to our research by adding the formulation “because of the state of my teeth” to the items 2, 3, 6, 7, 9, 10, 12, 14, 16-20. It is allowed even indicated by the authors to adapt their A-state scale to a specific situation for more accurate results.
- energetic measurements using the device described above

2. Statistical methods

- descriptive statistical indices
- correlations

The interpretation of the results was performed by the SPSS statistical program.

3.3. Sample of subjects.

The research was based on a group of subjects consisting of 30 patients, girls and boys aged between 11 and 18, randomly selected.

Toolbox used:

- clinical observation
- psychological questionnaire
- measuring device for highlighting energy level and stress status

3.4. Working procedure

The experimental study began with a clinical examination of each patient.

Following discussion and selection, the subjects were classified according to their age and sex.

3.5. Presentation and data analysis

Fig.1 shows the patients' distribution according to sex criterion.

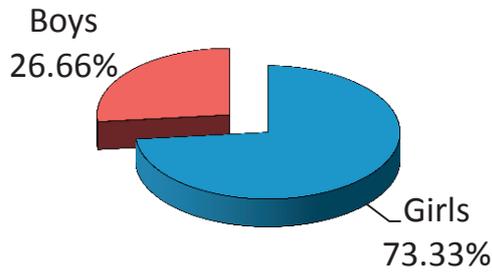


Fig. 1. Patient’s distribution according to sex criterion chart

So the randomly chosen sample contains mostly girls with a difference of 46.67% between girls and boys. Fig.2 shows the distribution of patients according to age.

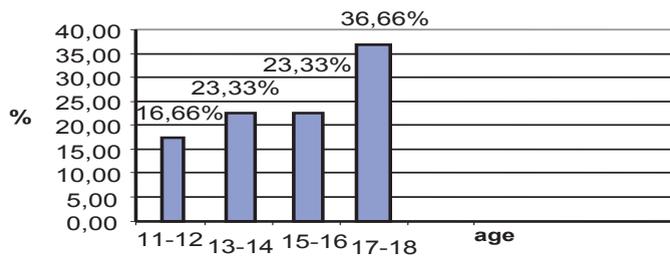


Fig. 2. Distribution of patients according to age

From the chart above we can see that the predominant adolescent age group (17-18 year old) represents 36.66% of the subjects investigated.

The patients from our sample filled in the Spielberger’s State -Trait Anxiety Inventory STAI with those two scales described above - A-trait and A-state - and the results are presented by the next charts:

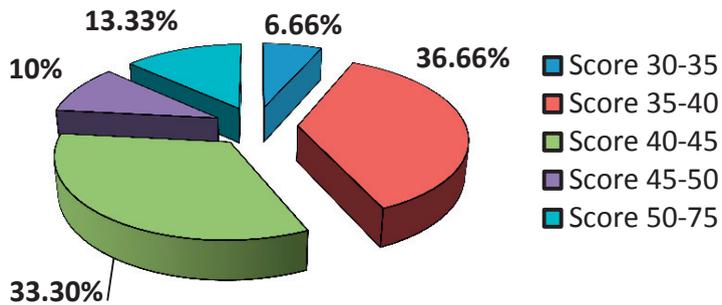


Fig. 3. Distribution of patients according to the values obtained at A-trait questionnaire

From the chart above we see that patients who scored values between 35 and 45 represent 69.99% of the research sample.

The patients’ distribution according to the values obtained at A-state questionnaire is presented in Fig.4.

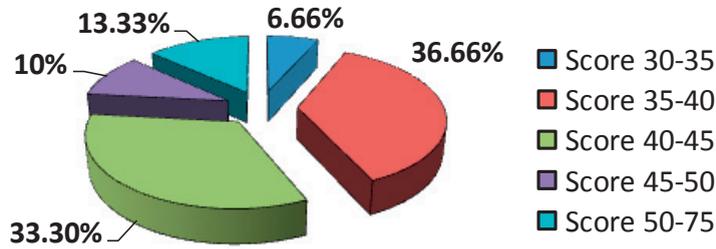


Fig. 4. Distribution of patients according to the values obtained at A-state questionnaire

Fig.5 shows the distribution of patients according to the energetic level of the body, “E”.

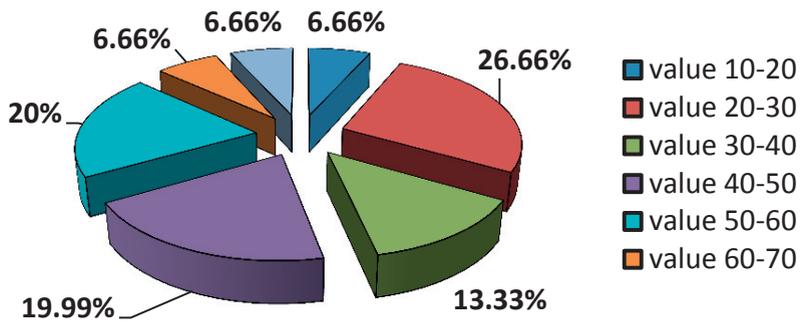


Fig. 5. Distribution of patients according to the energetic level of the body, “E”

From the above chart we can see that the majority of patients, 59.98% which represents more than a half of the research group, were located between 25-55 normal values of this parameter.

The ANS normal values are from 0 to 2. More than 2 means we are dealing with a stress status.

The patients’ distribution according to the ANS parameter’s values is presented in Fig.6.

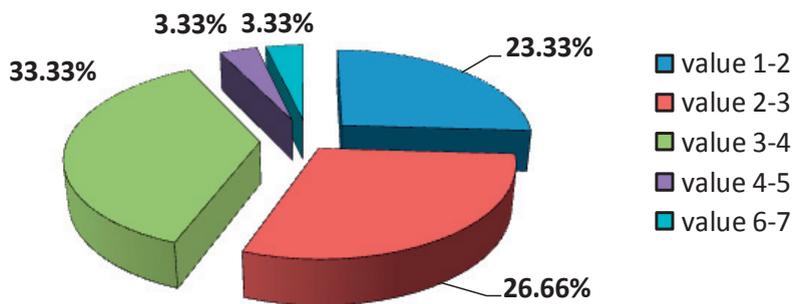


Fig. 6. Distribution of patients according to the ANS parameter

4. Results. Main findings

4.1. Results related to Hypothesis 1

We assume that changes in the normal values of trait anxiety can lower the body energy shown by Energy parameter (E) of the device and lead to diseases.

In order to verify this hypothesis we used correlations and t-test from statistical program SPSS. We correlated Variable 2-A trait with Variable 3-E and we saw that their means are relatively close which leads to the conclusion that there is a strong relation between the trait anxiety and the energetic level of the body.

Table 1: Means

	Cases	Percent	Excluded	Percent	Percent
VAR00002	Included				
VAR00001	N		N		
VAR00003	30	49.2%	31	50.8%	100.0%
VAR00001	30	49.2%	31	50.8%	100.0%

Legend: Var0001=age, Var0002=A-trait, Var0003=E

Table 2: Relations between Variable 2 and Variable 3

Total	Mean	Std. Deviation	N
	42.7333	6.4108	30
	41.4667	16.4981	30

Correlations

Table 3: Correlations between Variable 2=A-trait and Variable 3=A-state

		VAR00002	VAR00003
VAR00002	Pearson Correlation	1.000	.342
	Sig. (2-tailed)	.	.064
	N	30	30
VAR00003	Pearson Correlation	.342	1.000
	Sig. (2-tailed)	.064	.
	N	30	30

Legend : Pearson=correlation, Var 0002=Variable A-trait, Var0003=Variable E

One-Sample Statistics

Table 4: t-test

	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	30	42.7333	6.4108	1.1705
VAR00003	30	41.4667	16.4981	3.0121

Legend : Variable 1=age, Variable 2=A-trait, Variable3=E, N=subjects

$t = -0.342$ statistically significant at a significance of 0.05, which shows that the difference is significant and hypothesis 1 is valid.

So, we found out by statistical methods that hypothesis 1 is valid.

4.2. Results related to Hypothesis 2

We suppose that high values of state anxiety are related with high values of the ANS parameter which is shown by the device used in a strong relation with stress symptoms.

Case processing summary:

Table 5: Means

	Cases Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
VAR00001	30	100.0%	0	.0%	30	100.0%
VAR00002						

We correlated Variable 2-A trait with Variable 3-E and we saw that their means are relatively close which leads to the conclusion that there is a strong relation between the trait anxiety and the energetic level of the body.

Table 6: Report

	Mean	N	Std. Deviation
VAR00001			
VAR00002			
Total	48.2000	30	8.2813

From the table above we see a standard deviation of 8.2813 between the two variables A-state and ANS their mean being 48.200

One-Sample Statistics

Table 7: t-test

	N	Mean	Std. Deviation	Std. Error Mean	Error
VAR00001	30	48.2000	8.2813	1.5119	
VAR00002	30	2.7333	1.0694	.1952	

We see that mean between the two variables is 48.200 bigger than 45.4667 and standard deviation is 1.3167, which means that there is a connection between the stress status shown by ANS parameter of the device and anxiety as a state evidenced by A-state questionnaire.

Table 8: One-Sample Test

Test Value = 0						
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	Upper
VAR00001	31.879	29	.000	48.2000	45.1077	51.2923
VAR00002	14.000	29	.000	2.7333	2.3340	3.1326

Table 9: Correlations

	VAR00001	VAR00002
VAR00001	Pearson Correlation 1.000	.667
	Sig. (2-tailed) .	.000
	N 30	30
VAR00002	Pearson Correlation .667	1.000
	Sig. (2-tailed) .000	.
	N 30	30

** Correlation is significant at the 0.01 level (2-tailed).
 Legend : Variable 0001=A-state, Var0002=ANS

$t = -0.667$ statistically significant at a significance less than 0.01 which shows that the difference is significant and hypothesis 1 is valid.

So, we found out by statistical methods that hypothesis 2 is valid.

5. System implementation and testing

We choose to implement a web based expert system prototype. The architecture of the application is shown in Fig. 7.

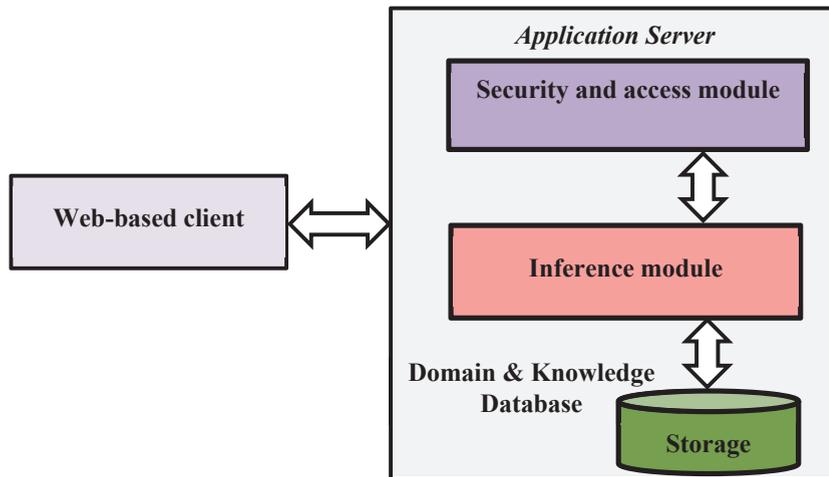


Fig. 7. Application architecture.

We determined strong correlations between A-trait and E, A-state and ANS; those allowed the design of an expert system developed to ease treatment decision.

Following we present the knowledge base of the expert system built to assist the dentist to take the most adequate therapeutic decision [13, 14, 15].

The rule base of the developed expert system is built on the following [16]:

- If E is between 25-55 and ANS less than 2, we start the treatment because stress status of the patient is normal.
- If E is less than 25 and ANS less than 2, we start the treatment because state anxiety has normal values but we suspect chronic diseases due to the lack of the body energy; so we advice the patient to see a doctor.
- If E is more than 55 and ANS less than 2, we start our treatment very carefully because any time the patient may become stressed.
- If E is between 25-55 and ANS more than 2, we postpone our treatment and apply psychological relaxation techniques.
- If E is less than 25 and ANS more than 2, we postpone our treatment and apply psychological relaxation techniques. We advice the patient to investigate his/her health because of lack of the body energy.
- If E is more than 55 and ANS more than 2, the treatment is compromised because of the exaggerated stress status of the patient.

The system was tested extensively, using historical medical records. The small number of rules and their semantic consistency generates fast and reliable solutions, with real support for the decision-making process.

For example:

- Patient A.I., female, 13 years, E=35, ANS=2.74, we postponed our treatment and applied psychological relaxation techniques. Then we could successfully complete treatment.
- Patient S.V., male, 14 years, E=22, ANS=1.71, we applied the treatment without any problems but in anamnesis the child reported diabetes.

- Patient B.I., female, 17 years, E=70, ANS=3.56, we could not even start our treatment because of the patient's high level of stress.
- Patient T.R., male, 15 years, E=67, ANS=1.87, we finished our treatment with some difficulties.
- Patient A.S., female, 17 years, E=45, ANS=1.62, we completed our treatment without any problems.
- Patient T.R., male, 16 years, E=21, ANS=3.11, we postponed our treatment and applied psychological relaxation techniques. We advised the patient to investigate his health because of lack of the body energy.

6. Conclusions

The present work was carried out a research on anxiety which led to the development of a medical decision support application.

We found out that changes in the normal values of trait anxiety can lower the body energy shown by Energy parameter of the device and lead to diseases.

We found that high values of state anxiety are related with high values of the ANS parameter which is shown in a strong relation with stress symptoms by the device used.

So, we can correlate the two device's parameters values with those given by the most common and used anxiety questionnaire, practically we validated the device's measurements. Then became possible to develop a software application designed to ease doctor's work by helping him with the treatment decision.

This expert system greatly eases clinical work by helping the dentist to take the best medical decision at the beginning of the young patient's treatment.

Acknowledgement

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