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CONTACT

Prof. Dr. S. Serhat Seker
Editor-in-Chief of The Journal of Cognitive Systems
Istanbul Technical University, Istanbul, Turkey

E-MAIL

cognitive@itu.edu.tr

WEB PAGE

www.cognitive.itu.edu.tr

URL

www.dergipark.gov.tr/jcs

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Computer-Aided Model for the Classification of Acute Inflamations via Radial-Based Function Artificial Neural Network

Mehmet Onur Kaya

Firat University, Faculty of Medicine, Department of Biostatistics and Medical Informatics, Elazig, Tturkey. (e-mail: mokaya@firat.edu.tr).

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Corresponding author: Mehmet Onur Kaya
✉ mokaya@firat.edu.tr
☎ +90 424 2370000 / 4672

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ABSTRACT

Objective: This study aimed to compare the classification performance of acute inflammation by applying the RBF ANN model on an open-access acute inflammation data set and determining the risk factors that may be associated with acute inflammation markers.

Material and Methods: In the study, Nephritis of renal pelvis origin was classified using the open access "Acute Inflammation" data set RBF ANN model, and risk factors that could be associated were revealed. The success of RBF ANN is presented by different performance metrics.

Results: The success of classifying Nephritis of renal pelvis origin with the RBF ANN model has been demonstrated to be excellent (AUC = 1, Accuracy = 100%). In addition, the RBF ANN model revealed that the most important variable among the risk factors that may be associated with Nephritis of renal pelvis origin is "temperature of patient".

Conclusion: As a result, the obtained findings show that the RBF ANN model provides very successful predictions in the classification of Nephritis of renal pelvis origin. Also, it has been shown that the importance values of factors associated with Nephritis of renal pelvis origin are estimated with the RBF classification model and can be used safely in preventive medicine applications.

1. INTRODUCTION

INFLAMMATION Occurs due to the cellular and molecular response of the body against biological, chemical, or physical stimuli. In the acute phase of inflammation, immune cells, cytokines, chemokines, and acute-phase proteins migrate to the injury site and initiate the process. In the acute phase of the inflammatory response, cells of the immune system migrate to the injury site in a carefully regulated sequence of events facilitated by soluble mediators such as cytokines, chemokines, and acute-phase proteins. A successful acute inflammatory response results in eliminating infectious agents, which was followed by the thawing and repair phase through macrophages. If the acute inflammatory response cannot eradicate the pathogen, the inflammatory process continues and acquires new properties. Neutrophil infiltrate is replaced by macrophages and, in case of infection, by T cells. If the combined effect of these cells is still insufficient, a chronic inflammatory condition involving the formation of granulomas and tertiary lymphoid tissues occurs [1,2].

Recently, studies conducted with neutrophil/lymphocyte ratio (NLR), thrombocyte/lymphocyte ratio (PLR), and erythrocyte distribution width (RDW) in peripheral blood and inflammation markers draw attention in the diagnosis and follow-up of inflammation. Hematology and clinical chemistry data obtained from standard laboratory studies may be the first indication of the presence and sometimes the location of the inflammation. Although they are sensitive indicators of inflammation, these markers cannot often identify the disturbing cause. The profile seen in a particular inflammatory condition depends on the severity, chronicity, and mechanisms involved in the inflammatory process and the response and adaptation capacity and type of the individual's immune system [3,4]. Although changes in hematology dynamics, acute phase proteins, complementary factors, and cytokines are common for almost all inflammatory conditions and can be measured by various techniques, it has been

reported that individual factors may be strongly associated with specific pathological events [5].

Artificial Neural Networks (ANNs) are computer systems designed to directly realize the features of learning, which are one of the characteristics of the human brain, such as the ability to derive, generate, and discover new knowledge without assistance [6]. Without any assumptions, ANN can provide nonlinear modeling without any prior knowledge of the input and output variables [7]. Artificial neural networks have proven to be efficient in many applications, including classification, modeling, and prediction [8,9].

Radial-based function (RBF) neural networks are three-layer feedforward networks with an input layer, an output layer, and a single hidden layer. The network's name as a transfer function comes from this hidden layer, which uses radial functions. Although the network's inputs are not linear, the output is [10]. The input layer, which is made up of source nodes, links the network to the outside world. The network's single hidden layer performs a nonlinear transformation from the input to the hidden field. A nonlinear constant transformation with radial-based transfer functions is used to convert the input layer to the hidden layer. The output layer is a linear layer that responds to the network, represented by the transfer signal applied to the input layer. An adaptive and linear transformation is implemented from the secret layer to the output layer [11].

This study aimed to compare the classification performance of acute inflammation by applying the RBF ANN model on an open-access acute inflammation data set and determining the risk factors that may be associated with acute inflammation markers.

2. MATERIAL AND METHODS

2.1. Dataset

The data set “Acute Inflammations” was obtained from the database https://archive.ics.uci.edu/ml/datasets/Acute+Inflammations to analyze the performance of the RBF ANN model and to assess risk factors in this study [12]. The names, types, and properties of the data set variables are presented in Table 1.

TABLE 1
PROPERTIES OF THE VARIABLES IN THE STUDY

Variable	Variable Description	Variable Type	Variable Role
V1	Temperature of patient (35°C – 42°C)	Quantitative	Input
V2	Occurrence of nausea (0: No, 1:Yes)	Qualitative	Input
V3	Lumbar pain (0: No, 1:Yes)	Qualitative	Input
V4	Urine pushing (0: No, 1:Yes)	Qualitative	Input
V5	Micturition pains (0: No, 1:Yes)	Qualitative	Input
V6	Burning of urethra, itch, swelling of urethra outlet (0: No, 1:Yes)	Qualitative	Input
V7	Inflammation of urinary bladder (0: No, 1:Yes)	Qualitative	Input
V8	Nephritis of renal pelvis origin (0: No, 1:Yes)	Qualitative	Output

2.2. Radial-Based Function Artificial Neural Networks

The Radial Based Function Artificial Neural Network (RBF ANN) was created in 1988 and joined the history of ANN by adding it to the filtering problem. It was inspired by the impact reaction behaviors found in biological nerve cells. The teaching of RBF ANN models can be seen as a multi-dimensional curve-fitting approach. As a result, the RBF ANN model's training efficiency becomes an interpolation challenge, requiring the model to find the most suitable surface for the data in the output vector space. The input layer, hidden layer, and output layer of RBF ANN models are represented in three layers, similar to the general ANN architecture. RBF ANNs, on the other hand, use radial-based activation functions and nonlinear cluster analysis in the transformation from the input layer to the hidden layer, unlike traditional ANN structures [13,14]. As with other ANN forms [15], the arrangement between the hidden and output layers continues to work.

In the construction of the RBF ANN model, about 63% and 37% of the complete dataset were utilized for training and testing steps, respectively. The rescaling technique for the input variables was standardized for the related model. The number of units in the hidden layer was 10, the hidden layer activation function was Softmax, the number of units in the output layer was 2, and the output layer activation function was Identity, and the error function was Sum of Squares. Hyperparameters of the models were optimized by the scaled conjugate gradient method.

2.3. Performance Evaluation of the RBF ANN Model

Performance metrics [16] such as Accuracy, Sensitivity, Specificity, Positive predictive value (PPV), Negative predictive value (NPV), F-score, and Area under the curve (AUC) were used in the performance evaluation of the RBF ANN model to predict factors that may be associated with acute nephritis.

2.4. Data Analysis

IBM SPSS statistics 26.0 program was used for all analyzes in the study. The compliance of continuous variables to the normal distribution was evaluated using the Shapiro Wilk test. The comparison of continuous variables that do not provide the assumption of normal distribution between two independent groups (Decision outcome: Yes and No) was performed with the Mann Whitney U test, and descriptive statistics were presented as median (min-max). In the analysis of categorical variables, Pearson chi-square test was used and descriptive statistics were presented as frequency (%). The significance level was accepted as 0.05.

3. RESULTS

Table 2 shows the statistical analysis results for the variables in the data set. Statistically, important p values are bolded in the table. As can be seen from the table, statistically significant differences were found for other variables, except for the "Micturition pains" variable.

TABLE 2
STATISTICAL COMPARISONS OF VARIABLES ACCORDING TO DECISION: NEPHRITIS

Variables		Nephritis of renal pelvis origin		p-value
		No (n=70)	Yes (n=50)	
Temperature of patient [Median (Min-Max)]		37.30 (35.50 – 41.50)	40.55 (38.00 – 41.50)	<0.001
Occurrence of nausea n(%)	No	70 (100.00%)	21 (42.00%)	<0.001
	Yes	0 (00.00%)	29 (58.00%)	
Lumbar pain n(%)	No	50 (71.40%)	0 (00.00%)	<0.001
	Yes	20 (28.60%)	50 (100.00%)	
Urine pushing n(%)	No	30 (42.90%)	10 (20.00%)	0.009
	Yes	40 (57.10%)	40 (80.00%)	
Micturition pains n(%)	No	40 (57.10%)	21 (42.00%)	0.102
	Yes	30 (42.90%)	29 (58.00%)	
Inflammation of urinary bladder n(%)	No	30 (42.90%)	31 (62.00%)	**0.039**
	Yes	40 (57.10%)	19 (38.00%)	
Burning of urethra, itch, swelling of urethra outlet n(%)	No	50 (71.40%)	20 (40.00%)	**0.001**
	Yes	20 (28.60%)	30 (60.00%)	

Classification matrices of training and testing steps for the RBF ANN model are given in Table 3.

TABLE 3
CLASSIFICATION MATRICES OF TRAINING AND TESTING STEPS

Training Step

		Reference		Total
		No	Yes	
Predicted	No	46	0	46
	Yes	0	30	30
	Total	46	30	76 (63.3%)

Testing Step

		Reference		Total
		No	Yes	
Predicted	No	24	0	24
	Yes	0	20	20
	Total	24	20	44 (36.7%)

The values of the performance metrics obtained from the RBF ANN model to classify acute nephritis in the test step are given in Table 4.

TABLE 4
ACUTE NEPHRITIS CLASSIFICATION PERFORMANCE METRICS OF THE RBF ANN MODEL

Performance Metrics	Value
Accuracy (%)	100
Sensitivity (%)	100
Specificity (%)	100
PPV (%)	100
NPV (%)	100
F1-score (%)	100
AUC	1

The importance values of the input variables in the data set obtained from the RBF ANN model are presented in Table 5 and Figure 1, respectively.

TABLE 5
THE IMPORTANCE VALUES OF THE INPUT VARIABLES

Independent Variables	Importance
Occurrence of nausea	0,0100
Lumbar pain	0,1210
Urine pushing	0,0990
Micturition pains	0,0000
Burning of urethra, itch, swelling of urethra outlet	0,0990
Inflammation of urinary bladder	0,0870
Temperature of patient	0,5830

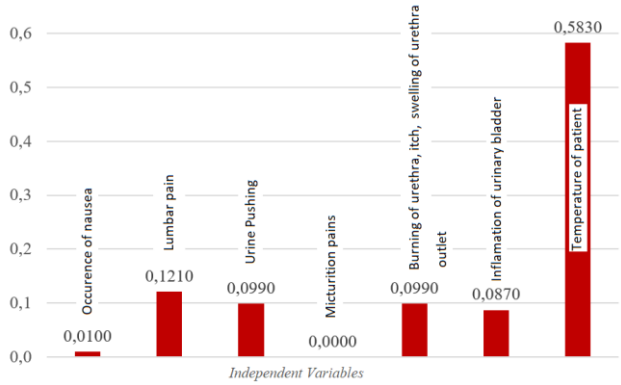

Figure 1. The importance values of possible risk factors associated with nephritis of renal pelvis origin.

4. CONCLUSION

Today, science and technology, which are developing in a very dizzying way and growing at an incredible rate, provide us with great products that make our daily life much easier. One of the advanced science and technology products that we can encounter in almost every field in our lives is artificial intelligence. Artificial intelligence, or in other words, artificial neural networks, as in many areas, provide us with valuable contributions by working very quickly and successfully in very sensitive and difficult situations, especially in the field of medicine. It stands out as a very successful clinical decision support system in clinical diagnosis and diagnosis.

Artificial neural networks generally consist of a two-stage process, training and testing. First of all, training is carried out with most of the data set, and it is ensured that the artificial

neural network learns the problem and solution. In the next step, a test set is given to the learning artificial neural network to determine the solution to the problem. The findings of the artificial neural network are presented with some performance parameters and it can be shown that the relevant network is now ready to solve the desired problem.

This study aimed to classify open-access acute inflammation data of a radial-based functional artificial neural network and reveal the related factors. The performance of the created model has been evaluated using different criteria. Besides, the importance levels of the factors (independent variables) that can be associated with the Nephritis of renal pelvis origin (Dependent variable) for use in preventive medicine practices were also obtained from these models.

According to the results of the performance criteria (accuracy, AUC, sensitivity, negative predictive value, and F score) obtained from the study, it was seen that the RBF ANN made a perfect classification and gave a complete success. While the most important risk factor that may be associated with nephritis of renal pelvis origin is the temperature of the patient, it was observed that micturition pains were the least important.

As a result, the obtained findings show that the RBF ANN model provides very successful predictions in the classification of Nephritis of renal pelvis origin. In addition, it has been shown that the importance values of factors associated with Nephritis of renal pelvis origin are estimated with the RBF classification model and can be used safely in preventive medicine applications.

REFERENCES

[1] Medzhitov, R. (2008). Origin and physiological roles of inflammation. Nature, 454(7203), 428-435.

[2] Germolec, D. R., Shipkowski, K. A., Frawley, R. P., & Evans, E. (2018). Markers of inflammation. Immunotoxicity Testing, 57-79.

[3] Chaplin, D. D. (2010). Overview of the immune response. Journal of Allergy and Clinical Immunology, 125(2), S3-S23.

[4] Gaba, C., & Kushner, I. (1999). Acute-phase proteins and other systemic responses to inflammation. N Engl J Med, 340(6), 448-454.

[5] Sonnenberg, G. F., & Artis, D. (2015). Innate lymphoid cells in the initiation, regulation and resolution of inflammation. Nature medicine, 21(7), 698-708.

[6] Öztemel, E. (2003). Yapay sinir ağlari. PapatyaYayincilik, Istanbul.

[7] Haykin, S. (1999). Neural Networks, a comprehensive foundation, Prentice-Hall Inc. Upper Saddle River, New Jersey, 7458, 161-175.

[8] Güldoğan, E., Zeynep, T. U. N. Ç., Ayça, A. C. E. T., & Çolak, C. Performance Evaluation of Different Artificial Neural Network Models in the Classification of Type 2 Diabetes Mellitus. The Journal of Cognitive Systems, 5(1), 23-32.

[9] Vt, S. E., & Shin, Y. C. (1994). Radial basis function neural network for approximation and estimation of nonlinear stochastic dynamic systems. IEEE transactions on neural networks, 5(4), 594-603.

[10] Kilic, E., Ozbalci, U., & Ozcalik, H. R. (2012). Lineer Olmayan Dinamik Sistemlerin Yapay Sinir Ağları ile Modellenmesinde MLP ve RBF Yapılarının Karşılaştırılması. ELECO2012 Elektrik-Elektronik ve Bilgisayar Mühendisliği Sempozyomu,(29.11. 2012-01.12. 2012).

[11] Haykin, S. O. (2009). Neural Networks and Learning Machines 3rd Ed. NY: NYL Pearson Prentice Hall.

[12] Czerniak, J., & Zarzycki, H. (2003). Application of rough sets in the presumptive diagnosis of urinary system diseases. In Artificial intelligence and security in computing systems (pp. 41-51). Springer, Boston, MA.

[13] Hwang, Y. S., & Bang, S. Y. (1997). An efficient method to construct a radial basis function neural network classifier. Neural networks, 10(8), 1495-1503.

[14] Wu, T. F., & Yu, T. H. (1998). Unified approach to developing single-stage power converters. IEEE Transactions on Aerospace and Electronic Systems, 34(1), 211-223.

[15] Kaynar, O., Görmez, Y., Işık, Y. E., & Demirkoparan, F. (2016). Değişik Kümeleme Algoritmalarıyla Eğitilmiş Radyal Tabanlı Yapay Sinir Ağlarıyla Saldırı Tespiti. In International Artificial Intelligence and Data Processing Symposium (IDAP'16).

[16] Güldoğan, E., Zeynep, T. U. N. Ç., Ayça, A. C. E. T., & Çolak, C. Performance Evaluation of Different Artificial Neural Network Models in the Classification of Type 2 Diabetes Mellitus. The Journal of Cognitive Systems, 5(1), 23-32.

BIOGRAPHIES

Mehmet Onur Kaya received his BSc from Fırat University in 2009. He received his MSc degree from Fırat University Applied Statistics in 2011 and his PhD degree from Bursa Uludağ University Biostatistics Department in 2016. His research interests are clinical biostatistics, meta-analysis, data mining, expert systems, artificial intelligence, bioinformatics and statistical shape analysis. He joined the Fırat University Biostatistics and Medical Informatics Department as an Assistant Professor in 2017 and is still a faculty member. He is engaged in teaching and research activities in artificial intelligence, data mining, statistical shape analysis and meta-analysis.

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The Interplay Between Test Takers' Emotions and Test Results

Jagoda Mikołajewska
Adam Mickiewicz University, Faculty of Pedagogy and Fine Arts in Kalisz, Department of English Studies, Poland. (e-mail: jagodamikolajewska@wp.pl)

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Corresponding author: Jagoda Mikołajewska
✉ jagodamikolajewska@wp.pl
☎ +48 601 931 794

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ABSTRACT

This study presents how emotions influence learners' success in the second language acquisition context. The objective of the research is to focus on the accompanying feelings before and after the vocabulary test in a sample of two students. The learners were chosen deliberately to contrast the low achieving one with the high achieving learner. The feedback was gathered by a teacher who provided the interviews with the participants who answered the questions before and after the vocabulary test. Data analysis indicates that both Student 1 and Student 2 feel tension before and after the test but their attitude towards learning is different. The study proves that because the high-achiever puts a lot of effort into studying, the one cares about the results, but the low-achiever hopes that the holistic knowledge would allow him to pass what is tested or examined. The findings also reveal that positive emotions foster being successful but negative emotions contribute to failures due to high results achieved from the test motivate the high-scorer for further learning, making him more curious and willing to succeed, whereas the low-scorer becomes easily frustrated and feels tension throughout the whole process of studying and tests or exams taking. Considering the study results, it can be stated that there is a link between emotions and success in language learning.

1. INTRODUCTION

POSITIVE psychology posits peoples' strengths and development worth investigating. Therefore, the strengths and development take place under certain circumstances simultaneously, to which emotions usually appear. As emotionality accompanies almost all everyday situations, particular types of feelings occur among learners as well as teachers. MacIntyre and Gregersen [1] imply that emotions are experienced as pleasant versus unpleasant, that is why they determine the extent of L2 learners' success. Hence, in accordance with the broaden-and-build theory by Fredrickson [2], positive emotions are stated as extremely vital affective factors for SLA, which objective is to motivate L2 students for future learning [3]. Thus, the study was created to investigate the influence of emotions and attitude towards learning on being successful by the two students with diverse features. Thanks to the answers of the respondents, we concluded that there is a link between positive emotions and achieving success. Moreover, we have also found that the application of positive psychology principles has a significant role in second language acquisition. Thus, the paper aims to introduce formerly mentioned dimensions due to their significant roles which they play in a classroom setting of L2 [3].

2. POSITIVE PSYCHOLOGY

By the time the idea of positive psychology was formulated, researchers tried to develop knowledge about how to teach, how things are learned by students, how to make learners reach well-being, etc. [4]. However, after the three pillars of positive psychology were established by Seligman and Csikszentmihalyi [5] namely: positive experiences, positive character traits, and positive institutions, Snyder and Lopez (2002) published the Oxford Handbook of Positive Psychology, as well as plenty of researchers, decided to write articles with a great number of ideas from the field of positive psychology thereby encouraging others for further research by MacIntyre [6]. A range of contexts from the book became an inspiration to develop the idea of well-being as a salient principle of future education in terms of individuals as well as communities [6]. That is why the links between SLA and positive psychology were explored. MacIntyre [6] explores

that within the years, a variety of contributions have been made in the area, suggesting several dimensions of further development of positivity, to which belong: "From Negative to Positive Emotion" (a theory based on a difference between positive and negative emotions by Fredrikson [7], "From Deficiencies to Strengths" (a model of character strengths, VIA inventory of character strengths, but also Seligman's "signature strengths"), and "From PERMA to EMPATHICS" (discussed below). What is more, MacIntyre and Mercer [8] claim that throughout the years a range of research on positive psychology was transformed into practice.

Reviewing the notion of positive psychology, it has to be mentioned that all the various studies brought new insights, extended the theory as well as focused on multidimensional and additional aspects of what was initially discussed. One of the examples is Oxford's concept of EMPATHICS [9] thanks to which the author develops the idea of well-being in a language learning context, suggesting factors that contribute to being a high-achiever student and explaining why low-achievers experience indifference, anxiety, frustration. The letters of the acronym mean: "E" - empathy and emotion, "M" - motivation and meaning, "P" - perseverance together with optimism, resilience and hope, "A" - autonomy and agency, "T" - time, "H" - habits of mind and hardiness, "I" - intelligences, "C" - character of strengths, "S" - self-factors, including self-esteem, self-concept, self-verification, self-efficacy [9]. The author claims that all the components are related to a complex dynamic system, which means that they are interconnected, and they evolve, simultaneously affecting the development of a student's well-being. However, being a high achiever is influenced not only by the EMPATHICS elements but also by culture, learning contexts and a language learning process created by teachers. At this point, Oxford (2016, p. 72) [9] suggests providing "teacher development sessions" that would contribute to establishing "well-targeted language learner development on interrelated positive psychology topics" which stick to the individual differences of second language learners.

One of the most salient ideas while discussing positive psychology studies is the theory of Positive Psychology Interventions (PPIs). PPIs can be defined as a combination of strategies and tools of which target is to boost L2 learner's personal growth, as well as to increase well-being, happiness, positive emotions, and behaviours. According to the authors Sin & Lyubomirsky [10], Positive Psychology Interventions are composed of two crucial elements to which belong maintaining long-term effects of PPIs together with enhancing positive well-being through positive feelings, experience, and thoughts. To investigate reasons and ways of PPI in stimulating L2 student well-being, Seligman et al. [11] undertook research aiming at checking which interventions work most effectively on members of a study group. The researchers proposed forty various examples of interventions, grouping them into three types of exercises to do: Placebo Control Exercise (participants were asked to write daily journals), Gratitude Visits (respondents were obliged to write letters containing gratefulness for those who have done something positive), and the 3 Good Things Task (research group members should have to record 3 things that raise their well-being and justify the reasons for choosing them). The gathered data presented that the most beneficial results appeared among respondents of Gratitude Visits and the positive emotions lasted after the research was ended. On the other hand, long-term effects were also noticeable among participants of the 3 Good Things and Placebo Control Exercise thanks to which positive feeling was maintained for up to six months. The research concluded that PPIs have an impact on positive responses and well-being levels. Sin and Lyubomirsky [12] add that even if PPIs effectively boost L2 learner's well-being, they are more beneficial in overcoming plenty of symptoms of depression. Furthermore, MacIntyre et al. [13] mention that all the interventions tend to have a greater influence, only if learners are motivated, older and treated individually by a teacher. What is more, such interventions should be adjusted concerning Individual Differences of students, their achievements and efficacy [12].

An exemplary study in terms of positive psychology was provided by Gregersen, MacIntyre and Meza [14] concerning the notion of building "social capital" for second language students thanks to exercises of positive psychology. The authors indicate three pillars of positive psychology in the context of language learning, to which belong positive emotions, positive character traits, and positive institutions [14]. To make SLA effective, a strong emphasis is put on providing activities that are beneficial for learners. Thus, the authors suggest six various types of PPEs – positive psychology exercises – that boost the experience of positive results as well as contribute to the gaining of happiness and the reduction of sadness. PPEs include laughter, physical activity, engaging altruism, interaction with pets, expressing gratitude, and listening to music. Due to the gathered data, it was stated that each of the activities creates an opportunity for learners to have resources and benefits from being a part of a community they belong to. Such a situation helps build social capital, through relations within a community, which plays a significant role in acquiring a target language [14].

The concept of positive psychology is evident in conclusions suggested by Lake [15] after providing research to the evident need for the article: "Accentuate the Positive: Conceptual and Empirical Development of the Positive L2 Self and Its Relationship to L2 Proficiency". The author decided to measure whether the idea of "a hierarchical model [of self-concept] could be used to organize various constructs that relate to positive self-constructs and motivation for L2 field". Lake [15] mentions that the hierarchy consists of the following stages: Positive L2 Self (passion, interest, being goal-oriented), The Global Positive Self (curiosity, flourishing, hope), and L2 Self-efficacy (reading, listening and writing in L2). According to the results, experiencing positive language situations from the earliest stages of acquiring a target language contribute to developing a positive self as a learner and user of L2, consequently boosting motivation, increasing language proficiency having a feeling of "greater good in a flourishing self" [15].

Ibrahim [16] emphasizes the role of positive emotionality on motivational engagement while learning a target language which is called Directed Motivational Current (DMC). The notion was originated by Dörnyei and Muir [17,18] who explain that DMC "is created when a structured pathway is set up towards a vision, in a way in which this pathway both reinforces momentum towards the vision and at each step intensifies it". In other words, DMC is a state when L2 learners' vision of being successful in the future together with the effort they put into studying L2 act as determination towards achieving goals [17,18]. What is more, its idea is to combine positive psychology notions, such as engagement,

flow or happiness into "a goal-oriented process" that may last for a long time [16]. The concept consists of three constituents: positive emotional loading, goal-orientedness, and a salient facilitative structure. Thus, according to Ibrahim [16], DMC may be exemplified by being engaged in improving language skills that would contribute to reaching goals while learning L2 or working in a group that thanks to collective power members can gain momentum to fulfill certain tasks. Furthermore, due to the DMC cases are goal-oriented, they take place only with a great energy investment of an individual. Then, an eventual goal should be perceived as desirable and meaningful for a learner [17-19]. Subsequently, Ibrahim [16] elaborates that having a valuable aim is insufficient to become a highly motivated student but maintaining a state of intensive motivation is a key to achieve a goal providing that it matches a concept of DMC. What is more, with the object of generating the DMC structure, several contextual conditions should exist. However, once DMC has begun, it maintains particular progress automatically through experiencing positive feedback by a student, reaching sub-goals, and the habitual routine a learner follows [17-19].

In terms of DMC, Ibrahim [16] gives an example of a learner who became easily frustrated of not understanding what her relatives were saying in English and that is why she began to study L2 on her own. The experience of a two-year learning process made her satisfied and aware of greater language skills. As a result, it inspired Ibrahim [16] to deepen the knowledge of DMC through providing a study. The research was designed to find affective factors of DMC, as well as to understand how positive emotions influence learning behaviour while experiencing DMC. Therefore, Ibrahim's salient idea [16] was to find a link between positive emotionality and motivation among learners. Seven participants were interviewed about their experiences of engagement. Six themes were identified that the respondents associated with engagement to which belong: a unique experience, L2 learning as a lifestyle, enjoyment/happiness, effort as not effort, sense of change, and sense of being lucky [16]. All the themes together with positive feedback, joy, excitement, and also flow are factors that prove the existence of DMC among the respondents.

On the grounds of gathered data, the author [16] states that positive emotions take place while experiencing DMC situations. However, having initial aims does not contribute to positive emotionality as to a high extent as having specific and self-concordant goals. What is more, it was observed that the respondents tended to combine various emotional resources to maintain the motivational levels they achieved. An example of the resources was the utilization of both anticipated and anticipatory emotions about an image of a future self. Then, an image of a future self is based not only on visualizing sensory moments but on conceiving pride, progress, and success an individual experiences while acquiring L2 goals. Though the DMC cases occur rarely, they lead to creating a conclusion of a positive affect role on motivational intensity while experiencing DMCs. For instance, despite having a vision of success as well as visualizing future L2 goals, the participants noticed that they were not motivated in a lasting way, although a state of excitement took place while learning the target language. The respondents were engaged more on a feeling of enjoyment it covered a longer period and the holistic process of learning L2 instead of being deliberately focused on aims. Besides, according to the results, enjoyment contributed to satisfaction appearance which made the research group have a sense of progress, further equated by the participants to a sense of change [16]. Such understanding is interpreted by them as a sign of improvement but also a sign of personal growth. The existence of personal growth is noticeable when one: is what he or she wanted to be, has a positive self-image and reaches unknown personal meaning and value in terms of own potential discovery. Then, an individual who experiences personal growth simultaneously fosters significant abilities, as well as becomes developed, improved, unique and a greater person.

While the research was carried out, negative emotions such as boredom and frustration were reported but they occurred when the progress perception was disrupted. Hence, it was claimed by [16] that the DMC situations combine both positive and pejorative emotions to regulate the emotional entity which is responsible for maintaining engagement. What is more, the author [16] indicates that neither engagement itself nor other feelings related to the pleasure of L2 learning contribute to having a sense of happiness to a great extent but having a sense of development is crucial while studying a language. Thus, due to the DMC cases take place, a process of learning L2 becomes a vital part of an individual's routine through automatized habits and favoured involvement which make a learner engaged in acquiring new skills. Finally, Ibrahim [16] highlights the significance of a link between happiness and personal growth as encouraging for further research in terms of positive emotionality.

As presented, positive psychology plays a vital role not only in the process of learning second languages but also in teaching them. What is more, positive psychology together with the notion of DMC became starting points for empirical consideration. The article includes the study provided to check whether emotions influence being successful by the two students of various characteristics as well as proving the existence of positive psychology in educational situations.

3. THE STUDY

3.1. Research objectives

The research was created to find out how emotions influence students' success in the second language acquisition context due to their significance in numerous aspects. The study presents a concept of positive emotions in the light of emotional experience in a sample of two students. The study was provided via teacher interviews with the two foreign language learners. The respondents were asked to describe accompanying feelings before and after the vocabulary test in the most detailed way possible due to a variety of tests and exams are emotion-laden events for students. The strengths and limitations of the provided research are elaborated on below. The following research questions have been addressed:

1) How do students with the highest and the lowest scores feel before and after the test?

2) What is the relation between emotions and success in test-taking?

3.2. Participants

The data was taken from interviews. The data was gathered by a teacher who provided the interviews with the students who answered the questions that were asked before and after the test. The learners were chosen purposefully to contrast the low achieving learner with the high achieving one.

The first student is an English major, his sex is male, and he is 21 years old. His English language proficiency is defined as B2 and he has experienced 11 years of learning the target language. The student might be described as motivated to learn but he usually achieves the lowest grades among members of the whole group that he belongs to at the university. What is more, worth mentioning is the fact that besides studying, the student has a full-time job. Subjects require studying a lot of theory and due to this fact, passing tests and exams cause a huge problem for this learner. Because of the student's full-time job, the time he has left to spend on studying is ultimately insufficient.

The second student is a 21-year-old male student of English Philology, as well. His English language proficiency is estimated as C1 and he has had the experience of learning the English language for 13 years. The learner can be characterized as motivated to study and he achieves the highest grades among all members of his group. It is essential to notice that the English language is a passion for this student and his studying equal's pleasure. He memorizes things quickly and the obtained knowledge from the earlier stages of education is so large that it enables him to achieve great scores without putting too much effort into studying.

3.3. The instrument

The interviews with each of the students were provided separately and in two sections – before and after the vocabulary test. The interviews aimed to gain information about students' feelings before and after the test, their preparation for the test, and their attitude towards learning. The learners were ordered to answer the following questions (appendix 1.1., 1.2.) elaborately, explaining their answers with as many details as possible.

3.4. Data analysis

In the research design, qualitative data were collected. Thanks to this, an efficient study design was made to analyze the case study, containing identified and compared all the main themes. The purpose of the qualitative data in the given approach was to compare two students of diverse achievements. The data were recorded and transcribed as well as combined in the discussing section below.

3.5. Results

3. 5. 1. Before the test – Student 1

The student is motivated to learn but achieves the lowest grades among members of the whole group that he belongs to at the university. He admits that he is not prepared for the test that will be provided in a while. He only guesses what material will be tested. Moreover, he adds: "[i]n general, the way I am prepared for tests depends on how much time I had before the test to learn, how tired I was, I work besides studying at the university, and I usually study at the last moment because this is my character trait". Furthermore, the student confesses that neither does he study hard nor is his overall knowledge of English rich enough, and that is why he often fails tests and must retake them as a result. It sometimes happens that he is not allowed to write exams during exam sessions because he tends to reach the limit of possible test retakes during the semester, which are often not passed.

In terms of studying particular subjects more or less, he claims that he spends the most time studying literature because, apart from the fact that reading itself is time-consuming, he must read various interpretations to understand a particular text better. What is more, he says: "I try to study lists of words for conversation classes tests but when I am obliged to find the meanings of the words, it often happens that I do not have time to study them. But when I notice that I will not have time to learn, I read the articles twice only to guess the meanings. Maybe during the test, I will come up with an idea of what the meaning of a tested word was". Due to the lack of time, the learner predicts or rather hopes, that he will manage to pass his tests with at least the lowest passing grade only because the items that were in the test were practised at classes.

The student observed that he is more successful when the tested material is practised several times during classes thus, "it may happen that the received grade will be 60-80% then", he adds. Therefore, the learner indicates: "it is much worse with grammar classes and lectures when I need to sit and memorize the theory. It is very tiring for me". But he does not feel the pressure of getting the best grades. The student learns for himself and he does not care to a great extent what grade he will obtain. He explains: if it's my first attempt, I am quite stressed but when I fail and I have to write the test for the second time, I am stressed a lot and angry as well because I should study it one more time and waste my time. Right now, before this concrete test, I feel the tension as well as stress because, as I said, I work, and I could not prepare myself efficiently for the test because I did not have enough amount of time to study". As it can be observed, the learner does not consider studying beneficial for broadening his knowledge and developing his language skills. He treats a retake as a waste of time and a situation that triggers feelings of anger and stress. As a justification for his point of view, he mentions that tests and exams may be surprising, due to the possibility that they may contain a particular material that was not studied in classes and require additional knowledge apart from a provided curriculum. Consequently, the student claims: "there is a great probability that even if we learn hard, we may not get good grades – ones which will satisfy us". That is why, the learner subordinates received grades not only to his knowledge as well as the way of being prepared but to the validity of the test – whether a test or an exam measures what should be accurately measured. He is prepared not to pass the test and he is aware that his current knowledge may not contribute to receiving a grade of 60% and passing the test.

3.5.2. Before the test – Student 2

The second student is motivated to study and achieves the highest grades among all members of the group. In terms of being prepared for tests and exams in general, he claims that: "I have a feeling that I am always not prepared well for the test but it turns out in the end that I am usually the best prepared from the rest of my group so I can say that it is a kind of irony". The learner adds that before this particular test which will be provided, he feels prepared efficiently since he was focused when the tested material was explained and practised during classes but also, he was studying all the items at home. It must be mentioned that learning English equals pleasure for this particular student, that is why being prepared does not mean that he has had to force himself to study. Moreover, the student says: "I feel that I will succeed, and I will be successful during my studies because the knowledge I obtained previously allows me to achieve the best grades and perform well not only during classes but also in real-life

situations when I am obliged to use English to communicate". Hence, the quote shows the reason for being successful according to the second learner. He is an example of a student who reaches satisfying grades and goals not only by studying hard but because of knowing the previous school stages that allows him to be successful without putting too much effort into it. However, in this case, the learner is highly motivated, willing to learn, and he is curious about the target language as well.

The learner confesses that he tends to be almost calm before tests and exams because he is prepared well. He memorizes things very quickly, in classes as well as while studying at home and that is why the learning process of this particular student begins at classes and continues to take place at home. It can be described as consistent, regular, and permanent – which is what leads to collecting and preserving items in long-term memory. The material is always studied in advance by the learner and the student himself is curious about the tested topic. This in turn leads to the student looking for and finding additional information not only because the student intends to surprise a lecturer but because of the student's curiosity and a willingness to broaden his horizons and the current knowledge he possesses. Therefore, no subject would study to a smaller or a greater extent; he devotes the same quality and equal amount of time studying all the required material. The learner is engaged steadily in learning but there are certain university subjects he enjoys to a lower or a higher degree.

The student can predict the grades he will gain in a precise way. The reason why he can do it is the fact that he is almost perfectly prepared for all the tests and exams. The only exception would be a situation when the test validity would be inaccurate. The learner adds: "I aim to get the best grades – I mean 100% and my main goal is not to be required to write exams during the winter and summer exam sessions – which is possible at our university when our average test grade is 4.5. The greatest pleasure for me is when I can relax and I have leisure time during the winter and summer exam sessions when the rest of the whole group has to write exams, but I do not. It is the greatest satisfaction for me". Furthermore, the learner mentions that: "[i]n the morning on my way to the university I feel quite stressed before tests, I feel only my heart beating a little bit faster than usual, but when I notice that the rest of the group is less prepared than me – it makes me calm. It is the same right now. I was talking to my groupmates and it seems that I am one of the best-prepared persons among my whole university group. I feel greatly confident right now". While providing the interview with the learner, a slight smile was noticeable on his face. His self-esteem is visible which makes others perceive him to be a successful student.

3.5.3. After the test – Student 1

The first student states that he is convinced that the extent of being prepared as well as the knowledge he possessed would allow him to pass the test. He explains as follows: "I hope I will pass the test because I was active during the classes and I remembered the vocabulary. Maybe I did not remember the meanings of all of them, but I could associate them and guess the meaning, so I can say that I am satisfied with how I performed during the test". The results were announced by the teacher a moment after the test. The learner confessed that he is satisfied with the result he gained, which was 63% – which means he almost passed, and he was not counting on a higher grade, to begin with. Among the whole group, the result this particular student obtained, was one of the lowest.

Asking the student about the overall results he gains, he answered that he is always satisfied when the test is passed. The learner is aware that he is not the student with the widest knowledge, his private life does not allow him to dedicate his whole life to learning the language, he spends the majority of his time at work and not on studying. He adds that he will probably not become the student achieving almost always 100% from all the tests and exams but being successful for him means reconciling studying at the university simultaneously with working and earning money to make a living.

The student explains that whether tests make him stressed or not, depends on what knowledge the tests examine – if it is practical or theoretical knowledge. He describes it in the following way: "I perform well at group-work and presentations. I am angry after grammar and morphology tests which examine our theoretical knowledge. I think we should be tested on practical knowledge". The student adds that the knowledge he possesses is very frequently insufficient to pass tests and exams, but he is stressed and nervous to the highest extent when he has to learn theory by heart and when no practical skills or knowledge will be tested. He is angry that the holistic knowledge he obtained during the previous learning stages only helps him to a small degree to perform during tests and exams but does not allow him to pass the material that he is being tested on.

The learner states that his emotions change throughout each test that he has to write, and the same situation was a moment before when he was required to write this particular test. He elaborates: "When I get the paper and see that my knowledge is poor, I am frustrated, and I wait for the results. If I fail a test or an exam, then I am frightened during the retake because I may fail it one more time, which causes a huge problem for me". The student mentioned that the intensity of the emotions he felt while he was writing the test lowered when he read the tasks that he had to do. The reason why the tension decreased was the fact that the difficulty of the test was average, which means that thanks to practising the material during the classes and the knowledge he has from the earlier learning stages, the student has gotten the opportunity to fulfill the tasks and gain 60% without perfect preparation. That is why it can be claimed that the level of difficulty influences the emotions that accompany this particular student while writing the test.

After the test, a general feeling of the learner is happiness because the test was not failed. However, the student says that even if he experiences failures, he tries not to give up and overcome such troubles through simply sitting and learning. He claims: "I learned how to handle failures. In the first year, I was incredibly angry at myself but now, even if I fail a test or an exam or even some of them, I try not to give up and retake everything that was not passed by me". Such situations motivate the student to study, and they tend to be current priorities. He adds: "[i]t always happens that when I fail the test, it is the only thing I keep thinking about and I have to start doing something not to think about my failure. That is why, I notice myself shaking; I start to smoke, and I look for somebody to talk to as well". The student explained that looking for a person to talk to makes him forget about the stress and the retaken test; the conversation occupies his thoughts and allows him to be a little bit relaxed.

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3.5.4. After the test – Student 2

The second student, whose target while studying English studies is gaining only the best grades and performing impeccably, is fully satisfied with the score he received. He got 100% and it is the only reason why he is delighted about how he performed. He reveals: "When I receive 95% from the test, it is insufficient for me. 100% is the ideal. If I get a grade below 100%, I feel unrealized, I have remorse that I should have studied more, I should have devoted more time to learning. I love English, I love studying everything that is connected to it and I feel angry at myself when I should know something but in actuality I do not know. Even if it is an additional material". The learner says in the summary that it is his greatest character trait to aim at the best results in every field of life. Sure enough, he is usually satisfied with the grades he gets since they are almost always around 100%.

The student admits that tests and exams themselves do not stress him out and after each of the tests or the exams he tries to feel free from contemplating whether he passed them or not. He says: "I am chilled out because I know how I performed, and I can predict what grade I will get. I usually have a feeling that the grade will satisfy me because I know the answers to all of the questions." The student claims that he is always sure that the knowledge he possesses is sufficient and it may allow him to achieve 100%. It has never happened that he had a feeling of being not completely prepared. That is why his self-esteem is exceedingly high and it is the reason for him being calm while writing tests or exams. During this particular test, the learner was calm but felt a little bit of tension. Nevertheless, the extent of the tension was minimal. His emotions were stable but, after the test, the learner was feeling incredibly positive. He mentions: "I am positive after the tests and it was the same in this case. What is interesting, I am euphoric, energetic then but after 10 minutes it disappears. Maybe because it is normal for me that I performed well on the test and I will pass it surely with one of the best grades that can be gained. When I know that I performed ideally, accurately and precisely, I feel that I can move mountains. I am satisfied and proud of myself. I do not need to wait until the results will be announced. I may sleep well without thinking of what I wrote. It happens that I even forget that I wrote some tests or exams. I focus on other things to study and to pass".

The learner remembers that when he got the paper with the test, he felt stressed to a small extent but when he read the questions, he got relaxed. The student explains in the following manner: "the material we had to study was not very difficult for me as some other material used to be from more requiring subjects, such as syntax and morphology. We practised the items for the test during classes so I think that even if we have not studied at home, we would have been able to write the test in a way that we pass it and achieve 60% without putting too much effort into previous preparation. I do not mean that the test was simple itself but, the teacher guided us to remember as much as it is possible from the lesson and the job we had to do at home, which was just to memorize all the items from classes. In my opinion, there was nothing fiendish in the test, and therefore I reckon that it was quite easy to pass it". He was greatly confident before and after the test but after the results were announced, the student is convinced that the required material was not demanding enough that it would not be easily achievable to get at least 60% from the test.

In terms of emotions, the student feels the happiness that the test was passed perfectly. He is satisfied, calm and has a smile on his face. He elaborates: "I notice my hands are a little bit shaking after the test – when I hand in the test – even if I performed well or not. It always happens and I got used to it that it is my characteristic feature". Among the whole group, this learner was the calmest before the test, a moment after writing it and when the results were announced.

3.6. Discussion

The research aimed to explore how emotions both positive and negative influence students' success in the second language acquisition context due to them playing a vital role in the process of learning the target language. The two research questions stated above indicate the reflection of whether the two learners of diverse attitudes, motivations, emotions and grades perform similarly or differently while being tested.

The first research question: "[h]ow do students with the highest and the lowest scores feel before and after the test?" leads to a conclusion that both Student 1 and Student 2 feel tension before and after the test but their attitude towards learning is different. It can be stated that Student 1 is a low-achiever, and that is why he becomes stressed when he does not pass tests. Moreover, he permanently feels the tension due to his knowledge being insufficient to allow him to perform well during tests or taking exams. The only situation that makes him calm and relaxed is when the results of tests or exams are announced, and the student gets to know that he achieved the result that made him pass the test. Thus, it can be claimed that the tension of Student 1 takes place before taking the test and until receiving a grade. The learner mentioned that to lower the extent of nervousness and anxiety as well as not to shake himself, he has to start smoking and look for a person or people to talk to. After the test, when it is passed, he is satisfied when he would not need to retake it and study one more time, supposing that the material had been studied before. On the other hand, when the test is failed, he has a feeling that he will "waste his time studying one more time the same items". He gets even angrier when theoretical knowledge is tested, and not practical. The reason for the frustration is that because of not being ideally prepared, the learner loses a chance to pass a test or an exam in as minimal way as possible. Then, the holistic knowledge that he obtained during the previous learning stages, would not allow him to perform at least to get 60% and pass what was tested or examined. On the other hand, Student 2 is a high-achiever, and he is aware of his knowledge, which allows him to be satisfied with the grade he received. The learner gets calmer when he compares the knowledge he possesses and the extent of being prepared with the knowledge and preparation of his groupmates. In this way, he finds out that the time he spent on learning, as well as the background he has, would allow him to perform the way he expects, which means aiming at getting a 100% score. After the collection of tests or exams by lecturers, the learner is peaceful, and he does not feel any tension. Moreover, he can predict what kind of grade he will gain. However, performing below 100% makes the learner disappointed and angry at himself that he made a mistake, has not studied enough or did not know a particular item well. The student notices his hands shaking each time when the tests or exams are collected but, as he admitted, it is his characteristic

feature. This particular situation may be evidence that because he puts a lot of effort into studying, the student cares about the results.

Answering the second research questions: "[w]hat is the relation between emotions and success in test-taking?", it can be claimed that Student 1 is less successful than Student 2. The reason for that is a discrepancy between their language proficiency but also their attitude towards learning. Student 1 has high expectations but the effort he puts in is insufficient. This student has little time for studying. The strategies he uses for compensation turn out to be ineffective, yet he still does not look for more effective solutions. He seems to be disheartened and pessimistic. The learner does not have a feeling of being successful, and that is why the emotions he has are pejorative. He becomes easily frustrated and feels tension throughout the whole process of studying and tests or exams taking. The student is motivated to learn but does not do too much to move in this direction. On the one hand, he would like to be the most successful among the whole group, whereas, on the other hand, he does not put a lot of effort into the learning process. The learner would like his overall knowledge and logical thinking to help him pass all tests and exams. If it is insufficient to be successful, the extent of negative emotions arises. Conversely, Student 2 is optimistic and highly motivated. He is also self-confident, curious, and derives pleasure from learning. He shows a streak for competitiveness and enjoys outperforming other students. Even if his hands are shaking while handing in the test, he is calm and aware of his knowledge. He does not feel much tension due to him being able to predict what kind of grade he will obtain. However, if the score does not satisfy him, he feels disappointed and has a feeling that he should have studied more and could have answered the questions more precisely by giving more details. All the results motivate the learner for further learning, making him more curious and willing to succeed. Having achieved one of the highest scorers among the whole group, he is proud of himself and he tries to maintain this particular situation, which is ultimately what gives him power for the future. According to the pillars of positive psychology, successful learning of L2 takes place only when the students' characteristics together with emotional experiences are integrated with the learning situations. Hence, the goals of learning language are individuals' positive self-development, enjoyment, but also positive interactions with others which are positive psychology topics. Taking the instances of Student 1 and Student 2, it may be stated that positive emotions foster being successful whereas negative emotions contribute to failures. The learners are affected by factors included in Oxford's concept of EMPATHICS [9] what brings an explanation to the fact that their well-beings vary from each other. Moreover, being English majors verifies to what extent the respondents are engaged in the process of learning the language what consequently influences their success. Because of being obliged to do various exercises while being university students, they are unaware that certain exercises are PPEs chosen deliberately by teachers to build "social capital" [14,21]. Furthermore, it was observed while researching those positive relations with others as well as Positive L2 Self contribute to lowering stress. Relating to Lake's article [15], experiencing positive language situations causes Positive L2 Self-development, simultaneously enhancing motivation and L2 proficiency. What is more, it has to be mentioned that a discrepancy between motivation levels does not impact future L2 aims of the participants because they both are willing to associate their lives with the English language. That is why, in reference to the idea of PPIs, the learners try to combine the most effective strategies and tools while learning L2 to become as successful as it is possible. Finally, the gathered data present that achieving goals is subordinated to the dimension of effort what as a consequence provokes various emotions to appear. Referring to the concept of DMC [16-18], effort plays a vital role in language learning together with a vision of success because they motivate students for future development in the process of learning L2. While discussing the role of DMC, it must be highlighted that when the L2 learning process is crucial for a learner, it becomes a part of an individual's routine through habits as well as involvement which make a student engaged in acquiring new skills. The extent of learning process significance verifies how Student 1 and Student 2 are successful while test-taking and learning L2.

4. CONCLUSIONS

The results imply that there is a link between emotions and success in language learning. Positive emotions foster language learning; however, they are interrelated to negative emotions. Every student at every learning stage experiences these types of emotions to a higher and lower extent. However, it must be remembered that they both have their roles. Fredrickson and Losada [20], in the article *"Positive Affect and the Complex Dynamics of Human Flourishing"* present the research results which prove that the excessive existence of positive emotions over negative emotions is not convenient for the positive development of well-being, but on the other hand, too many negative emotions is not beneficial, as well. The researchers made calculations that to experience flourishing, for only one negative emotion everybody should experience between 2,9 and 11.6 positive emotions [20].

In terms of the pedagogical implications that might be suggested after providing the research that not only a university life, but life as a whole verifies the students' overall attitude toward learning and the goals, they are going to reach. A very crucial role at this point may be played by a lecturer. This person should be a tutor who shows which path the students should follow to learn most efficiently but also, to memorize as much as it is possible from the classes during which the material, which will be tested afterwards, was practised and explained clearly and understandably. What is more, a teacher should become an observer who should be able to adjust a provided material taking into consideration learners' autonomy and individual differences. Furthermore, while arranging tests and exams, a lecturer should compose all the tasks per criteria, characteristics of a good test or an exam, which are: a reason for the assessment, what skills are going to be checked, a written or an oral form of a test or an exam, subject of testing, content, and structure but also, test validity and reliability.

There are certain limitations to a research design. The research is an example of a case study that was created to compare two male students of diverse character traits, motivation, attitude towards learning, and success they experience while being English majors. It can be suggested to provide this kind of study between two female students or at a greater sample or to choose the participants depending on their attitude towards learning, motivation, autonomy, individual differences, strategies they use, etc., since the results may

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bring new insights into the studied topic which did not take place while considering this particular case study.

Summing up what was presented in this article, it can be said that the example of the two students participating in the study proves the existence of the saying" nothing succeeds like success" but also the saying," nothing succeeds like positive emotions".

APPENDIX

1. 1. Questions asked before the test:

1) How would you describe the extent of your preparation for this test in particular and exams in general?
2) Are you prepared for the test and exams because you study hard or because your overall knowledge of English is rich?
3) Do you study in advance or at the last moment?
4) Are there any subjects that you study more for and some that you study less for?
5) Can you predict what grade you will get for the tests or exams?
6) Do you subordinate your test or exam grade to what knowledge you have acquired during classes or lectures?
7) Could you describe what emotions accompany you right now before the test?

1. 2. Questions asked after the test:

1) Do you have a feeling that you could have been better prepared or are you satisfied with the result you achieved?
2) Are you satisfied with all the results that you have achieved?
3) Do tests themselves in general stress you or are you stressed because of your insufficient knowledge?
4) Were the extent of emotions that you felt stable or fluctuating? What was their intensity?
5) What emotions accompanied you when you received the test on a paper?
6) Could you describe what emotions accompany you right now after the test?

REFERENCES

[1] MacIntyre, P., & Gregersen, T. (2012). Affect: The role of language anxiety and other emotions in language learning. In Psychology for language learning (pp. 103-118). Palgrave Macmillan, London.
[2] Fredrickson, B. L. (2004). The broaden–and–build theory of positive emotions. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 359(1449), 1367-1377.
[3] Ibrahim, Z. (2016). 11 Affect in Directed Motivational Currents: Positive Emotionality in Long-Term L2 Engagement. In Positive psychology in SLA (pp. 258-281). Multilingual Matters.
[4] Oga-Baldwin, W. Q., Fryer, L. K., & Larson-Hall, J. (2019). The critical role of the individual in language education: New directions from the learning sciences. System, 86, 102118.
[5] Seligman, M. E. P., & Csikszentmihalyi, M. (2000). Positive psychology: An introduction, american psychologyst, 55, 5-14. Edición especial.
[6] MacIntyre, P. D. (2016). So far so good: An overview of positive psychology and its contributions to SLA. Positive psychology perspectives on foreign language learning and teaching, 3-20.
[7] Fredrickson, B. L. (2003). The value of positive emotions: The emerging science of positive psychology is coming to understand why it's good to feel good. American scientist, 91(4), 330-335.
[8] MacIntyre, P. D., & Mercer, S. (2014). Introducing positive psychology to SLA. Studies in Second Language Learning and Teaching, 4(2), 153-172.
[9] Oxford, R. L. (2016). 2 Toward a Psychology of Well-Being for Language Learners: The 'EMPATHICS'Vision. In Positive psychology in SLA (pp. 10-88). Multilingual Matters.
[10] Sin, N. L., & Lyubomirsky, S. (2009). Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: A practice-friendly meta-analysis. Journal of clinical psychology, 65(5), 467-487.
[11] Seligman, M. E., Steen, T. A., Park, N., & Peterson, C. (2005). Positive psychology progress: empirical validation of interventions. American psychologist, 60(5), 410.
[12] Lyubomirsky, S., & Layous, K. (2013). How do simple positive activities increase well-being?. Current directions in psychological science, 22(1), 57-62.
[13] MacIntyre, P. D., Gregersen, T., & Mercer, S. (2019). Setting an agenda for positive psychology in SLA: Theory, practice, and research. The Modern Language Journal, 103(1), 262-274.
[14] Gregersen, T., MacIntyre, P. D., & Meza, M. (2016). 6 Positive Psychology Exercises Build Social Capital for Language Learners: Preliminary Evidence. In Positive psychology in SLA (pp. 147-167). Multilingual Matters.
[15] Lake, J. (2016). 10 Accentuate the Positive: Conceptual and Empirical Development of the Positive L2 Self and Its Relationship to L2 Proficiency. In Positive psychology in SLA (pp. 237-257). Multilingual Matters.
[16] Ibrahim, Z. I. (2016). Directed motivational currents: optimal productivity and long-term sustainability in second language acquisition (Doctoral dissertation, University of Nottingham).
[17] Dörnyei, Z., Muir, C., & Ibrahim, Z. (2014). Directed motivational currents. Motivation and foreign language learning: From theory to practice, 9-30.
[18] Dörnyei, Z., Ibrahim, Z., & Muir, C. (2014). 10.'Directed Motivational Currents': Regulating Complex Dynamic Systems through Motivational Surges. In Motivational dynamics in language learning (pp. 95-105). Multilingual Matters.
[19] Muir, C., & Dornyei, Z. (2013). Directed motivational currents: Using vision to create effective motivational pathways. Studies in Second Language Learning and Teaching, 3(3), 357-375.
[20] Fredrickson, B. L., & Losada, M. F. (2005). Positive affect and the complex dynamics of human flourishing. American psychologist, 60(7), 678.
[21] MacIntyre, P. D., Gregersen, T., & Mercer, S. (2019). Setting an agenda for positive psychology in SLA: Theory, practice, and research. The Modern Language Journal, 103(1), 262-274.

BIOGRAPHIES

Jagoda Mikołajewska is a lecturer at the Department of English Studies, Faculty of Pedagogy and Fine Arts of Adam Mickiewicz University in Kalisz. Her research interests center around anxiety, willingness to communicate, flow, and engagement. In particular, she investigates the influence of anxiety on students' oral performance, as well as, factors impacting success of L2 learners in the light of positive psychology.

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Computational Framework of Goal Directed Voluntary Motion Generation and Control Loop in Humanoid Robots

Evren Daglarli

Istanbul Technical University, Computer and Informatics Engineering Faculty, Istanbul, Turkey. (e-mail: evren.daglarli@itu.edu.tr).

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Corresponding author: Evren Daglarli
✉ evren.daglarli@itu.edu.tr
☎ +90 212 2857535

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ABSTRACT

In this paper, it is aimed to construct a computational framework related to bio-inspired motion generation and control systems for humanoid robots. To acquire natural motion patterns in humanoid robots, behaviors observed from biological motor systems in humans and other mammals should be analyzed in detail. Computational mechanisms are mainly placed on the bio-physical plausible neural structures embodied in different dynamics. The main components of the system are composed of the limbic system, neocortex, cerebellum, brainstem, and spinal cord modules. Internal dynamics of these modules include a nonlinear estimator (e.g. chaotic attractor), memory formation, learning (neural plasticity) procedure. While the proposed novel neuro-cognitive framework is performing goal-directed voluntary motion generation and control tasks, also it estimates the amount of motion errors and computes motion correction signals. By this study, some motion-based central nervous system lesions (e.g. epilepsy, Parkinson, etc.) can be computationally modeled so that impairments of motor control commands are detected. Thus motion disorders can be reconstructed not only in humanoid robots but also in humans via some locomotion equipment.

1. INTRODUCTION

THE motion-based behavioral activity is very crucial for soft robotic systems which are diverse time-varying, non-rigid flexible dynamical systems [1]. Recently, these systems have gained the opportunity to interact more with their environment or people in many different social areas as a kind of special assistant performing rehabilitation tasks due to their structural features [2, 3]. Especially, the robots which can be used in applications involving dexterous motion skills need natural (smooth) motion patterns while they are performing some complex gestural tasks containing upper/lower torso physical behaviors with arm, hand, finger, leg, neck (head) movements. To acquiring more natural motion patterns in humanoid robots, behaviors observed from biological motor systems which produce new motions reusing and combining existing knowledge before performing the motion in humans and other mammals should be analyzed in detail [4, 5].

The fundamental dynamics of the human motor behavior system which is vigorous, versatile, and entirely adaptable present motivation to advanced robotic systems [6-8]. Like the gesturing assignment, the pointing assignment to various targets is one of the typical robotic tasks that human motor skills can be implemented. Besides pointing and gesturing assignments, the manipulation ability of basic tools is an essential asset for these systems.

In conventional systems, movements derived from these tasks should be validated once they are created so that the robot configurations involved are appropriate. Numerous biologically plausible visual and motor coordination models have been developed for achieving these tasks. Eventually, the aftermost objective will be imitating the human mental and motor skills as the fundamental objective is replacing people in perilous and monotonous tasks for improving motor behaviors of robots [9, 10]. Thus, developing comprehensive computational frameworks for understanding and approximating the motor behavior system of the human brain is one of the sensible approaches to achieve this. As a natural way, computational modeling of the central nervous system and brain can help for developing a novel motion generation and control system for robots [11-13].

The cerebellum which may indirectly affect both action and perception is one of the major components in the motor behavior system in the human brain to guarantee dexterous manipulation and coordinated movements although its lesions do not lead to a complete loss of motor functions [14]. Researches promise that it behaves as a forward model giving expected regulatory signals to the motion generation systems processing observed tactile stimuli [15]. Several works including spiking neural networks regard the deviation in task-space while other studies are dealing with providing the correction margin as an error signal in joint-space. Self-organizing robot navigation in the field with uncertainties has pulled in much consideration of researchers over the previous many years, and numerous biologically plausible heuristic route planning models have been introduced, like the cerebellum and basal ganglia models [15, 16]. As an approximate model, the cerebellum model which is constructed by information experienced from functional analysis and experiments related to dynamics (or behaviors) of this region in the human brain acts a critical role inside the robust motion generation framework to accomplish accurate and precise movements [17, 18]. In some examinations, it was shown that the learning cycle depends on the joint space perturbation. Motor control commands transmitted from the spinal cord model of system architecture involve joint angles and torques of the autonomous robot.

In this paper, it is proposed a novel computational neural model to be able to evolve different specific cortical regions of the artificial brain framework which can execute tasks related to cognitive abilities with complex movement-based motor behaviors involving dexterous skills for autonomous robots. Therefore, the framework performing its tasks should continuously adapt to accommodate these changes. This is a difficult issue because of the model complexities. Self-organizing regulators that can handle model vulnerabilities are a reasonable choice for this situation. The computational framework is based on a biologically plausible (spiking) neural model connecting various cortical regions with parallel and distributed network of neural populations which can be attributed spatial-temporal, multi-dimensional, and high-density information patterns by describing shared or distributed associative memory structures such as long term declarative memories (e.g., semantic and episodic), short term memory (working memory) and procedural memory (behavior motor skills and establishing sensory-motor association functions). As indicated by this viewpoint, a particular issue emerges structure detailing of movement task coordination application which is a basic cognitive skill of artificial brain framework in the robot.

The article following chapter 2 refers to related work which expresses features of previous studies associated with the proposed framework. The following section, chapter 3 determines the design principles of computational brain-inspired cognitive framework generating, planning, and correcting motor behaviors. Finally, concluding remarks and future works are presented in chapter 4.

2. RELATED WORKS

In the human brain, some areas of cortical and cerebral zones responsible for cognitive functions [19]. Connectionist neural network models such as cellular automata, Boltzman machines, recurrent neural networks, and self-organizing maps comply with the motivation behind the development of computational brain structures that can imitate motor behaviors of humans [20]. To achieve this, various kinds of cells (neurons) may involve in developing the computational structure of a large central nervous system for soft robotic systems [21]. While conventional neural network models utilize the McCulloch-Pitts neuron model, biologically inspired computational neurons such as spiking neural models (e.g, Integrate & Fire, Izhikevich, and Hodgin-Huxley model) are available (Hodgin et al., 1952) may be preferred in mathematical models of nervous systems for representing human's mental functions [22, 23].

Tieck et al. presented a procedure creating pointing behaviors for a robot with spiking neural model-based architecture [24]. They depicted a basic model of the human engine cortex producing movements utilizing motor functions. The system is trained to perform a simple motor function for pointing at an objective in the middle, and four adjustment functions to point at focuses up, right, left, and down from the base function. According to this, some basic functions can be merged to access various targets. They assess the efficiency of the system embodied a humanoid robot pointing at various targets indicated on a platform. The system achieved to merge one, two, and three motor functions simultaneously to manage the robot progressively to access a particular objective [24]. Besides, they studied to stretch out their work from pointing to a given target to execute a grasping or tool manipulation task. Also, their work has numerous applications for designing and industry including genuine robots. Given the perception and formative component of the science, the study conducted by Wang et al. aims a route planning model utilizing the motivated developmental network (MDN) to emulate the administered learning of the cerebellum and the reinforcement learning dependent on the radial basis function neural network (RBFNN) to mimic the award based learning of the basal ganglia, and coordinates them together to develop a mixture complex comprehension model, to explore a wheeled robot in the area with uncertainty [25]. While the artificial agent is discovering the field for unexplored regions, it employs the cerebellum model to decide action, instead of the greedy method, to speed up the learning optimization performance of the basal ganglia. In addition, their model straightforwardly utilizes the basal ganglia involving the RBFNN to discover and optimize the knowledge base of the cerebellum which allows accomplishing better choice in the accompanying investigation for discovered regions [25]. Their model executes the two-way data transmission between the cerebellum and basal ganglia. Their exploratory outcomes indicate that the model can empower the agent to self-governing advancement its knowledge through hybrid learning.

Wu et al. developed a model to imitate visual data processing, motor behaviors and organize peripheral and central neural structures of humans [26]. Their system involves simulating the function of the human dorsal visual pathway ("where" pathway) and the hierarchical structure and function of the human ventral visual pathway ("what" pathway) in humans for localization and recognition of objects respectively [26]. After that, it is responsible for performing motor behavior skills created from the blend of control signals from past experiences, and simulating exact motor actions which imitate calibration of movement errors in past experiences and the alignment of movement from the

cerebellum to achieve high precision. Their system mirrors designs and elements of human perception (visuomotor coordination), cognition, and accurate motor behavior [26]. Tests on item placement, perception, cognition, and accurate motor behavior exhibit that their model can achieve visuomotor coordination assignments, yet in addition accomplish high exactness development with learning capacity. Then, their outcomes additionally demonstrated the legitimacy of the presented instruments. Besides, their model was implemented to different frameworks, like mechanical and electrical frameworks in mechanical technology, to accomplish quick reaction, high accuracy development with learning capacity.

Zahra et al. studied a work ensuring a completely spiking neural framework that depends on forward prescient learning through a cell cerebellar model [27]. According to their model, the forward model is learned because of the feedback signal over task-space and behaves as a Smith indicator. The last predict perceptual remedies in contribution to a differential matching spiking neural structure while a robot arm controller is experiencing visuomotor coordination behavior [27]. In addition, they improved their control framework to accomplish more precise objective approaching tasks and decrease the movement realization duration for the autonomous systems because of the cerebellar motion prediction abilities. In another study by Zahra et al., a comprehensive cell-based forward cerebellar model involving Golgi and Basket cells was created [28]. To save the bio-inspired attributes of the cerebellum in the created model, a hyperparameter optimization strategy updates the weights of the network. The effectiveness of the bio-inspired cerebellar regulator proved for various autonomous systems imitating motor behavior [28].

Kalidindi et al. introduced a cerebellum-based dynamic kinematic regulator. Their dynamic regulator developed on top of a rough reverse kinematic model [29]. In addition, their design ensures mistake minimization without past information about the reverse kinematic regulator and adapts utilizing task space error data [29]. They presented experimental outcomes diminishing tracking error online and the strength of their system. Wilson et al. developed a multizone cerebellar chip for adaptive control of sensorimotor tasks in robots [30]. The multizone cerebellar chip was assessed utilizing a specialized robotic system involving information coming from a group of tactile sensors [30]. They bestowed results of their system with admissible performance for the simultaneous, stable learning in each cerebellar zone. Qiao et al. investigated Brain-inspired intelligent robots which simulate behaviors of humans and animals, from inner mechanisms to external structures, through an integration of visual cognition, decision making, motion control, and musculoskeletal systems [31]. Their review study evaluated the state of the art research in the field of brain-inspired visual cognition, decision making, musculoskeletal robots, motion control, and their integration, which allows robots to perform some complex tasks such as compliant and precise manipulation, fast and flexible response, and deep collaboration between humans and robots [31].

3. MOTOR BEHAVIOR SYSTEM

The proposed framework is composed of some different core modules representing cortical regions in the human brain. These modules are the thalamus, basal ganglia, cerebellum, and brainstem. The rest of the other modules including the motor cortex, prefrontal cortex, sensory cortices, spinal cord, and limbic system (amygdala and hippocampus) are considered for supporting this framework as a motion generation system that realizes accurate and precise motor behavior skills. Each module in the computational framework involves a bio-inspired neural model composed of spiking neurons and these modules communicate with each other so that they can realize distributed associative memory structures such as long-term declarative memories (e.g., semantic and episodic), short term memory (working memory) and procedural memory (behavior motor skills and establishing sensory-motor association functions) with spatial-temporal, multi-dimensional and high-density information patterns. Especially, procedural memory known as muscle memory represents network weights in the computational framework to store these information patterns about visual-motor coordination and dexterous motor behaviors for autonomous robots. The motion error evaluated by the cerebellum model in the framework is a key element for motion learning correction as a regulation process over procedural memory like a muscle memory

Thus, as a self-organizing regulator, this framework which can adapt to model vulnerabilities and uncertainties is developed for performing cognitive tasks related to complex movement-based motor behaviors like dexterous skills.

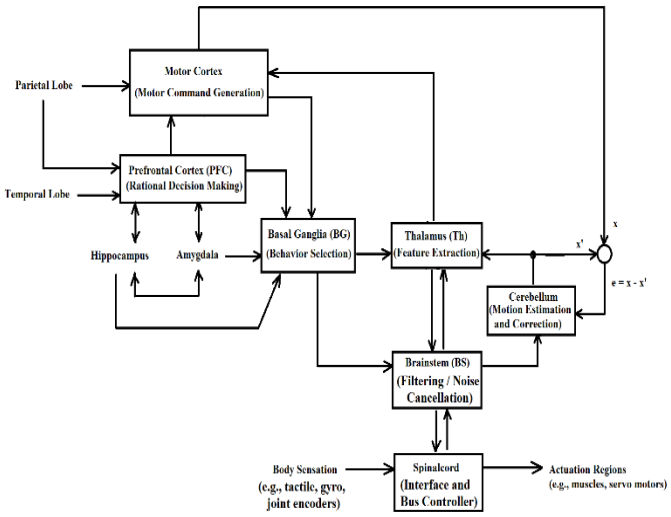

Fig.1. The Brain-Inspired Motor Behaviour Generation and Control Framework

In this computational framework, the basal ganglia model is a critical component that has dense neural links with cerebral cortex regions such as the thalamus, the sensory-motor cortices, the frontal lobe areas (e.g., prefrontal/orbitofrontal cortex), and other brain areas. It contains various nuclei with substantia nigra, striatum, subthalamic nucleus, external and internal globus pallidus.

The basal ganglia model is responsible for many cognitive skills like action selection, motion control, procedural learning related to routine motor behaviors or repetitive (habitual) movements. Mostly, the basal-ganglia model behavior is simulated as the winner-take-all (WTA) principle. According to this, in this computational framework, the basal-ganglia which is an adaptation mechanism performs a sequential decision-making process over motor commands for motion behavior planning of robots. These tasks executed in the basal-ganglia model are achieved by applying inhibitory

or excitatory effects on a group of motor systems. While the inhibition signal is suppressing some of the specific motor behavior activities, releasing the excitation signal enables a selected sequence of motor commands (actions) to be activated. The basal-ganglia model in this framework receives information resources from the basal-nucleus (amygdala), subiculum (hippocampus), associative cortices (prefrontal cortex), and motor cortex. Also, it produces response signals to brainstem components (midbrain, medulla, VTA, etc.) and thalamus modules.

The spiking neural network is utilized to build the basal-ganglia model. The internal topology of the basal-ganglia defining a part of procedural memory is stored in the interconnection matrix as weights. Besides, the basal ganglia model involves reinforcement learning techniques to shape motor behavior sequencing (planning) like switching tasks or action selection by the influence of the inhibitory or excitation signals of the basal ganglia module.

As a model of the computational framework, the brainstem model including some cortical regions like the midbrain, medulla, pons, and ventral tegmental area (VTA) is simply working as filtering, noise cancellation, and dopamine provider system that humanoid robot embodied computational brain inspired cognitive architecture can provide interacting with its dynamic environment. In this model, VTA works as a reward function applied to the basal-ganglia. In addition, a group of nuclei including midbrain, medulla, and pons is considered as an inverse kinematics controller utilizing information with real-time end-effector position.

The computational model of the cerebellum is designed for corrections of movements and motor control [6]. Input stream u (data flow) of the cerebellum model including information related to the desired end-effector motion pattern (displacement trajectory) in task space, and the current changes in each actuator variable (motor command) comes from the brainstem model.

$$x = cerebellum\ (u, e) \tag{1}$$

$$e = x' - x \tag{2}$$

Where e is a correction signal related to the motion error produced by the difference of responses between the cerebellum model x and the motor cortex model x'. It is contributed to coordination, precision, and accuracy of motor control of which timing, positioning (or postural), velocity, and acceleration in the backpropagation algorithm. The computational model of this module acting as an estimator or a non-linear filter can be helped to providing motor learning and improving the quality of movements. The weights are updated by the backpropagation method utilizing the stochastic gradient descent rule.

Like a bridge component, the spinal cord model is a major pathway including multi-modal and multi-channel connections in the central nervous system. Computational aspects of the spinal cord employ some functionalities such as an input-output interface and bus controller module. Also, it is responsible for monitoring and controlling data transmission between brain-inspired cognitive architecture and body regions of the humanoid robot. Body regions in the robot are considered as data acquisition and sensory environment (e.g., tactile sensors, joint encoders, gyro, etc.), actuation environment (e.g., servo motors). To interact the framework with the environment, the spinal cord model receives information from data acquisition and sensory environment (e.g., tactile sensors, joint encoders, gyro, etc.) and it relays motor commands to the actuation environment (e.g., servo motors). The spinal cord module is linked to brain-inspired cognitive architecture through the brainstem, motor cortex, thalamus models.

In the computational framework, motor commands (actions), or motor behavior primitives which form complex tasks with action sequence are generated by the motor cortex model. Mainly, it receives information from the sensory cortex and thalamus modules. The motor cortex model involves various components such as the primary motor cortex, premotor cortex, supplementary motor area, and posterior parietal cortex [6]. The major aim of the premotor cortex is to perform sensory guidance and direct control of movement. By this region (sub-module), various motor behavior primitives are produced. The primary motor cortex combines these motor behavior primitives to create compound motion patterns. Many different complex behaviors (tasks) can be generated by the sequence of these primitives in the supplementary motor area (SMA). This sub-module behaves as a motion planning engine involving a probabilistic dynamic programming methodology. The mapping process between multisensory information into motor commands is performed by the posterior parietal cortex (PPC). It contains very dense connections with prefrontal regions and sensory regions like visual, auditory, and somatosensory for the perceptual association. In addition, the motor cortex model forms a part of procedural memory related to motor behaviors. Particular motor systems (e.g. body control, arms, legs, and head/face) are modeled as cortical maps in the motor cortex model for neuromorphic robotic systems [7].

4. CONCLUSIONS

In this paper, the computational brain-inspired framework related to motor behavior system with cortical modules including the spinal cord, brainstem, thalamus, cerebellum, basal ganglia, and motor cortex is presented via other cortical units such as sensory modules, limbic system (amygdala and hippocampus) and prefrontal cortex. By this paper, as an adaptive control mechanism, a computational neurocognitive framework motivated by the motor behavior system in the human brain is provided. The computational model is mainly constructed by spiking neural structures. This computational framework can be adapted into various types of robotic platforms as well as humanoid robots.

The robot with the framework is efficiently able to simulate task planning problems with multiple targets or motion patterns under predefined cases involving motor behavior tasks. This computational framework is based on the neuromorphic principles of the behavior generation and control mechanism, which is shaped by procedural memory for soft robot systems.

Besides, a reinforcement learning-based adaptation procedure is suitable for behavior sequencing (action selection) procedures in the basal-ganglia model. Motion patterns produced as a result of motor behavior primitives in the motor cortex are constructed by this action sequence process and they are regulated with the cerebellum model.

This proposed framework may be further enhanced in the future, by integrating this framework with central pattern generators. In addition, this brain-inspired architecture can be

implemented in robotic systems with compliant mechanisms so that different motor behavior functions such as collaborative tasks which are not covered are being realized in this paper.

REFERENCES

[1] Nagabandi, A., Konolige, K., Levine, S., & Kumar, V. (2020, May). Deep dynamics models for learning dexterous manipulation. In Conference on Robot Learning (pp. 1101-1112). PMLR.

[2] Arimoto, S. (1995). Fundamental problems of robot control: part II a nonlinear circuit theory towards an understanding of dexterous motions. Robotica, 13(2), 111-122.

[3] Mattar, E. (2013). A survey of bio-inspired robotics hands implementation: New directions in dexterous manipulation. Robotics and Autonomous Systems, 61(5), 517-544.

[4] Ott, C., Eiberger, O., Friedl, W., Bauml, B., Hillenbrand, U., Borst, C., ... & Hirzinger, G. (2006, December). A humanoid two-arm system for dexterous manipulation. In 2006 6th IEEE-RAS International Conference on Humanoid Robots (pp. 276-283). IEEE.

[5] Maekawa, A., Matsubara, S., Wakisaka, S., Uriu, D., Hiyama, A., & Inami, M. (2020, April). Dynamic Motor Skill Synthesis with Human-Machine Mutual Actuation. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1-12).

[6] Abbatematteo, B., Rosen, E., Tellex, S., & Konidaris, G. (2021). Bootstrapping Motor Skill Learning with Motion Planning. arXiv preprint arXiv:2101.04736.

[7] Wang, N., Chen, C., & Di Nuovo, A. (2020). A framework of hybrid force/motion skills learning for robots. IEEE Transactions on Cognitive and Developmental Systems.

[8] Zeng, C., Chen, X., Wang, N., & Yang, C. (2021). Learning compliant robotic movements based on biomimetic motor adaptation. Robotics and Autonomous Systems, 135, 103668.

[9] Liu, R., Zhang, Q., Chen, Y., Wang, J., & Yang, L. (2020). A Biologically Constrained Cerebellar Model With Reinforcement Learning for Robotic Limb Control. IEEE Access, 8, 222199-222210.

[10] Tolu, S., Capolei, M. C., Vannucci, L., Laschi, C., Falotico, E., & Hernandez, M. V. (2020). A cerebellum-inspired learning approach for adaptive and anticipatory control. International journal of neural systems, 30(01), 1950028.

[11] Zahra, O., Tolu, S., & Navarro-Alarcon, D. (2021). Differential mapping spiking neural network for sensor-based robot control. Bioinspiration & Biomimetics, 16(3), 036008.

[12] Shin, D. J. (2020). A Convolutional Neural Network-based Policy Inspired by the Cerebellum.

[13] Yang, S., Wang, J., Zhang, N., Deng, B., Pang, Y., & Azghadi, M. R. (2021). CerebelluMorphic: Large-Scale Neuromorphic Model and Architecture for Supervised Motor Learning. IEEE Transactions on Neural Networks and Learning Systems.

[14] Parr, T., Limanowski, J., Rawji, V., & Friston, K. (2021). The computational neurology of movement under active inference. Brain.

[15] Rajendran, A., Vijayan, A., Medini, C., Nair, B., & Diwakar, S. (2021). Computational modeling of cerebellum granule neuron temporal responses for auditory and visual stimuli. International Journal of Advanced Intelligence Paradigms, 18(3), 356-372.

[16] Zhong, S., Zhou, J., & Qiao, H. (2021). Bioinspired Gain-Modulated Recurrent Neural Network for Controlling Musculoskeletal Robot. IEEE Transactions on Neural Networks and Learning Systems.

[17] Lobov, S. A., Zharinov, A. I., Makarov, V. A., & Kazantsev, V. B. (2021). Spatial Memory in a Spiking Neural Network with Robot Embodiment. Sensors, 21(8), 2678.

[18] Azimirad, V., & Sani, M. F. (2020). Experimental study of reinforcement learning in mobile robots through spiking architecture of thalamo-cortico-thalamic circuitry of mammalian brain. Robotica, 38(9), 1558-1575.

[19] Squire, L., Berg, D., Bloom, F. E., Du Lac, S., Ghosh, A., & Spitzer, N. C. (Eds.). (2012). Fundamental neuroscience. Academic Press.

[20] Kriegeskorte, N., & Douglas, P. K. (2018). Cognitive computational neuroscience. Nature neuroscience, 21(9), 1148-1160.

[21] Hassabis, D., Kumaran, D., Summerfield, C., & Botvinick, M. (2017). Neuroscience-inspired artificial intelligence. Neuron, 95(2), 245-258.

[22] Ghosh-Dastidar, S., & Adeli, H. (2009). Spiking neural networks. International journal of neural systems, 19(04), 295-308.

[23] Grüning, A., & Bohte, S. M. (2014, April). Spiking neural networks: Principles and challenges. In ESANN.

[24] Tieck, J., Schnell, T., Kaiser, J., Mauch, F., Roennau, A., & Dillmann, R. (2019). Generating pointing motions for a humanoid robot by combining motor primitives. Frontiers in neurorobotics, 13, 77.

[25] Wang, D., Hu, Y., & Ma, T. (2020). Mobile robot navigation with the combination of supervised learning in cerebellum and reward-based learning in basal ganglia. Cognitive Systems Research, 59, 1-14.

[26] Wu, W., Qiao, H., Chen, J., Yin, P., & Li, Y. (2016). Biologically inspired model simulating visual pathways and cerebellum function in human-Achieving visuomotor coordination and high precision movement with learning ability. arXiv preprint arXiv:1603.02351.

[27] Zahra, O., Navarro-Alarcon, D., & Tolu, S. (2020). Vision-Based Control for Robots by a Fully Spiking Neural System Relying on Cerebellar Predictive Learning. arXiv preprint arXiv:2011.01641.

[28] Zahra, O., Navarro-Alarcon, D., & Tolu, S. (2021). A Neurorobotic Embodiment for Exploring the Dynamical Interactions of a Spiking Cerebellar Model and a Robot Arm During Vision-based Manipulation Tasks. arXiv preprint arXiv:2102.01966.

[29] Kalidindi, H. T., Thuruthel, T. G., Laschi, C., & Falotico, E. (2019, April). Cerebellum-inspired approach for adaptive kinematic control of soft robots. In 2019 2nd IEEE International Conference on Soft Robotics (RoboSoft) (pp. 684-689). IEEE.

[30] Wilson, E. D., Assaf, T., Rossiter, J. M., Dean, P., Porrill, J., Anderson, S. R., & Pearson, M. J. A Multizone Cerebellar Chip for Bioinspired Adaptive Robot.

[31] Qiao, H., Chen, J., & Huang, X. (2021). A Survey of Brain-Inspired Intelligent Robots: Integration of Vision, Decision, Motion Control, and Musculoskeletal Systems. IEEE Transactions on Cybernetics.

BIOGRAPHIES

Evren Daglarli, received the B.Sc. from Marmara University in 2004, the M.Sc. degree in mechatronics engineering with a focus on intelligent systems and robotics from Istanbul Technical University (ITU) in 2007, and the Ph.D. degree in control and automation engineering with a focus on computational cognitive-neuroscience, human_robot interaction from ITU in 2019. He has worked as a Research Assistant with the Department of Electrical and Electronics Engineering, Atilim University. He has many publications that are published in international journals, conferences/symposiums related to mechatronics, intelligent control systems, and robotic areas. As a Researcher, he took some duties and responsibilities in several national/international projects. He has worked as a Project Engineer and the Department Manager at a private sector technology and engineering company. He is currently working as a Faculty Member and a Lecturer/Instructor with the Computer Engineering Department, Faculty of Computer and Informatics Engineering, Istanbul Technical University. He is a senior member of IEEE.

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Investigation with Structural Equation Model of the Relationship between Covid-19 Phobia and Secondary Traumatic Stress Level in 112 Emergency Service Personnel

[1]Serdar Derya, [2]Bora Tetik, and [3]Leman Acun Delen

[1]Malatya Training and Research Hospital, Department of Traumatology and Emergency Medicine, Malatya, Turkey. (e-mail: dr.serdarderya@gmail.com).
[2]Inonu University School of Medicine, Deparment of Neurosurgery, Malatya, Turkey. (e-mail: drboratetik@hotmail.com)
[3]Malatya Training and Research Hospital, Department of Anesthesiology and Reanimation, Malatya, Turkey. (e-mail: lmndelen@hotmail.com)

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Corresponding author: Bora Tetik
✉ drboratetik@hotmail.com
☎ +90 505 6212427

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ABSTRACT

The impact of the Covid-19 pandemic on healthcare workers is increasing day by day. It should not be forgotten that health professionals working in risky groups will be psychologically affected much more. The aim of this cross-sectional study is determine the relationship between covid-19 phobia and secondary traumatic stress level in 112 emergency service personnel via a structural equation model(n=416).A 1-unit change that was occur in the total score of the trauma scale causes an increase of 0.68 units in the phobia scale total score (β=0.68;p<0.001).In addition, it was determined that female personnel, those with a history of contact with a covid-19 positive colleague, and those who stated to be extremely worried about the possibility of a second wave, had a high level of phobia and STS levels. In addition to all risks, it should not be forgotten that 112 personnel exposed to psychologically affected in combating pandemic should be supported separately.

1. INTRODUCTION

THE struggle against the pandemic continues actively in our country, since March 11, 2020, when COVID 19 has been announced to be a pandemic by WHO. It was the same day the first case was reported, in our country. It is still unclear how long this process will continue, when the vaccine will be available and when global immunity will occur. Unavailability of a definitive cure, when a second wave of spread has been experienced in some countries, while the first wave is continuing in some countries, including Turkey, significantly increases the anxiety of people. As of September 2020 the number of patients diagnosed with COVID-19 was 29.125.191 in the world and 291.162 in Turkey [1].

Continuous publications in the press and the media, social distancing, shot down of schools and some workplaces within the scope of preventing the transmission of the disease, people's feelings of being imprisoned at home, and most importantly, the uncertainty of this period will probably have additional psychological effects on the healthcare professionals, who are working in a more risky environment. It is known that psychological stress makes people vulnerable to acute respiratory infections, and stress causes activation of the hypothalamus-hypophyse axis and autonomic nervous system [2,3]. The effects of COVID 19 pandemic on healthcare workers has been increasing day by day. The emotional state experienced by individuals as a result of witnessing a tragic event or being indirectly exposed to it because of their job is called secondary traumatic stress, and healthcare personnel are at risk in terms of secondary traumatic stress during the covid-19 process [4]. Furthermore, it is predicted that, those working in 112 Emergency Service, which is the most risky group, will more frequently be affected psychologically.

Both the increase in the number of patients and the increasing rate of positive cases, even deaths among

healthcare personnel make the situation more complicated. 112 emergency service personnel are in one of the most risky groups, in this process. In this study, we planned to investigate the psychological effects of the COVID-19 epidemic on 112 employees, prevalence of these effects, and the relationship between sociodemographic variables and the rate of taking precautions. To the best of our knowledge, this is the first study investigating the psychological effects of pandemic on 122 employees. We believe that the data we present will be guiding for both public health services and health-care administrators.

2. MATERIALS AND METHODS

2.1. Dataset

The aim of this cross-sectional study is determine the relationship between covid-19 phobia and secondary traumatic stress level in 112 emergency service personnel via a structural equation model.

2.2. Setting and Time of the Study

This study was conducted on 112 Emergency Service employees, working in a province located in the east of Turkey, between July 2020 and August 2020.

2.3. The Universe and Sample of the Research

The universe of the study was composed of all 112 emergency service personnel (ATT, Paramedic, Ambulance Driver, Doctor) serving within the relevant "Provincial Ambulance Service Chief Physician". The personnel working within the Provincial Ambulance Service Head Physician include 212 ATTs, 168 Paramedics, 45 Ambulance Drivers and 22 Doctors (total = 447). In the power analysis in order to achieve 5% error level, 95% confidence interval and the ability to represent the 80% of the universe, it has been calculated found the sample size should be at least 207 personnel. The study was conducted on with 416 Emergency Service personnel who voluntarily agreed to participate in the study.

2.4. Data Collection Tools

Personal Information Form, Coronavirus 19 Phobia Scale (C19P-S), and Secondary Traumatic Stress Scale (STSS) were applied to the participants.

Personal Introduction Form; This form consists of 12 questions that question the sociodemographic characteristics (age, gender, education level, etc.) of the participants and their experiences during the Covid-19 pandemic process.

Coronavirus 19 Phobia Scale (C19P-S); C19P-S is a 5-grade Likert-type self-assessment scale developed by Arpaci et al. (2020), to measure the phobia of corona virus. The questions were answered on a 5 grade scale where 1 represents “Strongly Disagree” and 5 “Strongly Agree”. It is consisted of 20 questions divided into 4 sub dimensions. Psychological Sub-Dimension includes the questions 1, 5, 9, 13, 17, and 20; Somatic Sub-Dimension includes the questions 2, 6, 10, 14, and 18; Social Sub-Dimension includes the questions 3, 7, 11, 15, and 19; and Economic Sub-Dimension includes questions 4, 8, 12, and 16. Sub-dimension scores are obtained by the sum of the scores of the answers given to the questions under that sub-dimension, the total C19P-S score is obtained by the sum of the sub-dimension scores. The total score from the C19P-S varies between 20 and 100. The higher of the scores indicate the higher level of corona phobia. The cronbach alpha value of the scale was determined to be 0.92 [5]. In this study, the cronbach alpha value was found as 0.95.

Secondary Traumatic Stress Scale (STSS); STSS was developed by Bride et al. and Turkish adaptation was conducted by Yildirim et al., in 2018. It is a 17-item, five-point Likert-type assessment tool. The scale has three sub-dimensions including involuntary involvement, avoidance, and arousal. The lowest score that can be obtained from the scale is 17 and the highest score is 85. A higher score indicates a higher level of exposure. The cronbach alpha value of the scale was determined to be 0.91, by Yildirim et al. [6]. In this study, the cronbach alpha value was found as 0.94.

2.5. Data Collection

Data collection forms were sent to 112 emergency service personnel, who agreed to participate in the study, via the telephone network and internet using the Google form method, and the forms were requested to be filled by the participants. At the beginning, the personnel who accepted to participate in the study were asked to approve the informed consent form by using the Google form method. All data were obtained by online self-report method and recorded by using Google form method. The data collection phase took about 5-8 minutes for each participant.

2.6. Evaluation of Data

The data were evaluated by using the AMOS 24 and SPSS 25.0 statistical package program. The descriptive statistics were presented as number, percentage, mean, standard deviation, min-max. In addition, in independent groups t test, ANOVA test, Pearson correlation analysis and structural equation model were used. Results were evaluated at 95% confidence interval and a value of $p < 0.05$ was considered statistically significant.

2.7. Ethical Approval

An institutional permission from the relevant Provincial Ambulance Service Chief Physician and ethical approval from the Inonu University Health Sciences Scientific Research and Publication Ethics Committee were obtained before the study was started (Decision No: 2020/953). In addition, permission of Republic of Turkey Ministry of Health Covid-19 for Scientific Research was obtained (Form Number: 2020-06-28T22_47_30). Informed Consent Forms were also obtained from the participants after the necessary explanations were made and before they filled the data collection forms.

3. RESULTS

The mean age of the participants is 29.54 ± 7.95; 51.2% are women; 54.5% are associate degree graduates; 52.9% are married; 89.4% are working as ATT / Paramedic; and 86.3% of them are working 112 stations. Sociodemographic characteristics of the 112 emergency service personnel and comparison of C19P-S and STSS scale scores are given in Table 1.

It was determined that Covid-19 Phobia and Secondary Traumatic Stress scores of female 112 emergency service personnel were statistically significantly higher than the male personnel ($p < 0.05$). It was also determined that the personnel

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working as ATT / paramedic had significantly higher C19P-S and STSS scores compared to the drivers (p <0.05).

TABLE 1
COMPARISON OF C19P-S AND STSS SCORES ACCORDING TO THE DESCRIPTIVE FEATURES OF 112 EMERGENCY SERVICES PERSONNEL (n=416)

Variables	n(%)	C19P-S (Mean±SD)	STSS (Mean±SD)
Gender			
Female	213 (51.2)	48.85±17.44	41.72±14.40
Male	203 (48.8)	45.16±16.38	37.81±16.35
Test / p		t=2.225	t=2.594
		p=0.027*	**p=0.010***
Education Level			
High school	96 (23.1)	43.04±16.36	36.12±13.10[a]
Associate Degree	227 (54.5)	48.73±17.01	40.25±15.66[b]
Bachelors Degree	86 (20.7)	46.95±17.67	42.45±16.82[c]
Postgraduate	7 (1.7)	49.00±9.27	44.00±16.53[d]
Test / p		F=2.575	F=2.918
		p=0.054	**p=0.034*** c>a
Marital status			
Married	220 (52.9)	47.19±17.20	39.96±16.14
Single	196 (47.1)	46.90±16.84	39.65±14.76
Test / p		t=0.172	t=0.204
		p=0.864	p=0.839
Occupation			
ATT/Paramedic	372 (89.4)	47.95±17.08[a]	40.73±15.36[a]
Driver	32 (7.7)	41.38±15.88[b]	34.12±14.64[b]
Doctor	12 (2.9)	50.58±15.96[c]	43.16±18.05[c]
Test / p		F=4.246	F=5.157
		p=0.015* a>b	**p=0.006*** a>b
Service Unit			
Coordination Center	57 (13.7)	47.68±19.88	42.50±16.71
Station	359 (86.3)	46.95±16.54	39.39±15.26
Test / p		t=0.300	t=1.414
		p=0.764	p=0.158
Age (Mean±SD) 29.54±7.95	416 (100.0)	r= -0.098 **p=0.045***	r= -0.066 p=0.177

t= Independent-samples t-test F=One-Way ANOVA *p<0.05
r=Pearson correlation analysis

In addition, it was found that STSS scores increased as the level of education advanced; 112 emergency service personnel with a bachelor's degree had higher STSS scores than high school graduates (p <0.05). On the other hand, it was determined that C19P-S scores decreased significantly as age increased in all 112 emergency service personnel (p <0.05) (Table 1).

Table 2 shows the distribution of 112 emergency service personnel according to Covid-19 experiences and the comparison of Covid-19 phobia and secondary traumatic stress levels according to these experiences. We found that 86.1% of the 112 emergency service personnel had transferred Covid-19 patients, 20.4% had a history of a contact with a Covid-19 positive patient, and 23.1% had a history of a contact with a Covid-19 positive colleague. The rate of those diagnosed with Covid-19, among 112 emergency service personnel is found to be 7.5%. In addition, 54.3% of the 112 emergency service personnel stated that they stayed in a guest house or a different house to protect their family members, and 37.3% stated that they were anxious about the possibility of a second wave (Table 2).

We found that 112 emergency service personnel with a history of contact with a Covid-19 positive colleague had higher C19P-S and STSS scores compared to those without a contact history.

TABLE 2
COMPARISON OF C19P-S AND STSS SCORES ACCORDING TO THE COVID-19 EXPERIENCES OF 112 EMERGENCY SERVICE PERSONNEL (n=416)

Variables	n(%)	C19P-S (Mean±SD)	STSS (Mean±SD)
Have you ever transferred Covid-19 patients?			
Yes	358 (86.1)	46.38±16.62	39.28±15.30
No	58 (13.9)	51.18±18.89	43.12±16.33
Test / p		t= -2.002	t= -1.755
		p=0.046*	p=0.080
Have you ever been in contact with a Covid-19 positive patient?			
Yes	85 (20.4)	48.94±19.53	42.42±17.95
No	331 (79.6)	46.57±16.30	39.14±14.74
Test / p		t=1.146	t=1.743
		p=0.252	p=0.082
Have you ever been in contact with a Covid-19 positive colleague?			
Yes	96 (23.1)	50.17±18.45	45.23±16.07
No	320 (76.9)	46.11±16.47	38.19±14.95
Test / p		t=2.058	t=3.980
		p=0.040*	**p=0.000***
Have you been diagnosed with Covid-19 ?			
Yes	31 (7.5)	44.61±17.49	41.51±13.69
No	385 (92.5)	47.25±16.98	39.68±15.63
Test / p		t= -0.830	t=0.634
		p=0.407	p=0.526
Measures taken to protect family members			
Staying in a guest house or a different home	226 (54.3)	47.96±17.68	40.12±16.16
Implementing social isolation / cleaning measures at home	190 (45.7)	45.97±16.16	39.45±14.68
Test / p		t= 1.189	t= 0.440
		p=0.235	p=0.660
Level of anxious about the probability of a second wave			
Not at all	35 (8.4)	34.51±11.89[a]	32.14±15.36[a]
Partially anxious	94 (22.6)	39.41±12.28[b]	33.53±11.36[b]
Anxious	155 (37.3)	46.15±12.46[c]	36.40±11.28[c]
Very anxious	132 (31.7)	56.87±20.21[d]	50.34±16.97[d]
Test / p		F=34.020	F=39.408
		p=0.000* d>a,b,c c>a,b	**p=0.000*** d>a,b,c

t= Independent-samples t-test F=One-Way ANOVA *p<0.05

In addition, 112 emergency service personnel who stated that they were "very worried" against the possibility of a second wave were found to have the highest C19P-S and STSS scores compared to other anxiety levels (p <0.05).

We also found that C19P-S scores of the 112 emergency service personnel who did not transfer Covid-19 patients were statistically significantly higher than those who had transferred Covid-19 patients (p <0.05) (Table 2).

It was determined that the mean total C19P-S score of the 112 Emergency Service personnel was 47.05 ± 17.01, and the mean total STSS score was 39.81 ± 15.49. according to the results of the Pearson's correlation analysis, it was determined that there was a moderately significant positive correlation between the mean total C19P-S and STSS scores, and as STSS scores increased Covid-19 phobia increased significantly, in 112 emergency service personnel (p <0.001). In addition, it was found that there was a positive significant relationship

between the mean total and all sub-dimension scores of STSS and C19P-S (p <0.001). Data showing the relationship between covid-19 phobia and secondary traumatic stress levels in 112 emergency service personnel is shown in Table 3.

TABLE 3
THE RELATIONSHIP BETWEEN COVOD-19 PHOBIA (C19P-S) AND SECONDARY TRAUMATIC STRESS LEVELS (STSS) IN 112 EMERGENCY SERVICE PERSONNEL

	STSS (mean ±SD)			
C19P-S (mean ±SD)	Involuntary involvement (10.62±4.40)	Avoidance (17.00±6.52)	Alertness (12.19±5.56)	Total (39.81±15.49)
Psychological (16.55±6.55)	r=0.382 **p=0.000***	r=0.520 **p=0.000***	r=0.544 **p=0.000***	r=0.523 **p=0.000***
Somatic (9.78±4.04)	r=0.478 **p=0.000***	r=0.534 **p=0.000***	r=0.558 **p=0.000***	r=0.562 **p=0.000***
Social (12.72±5.15)	r=0.417 **p=0.000***	r=0.568 **p=0.000***	r=0.568 **p=0.000***	r=0.562 **p=0.000***
Economic (7.99±3.31)	r=0.381 **p=0.000***	r=0.453 **p=0.000***	r=0.464 **p=0.000***	r=0.466 **p=0.000***
Total (47.05±17.01)	r=0.461 **p=0.000***	r=0.588 **p=0.000***	r=0.604 **p=0.000***	r=0.596 **p=0.000***

*p<0.05

The effect of the scores obtained from the secondary traumatic stress scale on the scores obtained from the Covid-19 phobia scale was examined with the structural equation model (Figure covariances; It was found as $\chi 2$ 37.360, df 11 (p <0.05), $\chi 2$ / df 3.396, RMSEA 0.077, GFI 0.974, CFI 0.990, and IFI 0.990.

It was seen that the indexes of the model were in the desired range [7]. According to the structural equation model established, a statistically significant positive correlation was found between the score obtained from the secondary traumatic stress scale and the score obtained from the Covid-19 phobia scale. A 1-unit change that will occur in the total score of the trauma scale causes an increase of 0.68 units in the phobia scale total score (β= 0.68; p <0.001).

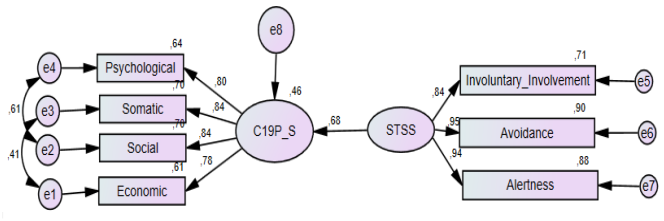

Fig.1. Structural equation model for secondary traumatic stress scale and covid-19 phobia scale.

4. DISCUSSION

Secondary traumatic stress is defined as "being in a professional relationship with the person or persons directly experiencing a traumatic event and being indirectly exposed to the trauma" [6] or "the stress resulting from the behavior or desire to help a person who has been traumatized or suffered"[8]. In this study, it was determined that the level of secondary traumatic stress developed in 112 emergency service personnel in the face of COVID 19 pandemic was 39.81 ± 15.49. In addition, it was found that STSS scores of female 112 emergency service personnel were higher compared to males and ATT / paramedic personnel had higher scores compared to drivers, undergraduate graduates had higher scores compared to high school graduates, and employees with a history of contact with a Covid-19 positive colleague compared to those without a history of contact (Table 1, Table 2, p <0.05 for all). In the literature, it has been stated that many factors such as health anxiety, social isolation, stigmatization, and changing working conditions can cause psychological problems such as secondary traumatization for healthcare workers [9]. It is known that acute or chronic stress attacks and psychological problems can cause chronic inflammatory changes in the brain [10]. In this study, it was determined that factors such as gender, education, occupational group and history of contact with a Covid-19 positive colleague are variables that affect the level of secondary traumatic stress. Since the number of the studies on the subject is limited, we suggest that these findings will contribute to the literature. For example, in the study of Arpacioğlu et. al., it has been reported that anxiety, depression, and secondary traumatization scores of healthcare workers who serve in the front lines, during the pandemic process, were significantly higher compared to other healthcare workers or non-medical employees [11]. In addition, in the same study, the factors including being a woman, being in newly beginner in the service, living with parents, having a history of chronic illness and trauma, and increased social media use were reported to increase the level of secondary trauma [11]. Trauma can develop due to many factors.

Many factors can cause trauma. For example, in Thailand, heavy workload of, the lack of protective devices, an ineffective infection control system, surprisingly aggressive attitude towards doctors and other healthcare personnel, vulgar verbal insults and intentional cough against medical staff are cited to be the reasons of trauma experienced by healthcare workers [12]. On the other hand, Li et al., in their study conducted in China, found that the secondary trauma scores of nurses working in the front line during the pandemic process were significantly lower than those who were not in the front line [13]. Although the number of studies limited and psychological impact and secondary trauma levels in healthcare workers are not clear yet, similar causes of trauma have been suggested. Covid-19 pandemic have been transforming into a global trauma due to the fact that the exact reason of the epidemic is not known clearly, the virus cannot be controlled, and all individuals in the world are at potential risk [9].

In this study, it was determined that the scores of C19P-S were higher in female 112 emergency service personnel compared to males; in ATT / paramedics compared to drivers, and in personnel with a history of contact with a Covid-19 positive colleague compared to those without a contact history (p <0.05). On the other hand, it was found that the mean scores of C19P-S was lower in those who had transfer Covid-19 positive patients compared to the others and the level of Covid-19 phobia decreased with increasing age (Table 1, Table 2, p<0.05). The main duty of health services is to ensure that individuals continue a healthy life and prevent diseases. Pandemic management and control of infectious diseases are of crucial importance in terms of public health. In the Covid-19 pandemic, healthcare workers are at substantially higher risk compared to the rest of the society [14]. For example, in China, where 76.000 cases have been diagnosed, it has been reported that 3000 cases were health personnel [15]. This increased risk as well as the existing workload of the healthcare personnel, leads to an increase in anxiety and stress levels.

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In a study published by Turkish Mental Health Association, it was reported that 50% of the society afraid of being infected by the virus and 59% stated that their health-related anxiety has increased [16]. In our study, it has been found that, 69% of the 112 Emergency Service employees were anxious or extremely anxious and the mean C19P-S score was 47.05 ± 17.01 (Table 2, Table 3). The level of anxiety regarding a second wave of spread is contemplating, while our country is still struggling in the first wave. In addition, in this study, we examined the relationship between Covid-19 phobia and STSS scores (Table 3; Figure 1) and we determined that a 1-unit change that will occur in the total score of the trauma scale causes an increase of 0.68 units in the Covid-19 phobia scale total score ($\beta = 0.68$; $p < 0.001$). This finding show that Covid-19 phobia and secondary traumatic stress levels important variables that affect each other and indicate the need for serious precautions in this regard.

In Italy, 8% of the Covid-19 cases are health care personnel. In Spain, this rate has been reported to be 14%. These high rates are challenging the health care system and leads to the collapse of the system, in some countries [17,18]. In our study, the rate of Covid-19 positivity was found to be 7.5%. During this process, healthcare personnel working in emergency healthcare services constitute a highly risky group. In our study, it was found that 54% of the 112 emergency service personnel did not live in their homes. This situation is thought to be due to their fear of infecting their families, since they were at greater risk. However, we concern that being away from home may significantly increase the anxiety and stress levels, during this epidemic that affects the whole world and is still uncertain when to end. We think that organizing the work schedules of health care personnel with longer resting times may help reducing the stress burden on them.

5. CONCLUSIONS

In this study we investigated the relationship between Covid-19 phobia and secondary traumatic stress level in 112 personnel and we found that as the level of secondary trauma increased, Covid-19 phobia increased significantly. We determined that secondary traumatic stress level is an important variable that increases covid-19 phobia. Among the 112 personnel, the rate of getting a diagnosis of Covid-19 was 7.5%. Covid-19 phobia was lower in personnel who transferred Covid-19 patients. It was determined that female 112 personnel, those with a history of contact with a Covid-19 positive colleague, and those who stated to be extremely anxious about the possibility of a second wave, had a high level of Covid-19 Phobia and Secondary Traumatic Stress levels. We also found that 54.3% of the 112 personnel have been living in a guest house or a different house, since the onset of the epidemic, to protect their family members. In addition, it was observed that as the age increased, the covid-19 phobia decreased and among all 112 employees, drivers had the lowest Covid-19 Phobia and Secondary Traumatic Stress levels.

The impact of the Covid-19 pandemic, which is a global public health problem, on healthcare workers is increasing day by day. It should not be forgotten that health professionals working in risky groups will be psychologically affected much more. In line with these results, it is very important for health managers to create online environments where healthcare personnel, who are at the forefront of combating the pandemic, can cope with stress, and to create a work order in which they can spend safe time with their families. We suggest that, strategies cope should be given through the in-service trainings in order to prevent Covid-19 phobia.

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REFERENCES

[1] Turkish Clinical Microbiology and Infectious Diseases Association (2020). https://www.klimik.org.tr/koronavirus/covid-19-salgininda-ulkelere-gore-olgu-sayilari/AccespDate: 14.09.2020

[2] Yang, Y., Li, W., Zhang, Q., Zhang, L., Cheung, T., & Xiang, Y. T. (2020). Mental health services for older adults in China during the COVID-19 outbreak. The Lancet Psychiatry, 7(4), e19.

[3] Seiler, A., Fagundes, C. P., & Christian, L. M. (2020). The impact of everyday stressors on the immune system and health. In Stress Challenges and Immunity in Space (pp. 71-92). Springer, Cham.

[4] Blanco-Donoso, L. M., Moreno-Jiménez, J., Amutio, A., Gallego-Alberto, L., Moreno-Jiménez, B., & Garrosa, E. (2021). Stressors, job resources, fear of contagion, and secondary traumatic stress among nursing home workers in face of the COVID-19: the case of Spain. Journal of Applied Gerontology, 40(3), 244-256.

[5] Arpaci, I., Karataş, K., & Baloğlu, M. (2020). The development and initial tests for the psychometric properties of the COVID-19 Phobia Scale (C19P-S). Personality and Individual Differences, 164, 110108.

[6] Yildirim, G., Kidak, L. B., & Yurdabakan, I. (2018). Secondary Traumatic Stress Scale: An adaptation study/Ikincil Travmatik Stres Olcegi: Bir uyarlama calismasi. Anadolu Psikiyatri Dergisi, 19(1), 45-52.

[7] Ozdamar, K. (2016). *Scale and test development in education, health and behavioral sciences: Structural equation modeling*, Eskişehir, Turkey: Nisan Publisher.

[8] Ratrout, H. F., & Hamdan-Mansour, A. M. (2020). Secondary traumatic stress among emergency nurses: Prevalence, predictors, and consequences. International journal of nursing practice, 26(1), e12767.

[9] Bozkurt, Y., Zeybek, Z. Aşkın, R. (2020). "COVID-19 Pandemıc: Psychologıcal Effects And Therapeutıc Interventıons", Istanbul Commerce University Journal of Social Sciences, 19(37), 304.

[10] Ramezani, M., Simani, L., Karimialavijeh, E., Rezaei, O., Hajiesmaeili, M., & Pakdaman, H. (2020). The role of anxiety and cortisol in outcomes of patients with Covid-19. Basic and clinical neuroscience, 11(2), 179.

[11] Arpacioglu, S., Gurler, M., & Cakiroglu, S. (2021). Secondary traumatization outcomes and associated factors among the health care workers exposed to the COVID-19. The International journal of social psychiatry, 67(1), 84.

[12] Joob, B., & Wiwanitkit, V. (2020). Traumatization in medical staff helping with COVID-19 control. Brain, behavior, and immunity, 87, 10.

[13] Li, Z., Ge, J., Yang, M., Feng, J., Qiao, M., Jiang, R., ... & Yang, C. (2020). Vicarious traumatization in the general public, members, and non-members of medical teams aiding in COVID-19 control. Brain, behavior, and immunity, 88, 916-919.

[14] Turkish Medical Association. Opinion of the Turkish Medical Association Ethics Committee on Outbreaks https://www.ttb.org.tr/makale_goster.php?Guid=4da9a49c-7674-11ea-b329-aa051764b049. Accessed: 05.09.2020

[15] WHO, "Mental health and psychosocial considerations during COVID-19 outbreak", 2020. https://www.who.int/docs/defaultsource/coronaviruse/mental-health considerations.pdf?sfvrsn=6d3578af_8. Accessed Jully 22, 2020.

[16] Mental Health Association, 2020. https://ruhsagligidernegi.org/etiket/korona-virusu/. Accessed Jully 25, 2020.

[17] Adams, J. G., & Walls, R. M. (2020). Supporting the health care workforce during the COVID-19 global epidemic. Jama, 323(15), 1439-1440.

[18] Stone, T. E., Kunaviktikul, W., Omura, M., & Petrini, M. (2020). Facemasks and the Covid 19 pandemic: What advice should health professionals be giving the general public about the wearing of facemasks?. Nursing & health sciences.

BIOGRAPHIES

Serdar Derya, obtained his BSc degree in doctor from Inonu University in 2007 and Medicinae Doctor Department of Traumatology and Emergency Medicine from Inonu University in 2017. He is currently Training and Research Hospital works as physician Malatya, Turkey. He is active in his Traumatology and Emergency Medicine, teaching and research.

Bora Tetik, obtained her BSc degree in doctor from Erciyes University in 2002 and Ass. Prof. Dr. Department of Neurosurgery from Ankara University in 2014. He is currently an Assistant Professor PhD of Inonu University School of Medcine, Department of Neurosurgery, Malatya, Turkey. He ise active in teaching and researching about neurosurgery.

Leman Acun Delen, obtained her BSc degree in doctor from Uludag University in and Medicinae Doctor Department of Anesthesiology and Reanimation from Health Sciences University.She is currently Training and Research Hospital works Malatya, Turkey. She is active in his Anesthesiology and Reanimation, teaching and research.

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Deep Learning-Based Prediction of Obesity Levels According to Eating Habits and Physical Condition

Mehmet Kivrak

Inonu University, Faculty of Medicine Dept. of Biostatistics and Medical Informatics,Malatya, Turkey. (e-mail: mehmetkivrak83@gmail.com).

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Corresponding author: Mehmet Kivrak
✉ mehmetkivrak83@gmail.com
☎ +90 533 5113432

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ABSTRACT

Obesity occurs as a result of excessive fat storage in the body and brings along physical and mental problems [1]. The physical function has been associated with impaired quality of life in various areas such as distress in society, sexual function, self-esteem, and work-related quality of life [2]. The prevalence of obesity has been steadily increasing over the past few decades and is now unprecedented. This increase has occurred in almost all ages, genders, and races. These data show that the segments of individuals in the highest weight categories i.e. (BMI> 40 kg / m2) increased proportionally more than those in the lower BMI categories (BMI <35 kg / m2) [3]. Given the numerous and important health consequences associated with obesity, there is an urgent need to develop highly effective interventions aimed at reversing these “obesogenic” drivers, including both government policies and health education and development programs. It is important to implement measures to be taken, including both government policies and health education and development programs, especially during the COVID-19 pandemic process we are in. In this study, the data set on the open-source access website was used for the prediction of obesity levels and consists of patient records of 17 variables created by the deep learning repository. In addition, the performance of deep learning methods in the prediction of obesity levels was examined and determined. Performance evaluation of models is compared in terms of accuracy, Fleiss's kappa, classification error, and absolute error.

1. INTRODUCTION

THE international incidence of obesity and weight problems has doubled because 1980 to an extent that virtually a third of the arena populace is now categorized as obese or chubby [4]. Weight problems adversely impact nearly all physiological functions of the physique and include a huge public health threat [5]. The World Health Organization (WHO) defines obese and obesity as irregular or immoderate fat accumulation that offers a hazard to wellness. Obesity occurs as a result of excessive fat storage in the body and brings along physical and mental problems [1]. The physical function has been associated with impaired quality of life in various areas such as distress in society, sexual function, self-esteem, and work-related quality of life [2]. The prevalence of obesity has been steadily increasing over the past few decades and is now unprecedented. This increase has occurred in almost all ages, genders, and races. These data show that the segments of individuals in the highest weight categories i.e. (BMI> 40 kg/ m2) increased proportionally more than those in the lower BMI categories (BMI <35 kg / m2) [3]. Given the numerous and important health consequences associated with obesity, there is an urgent need to develop highly effective interventions aimed at reversing these “obesogenic” drivers, including both government policies and health education and development programs. It is important to implement measures to be taken, including both government policies and health education and development programs, especially during the COVID-19 pandemic process we are in.

In this study, the data set on the open-source access website was used for the prediction of obesity levels and consists of patient records of 17 variables created by the deep learning repository. In addition, the performance of deep learning methods in the prediction of obesity levels was examined and determined. Performance evaluation of models is compared in terms of accuracy, Fleiss's kappa, classification error, and absolute error.

2. MATERIAL AND METHOD

1.1.2.1. Data Set

The dataset used for the analysis was obtained from https://archive.ics.uci.edu/ml/datasets[6]. The dataset includes data for estimating obesity levels in people between the ages of 14 and 61 years with various eating habits and physical conditions in Mexico, Peru, and Colombia countries

and consists of patient records of 17 variables. After all, the calculation was made to obtain the mass body index (BMI) for each individual, the results were compared with the data provided by WHO and the Mexican Normativity [6]. A detailed explanation of the variables is given in Table I.

TABLE 1
THE DETAIL EXPLANATION OF THE VARIABLES

Variables	*Explanation*
Obesity Level	Target (1:Insufficient Weight (BMI<18.5), 2:Normal Weight (18.5 to 24.9), 3:Overweight (25 to 29.9), 4:Obesity Type I (30 to 34.9), 5: Obesity Type II (35 to 39.9), 6: Obesity Type III (BMI>40)
Age	Age
Gender	Gender (1:male, 0:female)
Height	Height
Weight	Weight
History	Family History have overweight (1:Yes, 0: No)
FAVC	Eat High Caloric Food Frequently (1:Yes, 0: No)
FCVC	Frequency Eating Vegetables (1:Never, 2:Sometimes, 3:Always)
NCP	Number of main meals (Between 1 y 2, Three, More than three
CAEC	Consumption of food between meals (0:No, 1:Sometimes, 2:Frequently, 3:Always)
Smoke	Smoking (1:Yes, 0: No)
CH2O	Consumption of water daily (Less than a liter, between 1and 2 Lt, More than 2 Lt
SCC	The attributes related to the physical condition are: Calories consumption monitoring (1:Yes, 0: No)
FAF	Physical activity frequency (Not have, 1 or 2 days, 2 or 4 days, 4 or 5 days)
TUE	Time using technology devices (0-2 hours, 3-5 hours, More than 5 hours)
CALC	Consumption of alcohol (0:No, 1:Sometimes, 2:Frequently, 3:Always)
MTRANS	Transportation used (1:Automobile, 2:Motorbike, 3:Bike, 4: Public Transportation, 5:Walking)

2.2. Knowledge Discovery in Databases (KDD)

In the process of KDD; data selection (obesity dataset), data preprocessing (extreme and missing value analyses), data transformation (normalization, etc.), data mining and evaluation, and interpretation of the results were performed.

2.3. Deep Learning

Deep Learning can mechanically extract function representation from raw data, which is a new method of desktop finding out derived from artificial neural networks [7]. DL learns characteristic hierarchies with better hierarchy elements with a blend of low-degree aspects. Therefore, DL effectually solves problematic and extreme dimensional problems It's used. Convolutional Neural network (CNN) is one of the most positive deep studying units [8].

$$Z_{i,j,k}^{l} = w_k^{l^T} x_{i,j}^{l} + b_k^{l} \quad (1)$$

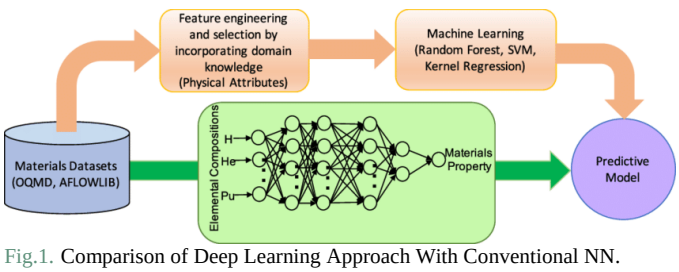

Fig.1. Comparison of Deep Learning Approach With Conventional NN.

The worth of the region of the layer l and its place within the *k* characteristic map (i, j),$Z_{i,j,k}^{l}$ can be estimated as shown in equation 1.

The place w_k^l and b_k^l are l^{th}, lth layers within the k property map are the weight vector and the bias. The activation value $a_{i,j,k}^l$ for the convolution feature $Z_{i,j,k}^l$ can be expressed, as shown in equation 2 [8].

$$a_{i,j,k}^{l} = a(Z_{i,j,k}^{l}) \quad (2)$$

Hyperparameters of the deep learning model are epsilon, rho, L1, L2, max w2, and dropout, which are tuned by using a grid search optimization algorithm.

2.5. Performance Metrics

Accuracy (AC) is outlined because the division of values incompatible eyes via the whole number of observations and is indicated via equation 3.

$$AC = \frac{TP+TN}{TP+TN+FN+FP} \quad (3)$$

Fleiss's kappa coefficient is a generalization of Scott's pi coefficient, which examines the problem of matching two valuers [9]. Similarly, it is related to Cohen's kappa coefficient [10]. However, while Scott's pi coefficient and Cohen's kappa coefficient require two valuers, Fleiss's kappa coefficient can be applied to any number of values greater than two. Just like them, it is expressed numerically between the values of 0 and 1 how much the match between a fixed number of values is not a matter of randomness and therefore how reliable it is [11].

Absolute Error is the amount of error in your measurements. It is the difference between the measured value and the "true" value [12].

3. RESULTS

3.1. Statistical Analysis

Quantitative data were summarized as the arithmetic means with standard deviation, median with min and max values, and qualitative data as numbers by percentage. After the suitability of the data to multiple normal distributions, the difference between the groups in normally distributed groups was examined by t-test in independent samples and the Kruskal Wallis H-test for variables that did not show normal distribution. When significant differences in categorical data were determined among the groups ($p<0.05$), pairwise comparisons were performed by the Bonferroni-adjusted Pearson chi-square test. Upon seeing significant differences ($p<0.001$) in the Kruskal Wallis H test, pairwise comparisons of the groups with significant differences were identified using the post-hoc Conover multiple comparison test. For statistical analysis, IBM SPSS version 22 [13], RStudio version 1.1.463 [14], and Rapid Miner Studio version 8.1.001 [15] were used.

1.2. 3.2. Data Mining

In this study, the performance of deep learning methods in the prediction of obesity levels was examined and determined. Performance evaluation of models is compared in

terms of accuracy, Fleiss's kappa, classification error, and absolute error.

1.3. 3.3. Model Development

The 10-fold cross-validation method was used in the performance evaluation of all classifier methods to verify the quality of the models. Cross-validation is the re-sampling procedure used to evaluate machine learning models in a data sample. The procedure has a single parameter named k that expresses the number of groups to split a given data sample. In 10-fold cross-validation, the models are trained and tested ten different times, and then, mean performance metrics (i.e., accuracy, precision, and so on) are estimated at the end of the process [16].

1.4. 3.4. Evaluation of the Models

Hyperparameters of the deep learning model were 1.0E-8 for epsilon, 0.99 for rho, 1.0E-5 for L1, 0.0 for L2, 10.0 for max w2, and 0.15 for dropout, respectively. Figure 2 depicts the pseudo-codes of CNN in the deep learning algorithm.

Algorithm 2 Training process of wCNN (wCNN=wCPNN+FCNN)

Input:
train_x, train_y, test_x and ***test_y*** are set same as the pseudocode of CNN
Output:
wc_{ij}^{l}, bc_{j}^{l}, ac_{j}^{l}: weights and bias of wCPNN ($l = 2, 4$, wCPNN have 5 layers)
w_{jk}, b_{k} : weights and bias of FCNN (FCNN have 2 layers)
Required parameters:
max_time and ***target_error*** are set same as the pseudocode of CNN
η_wCPNN,: learning rate of wCPNN
Initialization work:
t=1 and $loss(1) = 1$ are set same as the pseudocode of CNN
$wc_{ij}^{l}, ac_{j}^{l}, bc_{j}^{l}, w_{jk}, b_{k}$: weights and bias of wCNN are set as random number.
Begin:
1: Set the required parameters and complete the initialization work
2: **while** $t <$ ***max_time*** and $loss(t) >$ ***target_error***
3: **for all** *trainingSet*:
4: ***train_p*** (prediction of label) is calculated according to ***train_x*** and forward calculation formula 29-31 and 4-9.
5: **end for**
6: $loss(t)$ is re-calculated as $loss(t) = \frac{1}{2}\sum_{n=1}^{N}(train\_p(n) - train\_y(n))^2$, N is the total number of *trainingSet*.
7: $\Delta w_{ij}^{-1}, \Delta b_{j}^{-1}$ and Δw^{l} , Δac^{l} , Δbc^{l} are calculated according to the formula 22-23 and 34-36
8: $w_{ij}^{-1}(t), b_{j}^{-1}(t)$ and $w^{l}(t), ac^{l}(t), bc^{l}(t)$ are adjusted according to the formula 37-41
9: t++
10: **end while**
End

Fig.5. Pseudo Code of CNN

Which variable is more important in the deep learning algorithm is calculated and presented in table II.

TABLE II:
VARIABLE IMPORTANCE OF DEEP LEARNING

Variable	Relative İmportance
Weight	0.75
FCVC	0.36
Gender	0.29
Family His.	0.21
Age	0.21
CAEC	0.18
NCP	0.14
FAF	0.11
CALC	0.10
Height	0.10
TUE	0.10
FAVC	0.08
CH2O	0.07
MTRANS	0.07
SCC	0.04
SMOKE	0.01

Table II and figure 2. tabulates the importance levels of variables in obesity levels in the deep learning modeling. Weight (0.75), FCVC (0.36), Gender (0.29), Family His. (0.21), Age (0.21), and CAEC (0.18) were calculated from deep learning. In comparison, the lowest relative significance was estimated for Smoke (0.01) from deep learning.

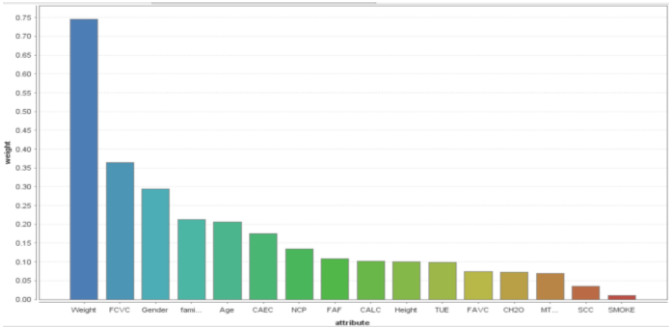

Fig.2. Variable Importance of Deep Learning

1.5. 3.5. General Assessment

According to the general assessment, the deep learning method provided the 0.82 accuracy value, 0.78 Kappa value, 0.18 classification error value, and 0.28 absolute error value. The performance metrics of the deep learning method presented in Table 3.

TABLE 3
MODEL PERFORMANCE METRICS

	Accuracy (%)	F.Kappa (%)	Clas.Error (%)	A. Error (%)
Deep Learning	**82.0**	**0.78**	**18.0**	**28.1**

Figure 3. shows that in the classification process performed with deep learning approaches the correct positive, and negative rates in the deep learning algorithm, according to the confusion matrix.

	true 2	true 3	true 4	true 1	true 5	true 6	class preci
pred. 2	116	39	0	5	0	0	72.50%
pred. 3	30	466	40	0	3	0	86.46%
pred. 4	0	67	270	0	9	2	77.59%
pred. 1	141	7	0	267	0	0	64.34%
pred. 5	0	1	40	0	285	1	87.16%
pred. 6	0	0	1	0	0	321	99.69%
class recall	40.42%	80.34%	76.92%	98.16%	95.96%	99.07%	

Fig.3. Confusion Matrix for the Model

4. CONCLUSION

Obesity is increasing all over the world due to urbanization, economic development, and lifestyle changes and is considered an epidemic health problem. In addition to the life-threatening diseases it has caused, it is understood how serious a public health problem it is when the negative effects of obesity on COVID 19 are seen in these extraordinary days that our world is going through. Individuals with asthma, chronic lung disease, diabetes, heart, and chronic kidney disease are at higher risk for COVID 19. Obesity plays a key role in the development of these chronic diseases (diabetes, heart diseases, asthma, etc.). These features of obesity suggest that it is one of the important factors for the increased risk of death in COVID-19 patients. In this study, using methods based on deep learning, eating habits and physical condition values and obesity levels were tried to be accurately predicted and the most important variables affecting the obesity risk level were determined. In the next period, studies on the

relationship between obesity and COVID 19 in terms of risk factors are recommended.

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REFERENCES

[1] Deniz, S., Şirin, H., Kıvrak, M., Kaplan, Z., Ketrez, G., & Üner, S. (2020). Factors associated with overweight and obesity in students of 5-14 age group in Mersin. Gülhane Tip Dergisi, 62(4), 245.

[2] Fontaine, K. R., Bartlett, S. J., & Barofsky, I. (2000). Health-related quality of life among obese persons seeking and not currently seeking treatment. International Journal of Eating Disorders, 27(1), 101-105.

[3] Wright, S. M., & Aronne, L. J. (2012). Causes of obesity. Abdominal Radiology, 37(5), 730-732.

[4] Global Burden of Disease Collaborative Network. (2017). Global Burden of Disease Study 2015 (GBD 2015) Obesity and Overweight Prevalence 1980-2015.

[5] Singh, G. M., Danaei, G., Farzadfar, F., Stevens, G. A., Woodward, M., Wormser, D., ... & Prospective Studies Collaboration (PSC). (2013). The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. PloS one, 8(7), e65174.

[6] Palechor, F. M., & de la Hoz Manotas, A. (2019). Dataset for estimation of obesity levels based on eating habits and physical condition in individuals from Colombia, Peru and Mexico. Data in brief, 25, 104344.

[7] Li, Y., Nie, X., & Huang, R. (2018). Web spam classification method based on deep belief networks. Expert Systems with Applications, 96, 261-270.

[8] Gu, J., Wang, Z., Kuen, J., Ma, L., Shahroudy, A., Shuai, B., ... & Chen, T. (2018). Recent advances in convolutional neural networks. Pattern Recognition, 77, 354-377.

[9] Scott, W. A. (1955). Reliability of content analysis: The case of nominal scale coding. Public opinion quarterly, 321-325.

[10] Cohen, J. (1960). A coefficient of agreement for nominal scales. Educational and psychological measurement, 20(1), 37-46.

[11] Fleiss, J. L. (1971). Measuring nominal scale agreement among many raters. Psychological bulletin, 76(5), 378.

[12] Findley, D. F., Kotz, S., Read, C. B., Balakrishnan, N., Vidakovic, B., & Johnson, N. L. (2006). Encyclopedia of Statistical Sciences.

[13] Yaşar, Ş., Arslan, A., Colak, C., & Yoloğlu, S. (2020). A Developed Interactive Web Application for Statistical Analysis: Statistical Analysis Software. Middle Black Sea Journal of Health Science, 6(2), 227-239.

[14] Campbell, M. (2019). RStudio Projects. In Learn RStudio IDE (pp. 39-48). Apress, Berkeley, CA.

[15] Hofmann, M., & Klinkenberg, R. (Eds.). (2016). RapidMiner: Data mining use cases and business analytics applications. CRC Press.

[16] Yadav, S., & Shukla, S. (2016, February). Analysis of k-fold cross-validation over hold-out validation on colossal datasets for quality classification. In 2016 IEEE 6th International conference on advanced computing (IACC) (pp. 78-83). IEEE.

BIOGRAPHIES

Mehmet Kıvrak obtained his BSc degree in statistics from Dokuz Eylul University (DEU) in 2001. He received the BSc. and MSc. diploma in Statistics from Dokuz Eylul University in 2001 and 2006 respectively, and Ph.D. degrees in the Graduate Department of Biostatistics and Medical Informatics of Inonu University in 2017. He was accepted as an expert statisticianTurkish Statistical Institute in 2009. His research interests are data mining, cognitive systems, reliability and genetics and bioengineering, and signal processing. His current research interests are genetics and bioengineering and data mining.

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Modeling of Telecommunication Revenue as a Percentage of Gross Domestic Product's for Countries with Fractional Calculus

N. Ozge Onal Tugrul, Esra Ergun, D. Can Koseoğlu, Kamil Karacuha, Kevser Simsek, Ertugrul Karacuha

Istanbul Technical University, Informatics Institute, Istanbul, Turkey. (e-mail: {onal16, ergunesr, koseoglu20, karacuha17, simsek18, karacuhae}@itu.edu.tr.

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Corresponding author: Nisa Ozge Onal Tugrul
✉ onal16@itu.edu.tr
☎ +90 212 2857391

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ABSTRACT

This study explores the modeling of the share of telecommunication revenues in gross domestic product from the year 2000 to 2018 for 5 countries including France, Germany, Italy, Turkey, the UK, and the OECD average. First, a new mathematical model based on Fractional Calculus and Least Square Method is proposed. Later, the telecommunication revenues in GDP dataset is modeled. Further, we compare the new Fractional approach to the classical Polynomial approach in three different settings. The results show that employing Fractional Calculus yields better modeling performance when compared to the classical Polynomial Approach in terms of Mean Absolute Percentage Error (MAPE). The Fractional approach outperforms the Polynomial approach by 0.1329 % MAPE on average. The largest MAPE is found for Turkey while the smallest MAPE is obtained for Italy in all settings.

1. INTRODUCTION

TELECOMMUNICATIONS can be defined as the exchange of any signals such as written messages, images, icons, sounds, or information by utilizing various media such as wire, radio, optical, or other electromagnetic systems [1, 2]. Early days of communication consist of visual and audial signals such as horns, drums, signal flakes, smoke signals. In 20th and 21th centuries, long-distance communication technologies evolved with the help of inventions such as the telegraph, the telephone, the radio, network, antenna systems, optical fiber, and communication satellites. In parallel, the demand for data exchange increased too. Therefore, understanding the changes of this demand and communication need in specific intervals are important and crucial for scientists, companies, and states for modeling and analyzing the pattern of progress.

In the last several decades, telecommunication need is increased drastically with the help of advancing technology. Communication systems used previously cannot support the state of the art technologies. Increasing data sizes and the need for reaching more than one user at a time leads to make progress. This progress has its advantages and disadvantages. One advantage is, communication quality and comfort have increased and the desired data can be accessed in a short time. The disadvantage is, legacy systems needs to be replaced by new technological tools which increases the cost for investors. These innovations or technology replacements affect firms and therefore the income of the countries. The expenses and revenues of the systems that have changed over the years constitute an important share of the countries' economy.

Previously, the "Marginal Revolution" and "Keynesian revolution" offered fundamental economic methods. Regarding these, the concepts of "marginal value", "economic multiplier", "economic accelerator", "elasticity" were studied [3-5]. These revolutions prompted the researchers, companies, and institutes to employ mathematical tools such as derivatives and integrals in modeling each specific case for their problem. Then, the economic models were understood and tested very easily with these equations including the differential, integral, or difference equations [3].

Integer-order derivatives and integrals are well-known and studied for centuries by researchers [3–8]. Fractional Calculus is the theory of non-integer or complex-valued derivatives and integrals [9–20]. The applications of such mathematical tools in practical and engineering problems are relatively new [3-11]. The fractional approach has the flexibility, hereditary, and dynamicity and therefore it can be applied to areas such as mathematical economics, management, and finance [3, 7, 12]. The main goals, notions, effects, and objectives of mathematical economics can be generalized, widen, and improved by including such new approaches [3].

In this study, we propose a new mathematical model based on Fractional Calculus and model the telecommunication revenue as a percentage of GDP for 5 countries including France, Germany, Italy, Turkey, the UK, and the OECD average. We name this new approach as Fractional Model-2. Later, we assess the performance of the newly proposed approach with the help of conventional Polynomial model and compare these two models.

The structure of this study is as follows. Section 2 provides the foundations of the employed fractional model. Then, in Section 3, Dataset and Performance Metrics are presented. Later, Section 4 reports the experimental results and lastly, the conclusion is given in Section 5.

2. MATHEMATICAL MODEL

The main motivation is to model the given discrete dataset and obtained a continuous curve representing the dataset with the minimum error. To achieve this goal, the Taylor expansion is employed at the first stage of the mathematical manipulations [18-21].

An arbitrarily chosen, continuous and analytical function $g(x)$ can be expanded as

An arbitrarily chosen, continuous and analytical function $g(x)$ can be expanded as

$$g(x) = \sum_{n=0}^{\infty} \tilde{a}_n \, x^{n+\alpha} \tag{1}$$

Then, the first derivative of the function with respect to x becomes $g'(x) = \sum_{n=0}^{\infty} \tilde{a}_n (n+\alpha)\, x^{n+\alpha-1}$. From (1), we would like to mimic the same approach for the function $f(x)$ which stands for the income of the telecommunication sector in years. Note that, in this case, x corresponds to years. To have a better modeling approach utilizing the non-locality and heredity properties of fractional calculus, the fractional derivative of $f(x)$ is expressed as Equation (2).

$$\frac{d^{\alpha} f(x)}{dx^{\alpha}} = \sum_{n=0}^{\infty} a_n (n+\alpha) x^{n+\alpha-1} \tag{2}$$

Here, α is the fractional-order and ranges from [0,1] [21]. The main motive is to find $f(0)$, a_n, and α representing $f(x)$ with minimum error. Before, going into details, it is better to define the fractional derivative. Caputo's definition of the fractional derivative is provided below [14, 18, 22].

$$\mathfrak{D}_x^{\alpha} f(x) = \frac{d^{\alpha} f(x)}{dx^{\alpha}} = \frac{1}{\Gamma(1-\alpha)} \int_{-\infty}^{x} \frac{f'(t)}{(x-t)^{\alpha}} dt \tag{3}$$

where fractional derivative $\mathfrak{D}_x^{\alpha}$ states that the derivative is taken with respect to x in the order of α ($\alpha \in [0,1]$), and f' stands for the first derivative.

Note that, $\Gamma(1-\alpha)$ is called Gamma function and given as Equation (4)

$$\Gamma(1-\alpha) = \int_{0}^{\infty} t^{-\alpha} e^{-t} dt \tag{4}$$

By generalizing the derivative operator, more flexible and fast converging modeling becomes possible.

To solve the fractional-order differential equation given in Equation (2), the Laplace Transform is taken and the differential equation is converted into an algebraic equation. In Equation (5) and Equation (6), two properties of Laplace Transform ($\mathcal{L}$) are listed [6, 19, 22].

$$x^{\alpha} \xrightarrow{\mathcal{L}} \frac{\Gamma(\alpha+1)}{s^{\alpha+1}} \tag{5}$$

$$\mathcal{L}\frac{d^{\alpha} f}{dx^{\alpha}} = \xrightarrow{\mathcal{L}} s^{\alpha} F(s) - s^{\alpha-1} f(0) \tag{6}$$

Note that, $F(s)$ is the Laplace Transform of $f(x)$. The properties are employed in Equation (2) and the following procedure is tracked.

$$\mathcal{L}\frac{d^{\alpha} y}{dx^{\alpha}} = \mathcal{L} \sum_{n=0}^{\infty} a_n (n+\alpha) x^{n+\alpha-1}$$

$$s^{\alpha} F(s) - s^{\alpha-1} f(0) = \sum_{n=0}^{\infty} a_n (n+\alpha) \frac{\Gamma(n+\alpha)}{s^{n+\alpha}} \Gamma(n+\alpha+1)$$

$$F(s) = s^{-1} f(0) + \sum_{n=0}^{\infty} a_n \frac{\Gamma(n+\alpha+1)}{s^{n+2\alpha}} \tag{7}$$

After obtaining the algebraic equation for $F(s)$ as given in Equation (7), the inverse Laplace Transform ($\mathcal{L}^{-1}$) is employed to obtain $f(x)$ which is provided in Equation (8).

$$f(x) = f(0) + \sum_{n=0}^{\infty} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x^{n+2\alpha-1} \tag{8}$$

For the numerical calculation, the infinite sum is truncated to N and approximate value of $f(x)$ is given in (9).

$$f(x) \cong f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x^{n+2\alpha-1} \tag{9}$$

At this point, theoretically, $f(x)$ function is achieved. To obtain the unknowns $f(0)$, a_n, and α, the discrete dataset is employed and then, by error minimization, continuous $f(x)$ function representing that specific dataset would be acquired. The dataset consists of Telecommunication GDP income per year. Here, telecommunication GDP income was defined as P_i and x_i represents the telecommunication income in years as expressed below.

$$P_i = [\ p_0\ p_1 \dots\ p_{K-1}]$$
$$x_i = [\ x_0\ x_1 \dots\ x_{K-1}]$$

Note that K values exist. At this point, function $f(x_i)$ will be the expected value for x_i^{th} year. According to the least square

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method ϵ_i, which is defined as the error between p_i and $f(x_i)$ values, is shown as follows.

$$(\epsilon_i)^2 = \left(p_i - f(x_i)\right)^2 \tag{10}$$

The total square of the error is defined as Equation (11) and according to the least-squares method, the sum of error squares ϵ_T^2 is tried to be minimized [18-20].

$$\epsilon_T^2 = \epsilon_0^2 + \epsilon_1^2 + \epsilon_2^2 + \cdots \epsilon_{K-1}^2 = \sum_{i=0}^{K-1} \epsilon_i^2 \tag{11}$$

For the sake of simplicity, the square of error for each point in the dataset can be obtained as follows:

$$(\epsilon_0)^2 = \left[p_0 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} {x_0}^{n+2\alpha-1}\right\}\right]^2$$

$$(\epsilon_1)^2 = \left[p_1 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} {x_1}^{n+2\alpha-1}\right\}\right]^2$$

$$\cdots$$

$$\epsilon_i^2 = \sum_{i=0}^{K-1}\left[p_i - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} {x_i}^{n+2\alpha-1}\right\}\right]^2$$

$$(\epsilon_{K-1})^2 = \left[p_{K-1} - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} {x_{K-1}}^{n+2\alpha-1}\right\}\right]^2 \tag{12}$$

For minimizing the total error given in Equation (11), the Least Squares Method is employed as given in (13) [18, 21]:

$$\frac{\partial \epsilon_T^2}{\partial f(0)} = 0, \quad \frac{\partial \epsilon_T^2}{\partial a_0} = 0, \quad \frac{\partial \epsilon_T^2}{\partial a_1} = 0, \quad \frac{\partial \epsilon_T^2}{\partial a_2} = 0, \quad \frac{\partial \epsilon_T^2}{\partial a_N} = 0 \tag{13}$$

Implementing Equation (13) leads to having $N+2$ equations and also Equation (9) has the same number of unknowns. Therefore, this problem can be solved. The Least Squares method leads to having a System of Linear algebraic equations (SLAE). Several specific derivative operations in Equation (13) are given below for the readers.

First example:

$$\frac{\partial \epsilon_T^2}{\partial f(0)} = -2\left[p_0 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_0^{n+2\alpha-1}\right\}\right]$$

$$-2\left[p_1 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_1^{n+2\alpha-1}\right\}\right]$$

$$-2\left[p_2 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_2^{n+2\alpha-1}\right\}\right]$$

$$\cdots$$

$$-2\left[p_{K-1} - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_{K-1}^{n+2\alpha-1}\right\}\right] = 0$$

Then, the procedure above can be written in the compact form as Equation (14):

$$\frac{\partial \epsilon_T^2}{\partial f(0)} = \sum_{i=0}^{K} p_i - \left[(K+1)f(0) + a_0 \frac{\Gamma(\alpha+1)}{\Gamma(2\alpha)} \sum_{i=0}^{K} x_i^{2\alpha-1} + a_1 \frac{\Gamma(\alpha+2)}{\Gamma(2\alpha+1)} \sum_{i=0}^{K} x_i^{2\alpha} + \cdots + a_N \frac{\Gamma(N+\alpha+1)}{\Gamma(N+2\alpha)} \sum_{i=0}^{K-1} x_N^{N+2\alpha-1}\right] = 0 \tag{14}$$

Second Example:

$$\frac{\partial \epsilon_T^2}{\partial a_N} = -2\left[p_0 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_0^{n+2\alpha-1}\right\}\right] x_0^{N+2\alpha-1} - 2\left[p_1 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_1^{n+2\alpha-1}\right\}\right] x_1^{N+2\alpha-1} - 2\left[p_2 - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_2^{n+2\alpha-1}\right\}\right] x_2^{N+2\alpha-1}$$

$$\cdots$$

$$-2\left[p_{K-1} - \left\{f(0) + \sum_{n=0}^{N} a_n \frac{\Gamma(n+\alpha+1)}{\Gamma(n+2\alpha)} x_{K-1}^{n+2\alpha-1}\right\}\right] x_{K-1}^{N+2\alpha-1} = 0 \tag{15}$$

Then, the procedure above can be summarized in the compact form as Equation (15):

$$\frac{\partial \epsilon_T^2}{\partial a_N} = \left[\sum_{i=0}^{K} p_i x_i^{N+2\alpha-1}\right] - \left[f(0)\sum_{i=0}^{K} x_i^{N+2\alpha-1} + a_0 \frac{\Gamma(\alpha+1)}{\Gamma(2\alpha)} \sum_{i=0}^{K} x_i^{4\alpha+N-2} + a_1 \frac{\Gamma(\alpha+2)}{\Gamma(2\alpha+1)} \sum_{i=0}^{K} x_i^{4\alpha+N-1} + \cdots + a_N \frac{\Gamma(N+\alpha+1)}{\Gamma(N+2\alpha)} \sum_{i=0}^{K} x_i^{4\alpha+2N-2}\right] = 0$$

The procedure is repeated for all cases in Equation (13). Then, the following SLAE is achieved.

$$[A]_{N+2xN+2}[\Omega]_{N+2x1} = [B]_{N+2x1} \tag{16}$$

Here,

$$A = \begin{bmatrix} K+1 & \sum_{i=1}^{k} c_0(x_i) & \sum_{i=1}^{k} c_1(x_i) & \cdots & \sum_{i=1}^{k} c_N(x_i) \\ \sum c_0(x_i) & \sum c_0(x_i)c_0(x_i) & \sum c_0(x_i)c_1(x_i) & \cdots & \sum c_0(x_i)c_N(x_i) \\ \sum c_1(x_i) & \sum c_1(x_i)c_0(x_i) & \sum c_1(x_i)c_1(x_i) & \cdots & \sum c_1(x_i)c_N(x_i) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \sum c_m(x_i) & \sum c_m(x_i)c_0(x_i) & \sum c_m(x_i)c_1(x_i) & \cdots & \sum_{i=1}^{k} c_m(x_i)c_N(x_i) \end{bmatrix}$$

$$[\Omega] = [f(0) \quad a_0 \quad a_1 \quad \cdots \quad a_N]^T$$

$$[\mathrm{B}] = \left[\sum_{i=0}^{K} P_i \quad \sum_{i=0}^{K} P_i c_0(x_i) \quad \sum_{i=0}^{K} P_i c_1(x_i) \quad \cdots \quad \sum_{i=0}^{K} P_i c_N(x_i)\right]^T$$

where,

$$c_m(x,\alpha) = \frac{\Gamma(m+\alpha+1)}{\Gamma(m+2\alpha)} x^{m+2\alpha-1}$$

Here, $m = 1,2,\dots N$

The vector Ω consist of unknowns $(f(0), a_n)$. By inversion of $[A]$, Ω vector can be obtained. Then, Equation (9) allows one to obtain $f(x)$ which represents the discrete dataset with minimum error. The optimum value of α is found by implementing a grid search. Note that, when the fractional order α is equal to one, the fractional approach is equal to the polynomial method.

3. DATASET AND PERFORMANCE METRICS

In this study, we model the telecommunication revenues as a percentage of GDP for countries and compare them from the year 2000 to 2018. The dataset of the telecommunication revenues for each country is extracted from OECD [24]. The dataset is reported in Figure 1 and Table A.1 of the Appendix for five countries (France, Germany, Italy, Turkey, and UK) and the average of the OECD members.

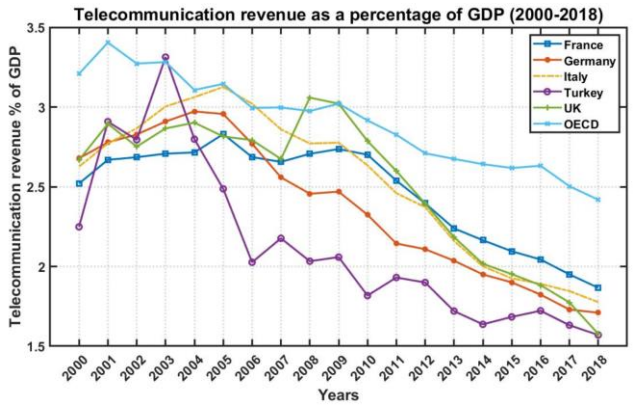

Fig.1. Telecommunication revenues as a percentage of GDP of the countries.

It is important to know that these selected countries are comparable and similar regarding the population, the number of subscribers, technological infrastructure. However, as expected, there are also differences among the selected countries such as the percentage of young people or adults over the total population which can affect the revenue of the telecommunication sector and total economical size of the country. Nevertheless, a key point in the present study is how the telecommunication share affects the countries economy.
All the results reported in tables are in terms of Mean Absolute Percentage Error (MAPE). The MAPE is calculated as in (19).

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{P(i)-f(x_i)}{P(i)}\right| \times 100 \qquad (19)$$

The average error in all percentiles is calculated by the formula in (20).

$$AMAPE = \frac{\sum MAPE}{M} \qquad (20)$$

4. EXPERIMENTAL RESULTS

This section will provide modeling results of Fractional and Polynomial methods with three different modeling settings. Each set has a different exponent value. Table 1 illustrates the modeling results of three N's for both fractional and polynomial models. When $N = 5$, the performance of the fractional approach outperforms the polynomial approach by 0.3152 % MAPE where the first model yields 2.2909 % and the latter yields 2.6061 % AMAPE.

When the exponent is 8, the fractional approach produces %1.7202 AMAPE where the polynomial approach yields 1.7861% AMAPE. Lastly, when the exponent is equal to 10, the fractional approach results in 1.7031% MAPE while the polynomial method results in 1.7208% AMAPE.

TABLE I
MODELING RESULTS OF THE TELECOMMUNICATION REVENUE AS A PERCENTAGE OF GDP (2000-2018).

N value	Models	Results	France	Germany	Italy	Turkey	UK	OECD
N=5	Fract.	MAPE	1.69	1.59	1.33	4.12	3.59	1.40
	Model	α	0.97	1	0.50	0.50	0.95	0.50
	Pol. Model	MAPE	1.70	1.59	1.44	5.80	3.61	1.50
N=8	Fract.	MAPE	1.16	1.23	1.05	3.71	2.13	1.01
	Model	α	0.50	0.50	0.92	0.50	0.50	1
	Pol. Model	MAPE	1.25	1.28	1.07	3.88	2.22	1.02
N=10	Fract.	MAPE	0.76	0.89	0.59	3.24	1.59	0.67
	Model	α	0.50	0.82	1	0.96	0.50	0.50
	Pol. Model	MAPE	0.82	0.93	0.60	3.25	1.94	0.80

For all three settings, the Fractional approach outperforms the polynomial approach. Also, for all exponent values, the largest MAPE is observed in Turkey and the smallest is observed for Italy. As expected, increasing the exponent value decreases the error rate.

The largest MAPE difference between the two models is observed when $N = 5$. Note that, when the fractional order α is equal to one, the fractional approach is equal to the polynomial approach. For Germany where $N = 5$, for OECD average where $N = 8$, and lastly for Italy where $N = 10$, the optimized fractional order is found as 1. In these three cases, the MAPE results of the two models are equal as reported in Table 1.

Figures 2, 3, and 4 illustrate the actual and the modeled data curves for both Fractional Model and Polynomial Model. In most cases, Fractional and Polynomial modeled curves are similar to each other. The biggest difference is observed for Turkey in Figure 2. As seen from the plot, the fractional model fits the data better. This is consistent with the MAPE results reported in Table 1. It can be seen from Figure 1, the Polynomial and Fractional Models produce similar results. Numerically, Italy has the highest revenue USD in millions among the others.
From the figures, one can see that Italy has the highest telecommunication revenue percentage while Turkey has the lowest revenue percentage among others in 2000. Germany started with 2.6 percent telecommunication revenue and decreased to 1.7%. Initially, Italy had 2.6% revenue in 2000 and decreased to around 1.77%. France started with 2.5% revenue and ended up at 1.8%. Turkey started with 2.24% revenue and decreased to 1.57%. As seen from the figure, the telecommunication revenue % of GDP decreased for all

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modeled countries and OECD average. The largest difference in percentage from 2000 to 2018 is observed for the UK. Also, Italy's trend is smoother compared to the others.

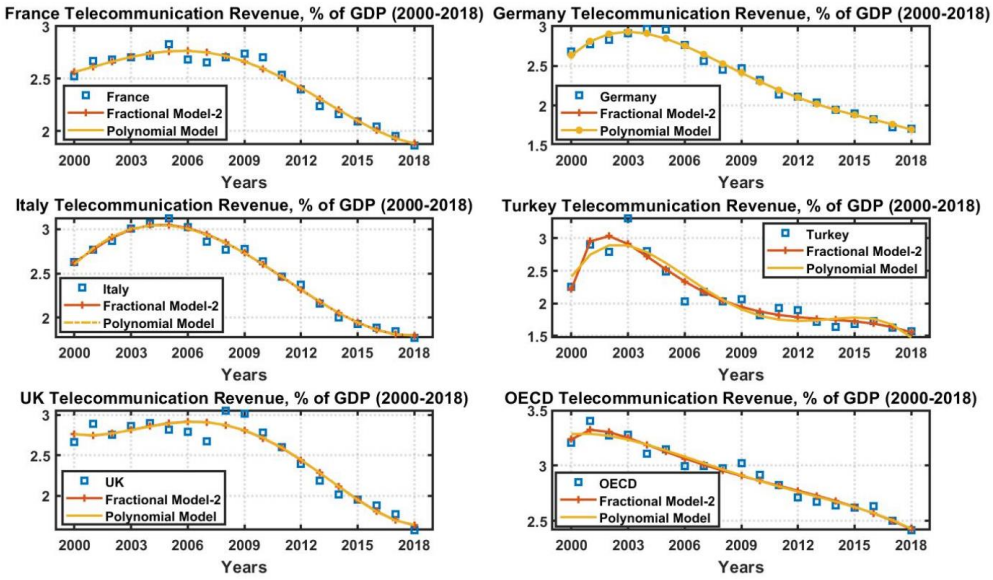

Fig. 2. Modeling of the countries using the Fractional model for $N = 5$.

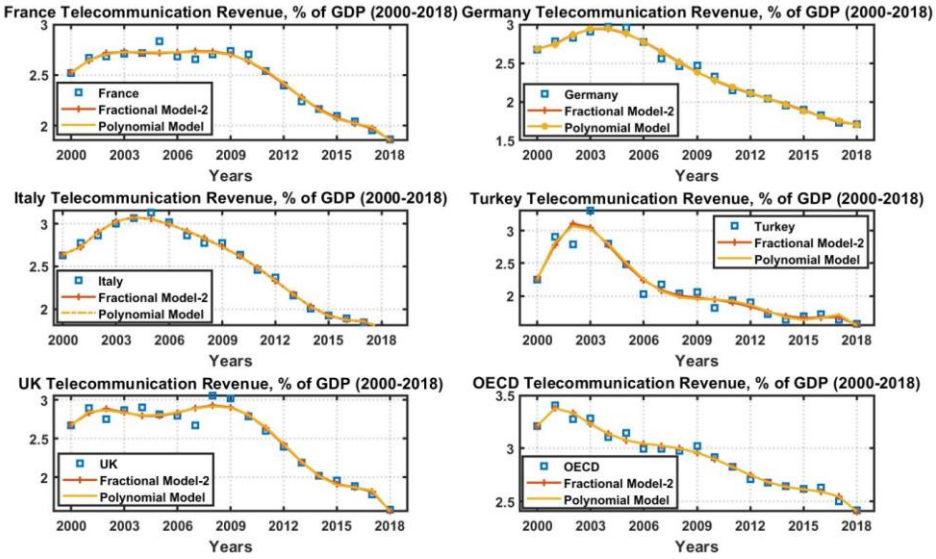

Fig. 3. Modeling of the countries using the Fractional model for $N = 8$.

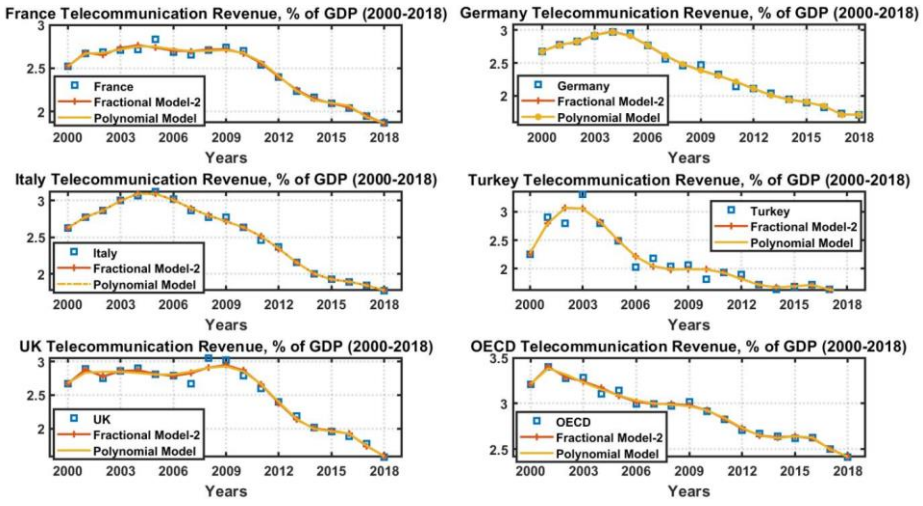

Fig. 4. Modeling of the countries using the Fractional model for $N = 10$.

5. CONCLUSIONS

In this study, we employed Fractional Calculus to model the telecommunications revenue as a percentage of the Gross Domestic Product of 5 countries (France, Germany, Italy, Turkey, and the UK) and OECD average. First, we proposed a new Fractional mathematical model that employs Least Square Methods named Fractional Model-2. Later, we compared the performances of the Fractional Model-2 and the Polynomial model. Results are reported for three experimental settings with three different exponent *N* values (5, 8, 10). As expected, increasing the exponent value decreased the error rate for both models. For all three settings, Fractional Approach resulted in better performance compared to the Polynomial Approach. The largest modeling error is obtained for Turkey while the smallest modeling error is observed in Italy. On average, the Fractional approach is superior to the Polynomial approach with 0.1329% MAPE.

APPENDIX

TABLE A.I
TELECOMMUNICATION REVENUE AS A PERCENTAGE OF GDP (2000-2018).

Years	France	Germany	Italy	Turkey	UK	OECD members
2000	2.520	2.678	2.626	2.249	2.668	3.209
2001	2.669	2.779	2.772	2.908	2.894	3.404
2002	2.685	2.828	2.866	2.794	2.752	3.272
2003	2.707	2.909	3.004	3.313	2.866	3.282
2004	2.715	2.972	3.062	2.798	2.902	3.106
2005	2.830	2.956	3.126	2.487	2.815	3.145
2006	2.686	2.770	3.020	2.026	2.792	2.995
2007	2.656	2.559	2.8597	2.1767	2.675	2.997
2008	2.707	2.456	2.771	2.033	3.059	2.974
2009	2.736	2.469	2.776	2.059	3.021	3.021
2010	2.701	2.324	2.634	1.817	2.787	2.916
2011	2.538	2.144	2.459	1.931	2.599	2.826
2012	2.396	2.108	2.372	1.899	2.394	2.710
2013	2.239	2.036	2.160	1.720	2.184	2.674
2014	2.165	1.950	2.001	1.637	2.017	2.642
2015	2.095	1.900	1.925	1.684	1.952	2.617
2016	2.043	1.823	1.891	1.722	1.883	2.631
2017	1.950	1.730	1.845	1.631	1.774	2.503
2018	1.866	1.710	1.776	1.570	1.577	2.418

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REFERENCES

[1] Regulations, R. International Telecommunication Union Std., November 2012. Online Available: http://www. itu. int/pub. RREG-RR/en. (accessed 7 June 2020).
[2] ITU. Constitution and Convention of the International Telecommunication Union. Online Available: http://handle.itu.int/11.1004/020.2000/s.020, (accessed 9 June 2020).
[3] Tarasov, V. E. (2019). On history of mathematical economics: Application of fractional calculus. *Mathematics*, *7*(6), 509.
[4] Schumpeter, J. A., & Joseph, A. (1908). The Nature and Essence of Theoretical Economics.
[5] Hayes, M. (2008). *The Economics of Keynes: A new guide to the General Theory*. Edward Elgar Publishing.
[6] Samko, S. G., Kilbas, A. A., & Marichev, O. I. (1993). Fractional Integrals and Derivatives-Theory and Applications Gordon and Breach. Linghorne, PA.
[7] Kiryakova, V. (1994). Generalized fractional calculus and applications longman (pitman res. notes in math. ser. 301).
[8] Podlubny, I. (1998). Fractional differential equations: an introduction to fractional derivatives, fractional differential equations, to methods of their solution and some of their applications. Elsevier.
[9] Kilbas, A. A., Srivastava, H. M., & Trujillo, J. J. (2006). Theory and applications of fractional differential equations (Vol. 204). elsevier.
[10] Diethelm, K. (2010). The analysis of fractional differential equations: An application-oriented exposition using differential operators of Caputo type. Springer Science & Business Media.
[11] Letnikov, A. V. (1868). On the historical development of the theory of differentiation with arbitrary index. Sbornik Mathematics (Matematicheskii Sbornik), 3(2), 85-112.
[12] Ross, B. (1975). A brief history and exposition of the fundamental theory of fractional calculus. In Fractional calculus and its applications (pp. 1-36). Springer, Berlin, Heidelberg.
[13] Ross, B. (1977). The development of fractional calculus 1695–1900. Historia Mathematica, 4(1), 75-89.
[14] Ross, B. (1977). Fractional calculus. Mathematics Magazine, 50(3), 115-122.
[15] Kiryakova, V. (2008). A brief story about the operators of the generalized fractional calculus. Fractional Calculus and Applied Analysis, 11(2), 203p-220p.
[16] Machado, J. T., Kiryakova, V., & Mainardi, F. (2011). Recent history of fractional calculus. Communications in nonlinear science and numerical simulation, 16(3), 1140-1153.
[17] Machado, J. T., Galhano, A., & Trujillo, J. (2013). Science metrics on fractional calculus development since 1966. Fractional Calculus and Applied Analysis, 16(2), 479-500.
[18] Önal, N. Ö., Karaçuha, K., Erdinç, G. H., Karaçuha, B. B., & Karaçuha, E. (2019). A mathematical approach with fractional calculus for the modelling of children's physical development. Computational and mathematical methods in medicine, 2019.
[19] Karaçuha, E., Önal, N. Ö., Ergün, E., Tabatadze, V., Alkaş, H., Karaçuha, K., ... & Nu, N. V. N. (2020). Modeling and Prediction of the Covid-19 Cases With Deep Assessment Methodology and Fractional Calculus. *Ieee Access*, *8*, 164012-164034.
[20] Karaçuha, E., Tabatadze, V., Karacuha, K., Önal, N. Ö., & Ergün, E. (2020). Deep assessment methodology using fractional calculus on mathematical modeling and prediction of gross domestic product per capita of countries. *Mathematics*, *8*(4), 633.
[21] Herrmann, R. (2011). *Fractional calculus: an introduction for physicists*.
[22] OECD Key ICT Indicators. Telecommunication Revenue, Online Available: oecd.org/internet/broadband/oecdkeyictindicators.htm (accessed 25 Feb 2020).
[23] Worldbank World Development Indicators. GDP (current US$). Online Available: https://databank.worldbank.org/source/world-development-indicators (accessed 25 Feb 2020).
[24] De Myttenaere, A., Golden, B., Le Grand, B., & Rossi, F. (2016). Mean absolute percentage error for regression models. *Neurocomputing*, *192*, 38-48.

BIOGRAPHIES

Nisa Ozge Onal Tugrul graduated from the School of Business at Istanbul University in 2016. She completed her M.Sc. degree Department of Applied Informatics from Istanbul Technical University in 2018. She is a research assistant and Ph.D. candidate at Istanbul Technical University in Turkey. Her research area is computational and applied mathematics.

Esra Ergun received the bachelor's and the master's degrees in Electronics and Communications Engineering and Computer Science departments from Istanbul Technical University, in 2017 and 2020, respectively. She is currently pursuing a Ph.D. degree in Computer Science. She is also a Research Assistant with Istanbul Technical University. Her research interests include continual learning, representation learning, and domain adaptation for deep neural networks.

Deniz Can Koseoglu was born in Hatay, Turkey, in 1997. He received the B.Sc. degree from Electronics and Communications Engineering, Kocaeli University, Kocaeli, in 2019. He is currently a VOIP engineer

in VTEL Communications and a Master's student at Istanbul Technical University.

Kamil Karacuha was born in Istanbul, Turkey, in 1993. He got his B.Sc. and double major degrees from Electrical & Electronics and physics departments of the Middle East Technical University (Ankara) in 2017, 2018, respectively. He is working on Electromagnetic Theory, Scattering and Diffraction Problems in Electromagnetics, Antenna design, and mathematical modeling. Currently, he is a research assistant at Istanbul Technical University.

Kevser Simsek received a bachelor's degree in electronics and communications engineering from Sakarya University, in 2005. She received the M.Sc. degree from the Department of Electrical Engineering, New York University, USA, in 2010. Now, she is currently pursuing a Ph.D. degree with the Department of Applied Informatics, Informatics Institute, Istanbul Technical University. She is also working as senior data analyst at Turkish Airlines Inc. Her research interests include data analytics, machine learning, and domain adaptation for deep neural networks.

Ertugrul Karacuha was graduated from Electronics and Telecommunication Engineering department of Istanbul Technical University in 1986. He received his master's and doctorate degrees from Istanbul Technical University, Çukurova University, and Istanbul University in 1990, 1992, 1993, and 1996 respectively. From 1988-1989, He worked as a research & development engineer in Teletaş, between 1989 and 1996 worked as a research assistant in Istanbul Technical University. From 1994 to 2001, Karaçuha was an assistant professor at Gebze Advanced Technology Institute. Between 2002 and 2013, he was the head of tariffs department and vice-president of Information and Communication Technologies Authority. He has been with Informatics Institute of Istanbul Technical University where he was appointed as a Professor and currently is the Dean of Informatics Institute.

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Performance Evaluation of Multilayer Perceptron Artificial Neural Network Model in the Classification of Heart Failure

Mehmet Onur Kaya

Firat University, Faculty of Medicine, Department of Biostatistics and Medical Informatics, Elazig, Tturkey. (e-mail: mokaya@firat.edu.tr).

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Corresponding author: Mehmet Onur Kaya
✉ mokaya@firat.edu.tr
☎ +90 424 2370000 / 4672

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ABSTRACT

Objective: The aim of this study was to compare the classification performance of heart failure using the MLP ANN model on an open-access "heart failure clinical records" data set, as well as to identify risk factors that may be linked to heart failure.

Material and Methods: The open-access "heart failure" data collection MLP ANN model was used to classify nephritis of the renal pelvis, and risk factors that may be involved were discovered. Different output metrics are used to demonstrate MLP ANN's progress.

Results: It has been shown that the classification of renal pelvic nephritis is quite high with MLP ANN model (AUC = 0.925, Accuracy = 93.9%, Balanced Accuracy = 89.2%, Sensitivity = 98.4%, Specificity = 80.0%). Furthermore, the MLP ANN model showed that "time" is the most significant variable among the risk factors linked to heart failure.

Conclusion: Consequently, in the analysis with the heart failure data collection, the MLP ANN model generated very positive results. Moreover, this model has gained important information in identifying risk factors that may be associated with heart failure. Thus, it has been understood that the relevant model will provide reliable information about any disease to be used in preventive medicine practices.

1. INTRODUCTION

HEART failure is a common clinical syndrome characterized by dyspnea, fatigue, and signs of volume overload, which may include peripheral edema and pulmonary rales resulting from impaired systolic and/or diastolic function of the heart. There is no single diagnostic test for heart failure. Therefore, the diagnosis is made with the patient's anamnesis, physical examination, and laboratory test. Symptoms of heart failure can vary depending on systolic or diastolic dysfunction. The prognosis of heart failure is closely related to the stage of the disease and the duration of the disease. Survival is 89.6 percent at one month after diagnosis, 78 percent at one year, and only 57.7 percent at five years. Given the poor prognosis, proper diagnosis and treatment of heart failure are important [1].

Although many diagnostic criteria have been specified in the diagnosis of heart failure, Framingham criteria are widely used in diagnosis. Framingham primary criteria are defined as Acute pulmonary edema, Cardiomegaly, Hepatojugular reflex, Neck vein distension, Paroxysmal nocturnal dyspnea or orthopnea, Rales, Third heart sound as gallop, and minor criteria are defined as Ankle edema, Dyspnea on exertion, Hepatomegaly, Nocturnal cough, Pleural effusion, Tachycardia (> 120 beats per minute). Diagnosis is made by considering these criteria [2]. Heart failure is diagnosed when there are two major criteria or one major and two minor criteria. Although the Framingham criteria are widely used in diagnosis, two different studies reported that heart failure occurs when Framingham criteria are not met [3,4]. It is known that early diagnosis and treatment in heart failure are also essential to take into account the poor prognosis. In this context, new developments are needed in diagnosis to start early diagnosis and treatment.

Artificial Neural Networks (ANNs) are computer systems developed to automatically realize skills such as generating new information, creating and discovering new information through learning, which are characteristics of the human brain, without any help [5]. ANNs can model nonlinearly without the need for any assumptions or prior

knowledge of input and output variables. In addition, the Multilayer Perceptron (MLP) is one of the most commonly used ANN models for the solution of nonlinear problems. There is at least one layer between the input and output layers in this feed-forward backpropagation network. The relation weight values between the layers are updated to decrease the calculated error value in the reverse propagation stage when the network's output and error value are measured in the forward propagation stage [6,7].

The aim of this study was to compare the classification performance of heart failure using the MLP ANN model on an open-access "heart failure" data set, as well as to identify risk factors that may be linked to heart failure.

2. MATERIAL AND METHODS

2.1. Dataset

In this study, the open-access data set named "Heart failure clinical records" was used to evaluate the performance of the MLP ANN model and to determine the possible risk factors [8] with heart failure.

The number of cases that make up the study sample is 299 patients. The patients ranged in age from 40 to 95 years old, with 105 women and 194 men among them. After a certain follow-up period, 96 (32.1%) of these patients were reported to die. Table 1 shows the variables in the data set and the properties of the variables.

TABLE 1
PROPERTIES OF THE VARIABLES IN THE STUDY

Variable	Variable Description	Variable Type	Variable Role
Age	Decrease of red blood cells or hemoglobin	Quantitative	Input
Anemia	Level of the CPK enzyme in the blood (mcg/L) (boolean)	Qualitative	Input
Creatinine phosphokinase	Level of the CPK enzyme in the blood (mcg/L)	Quantitative	Input
Diabetes	If the patient has diabetes (boolean)	Qualitative	Input
Ejection fraction	Percentage of blood leaving the heart at each contraction (percentage)	Quantitative	Input
High blood pressure	If the patient has hypertension (boolean)	Qualitative	Input
platelets	Platelets in the blood (kiloplatelets/mL)	Quantitative	Input
Serum creatinine	Level of serum creatinine in the blood (mg/dL)	Quantitative	Input
Serum sodium	Level of serum sodium in the blood (mEq/L)	Quantitative	Input
Gender	Woman or man (binary)	Qualitative	Input
Smoking	If the patient smokes or not (boolean)	Qualitative	Input
Time	Follow-up period (days)	Quantitative	Input
Death event	If the patient deceased during the follow-up period (boolean)	Qualitative	Output

2.2. Multilayer Perceptron Artificial Neural Network Model

The output of the MLP ANN method on the heart failure data set was investigated in this analysis, and risk factors that may be linked to heart failure were identified. Predictive ANNs are particularly useful in applications with a complicated mechanism. ANNs are currently gaining popularity as a solution to problems that cannot be solved with traditional methods, and they have been used successfully in a variety of medical applications. ANNs, unlike conventional spectral analysis, approaches model signals as well as generate signal classification solutions. Another advantage of ANNs over other methods for analyzing biomedical signals is that they are speedy after being educated. The MLP ANN model is a nonparametric artificial neural network technique that can perform a wide range of detection and prediction tasks [9].

Approximately 73% and 27% of the entire dataset is used for the training and testing process, respectively, to create the MLP ANN model. The number of units in the input layer was 12, the number of units in the hidden layer was 2, the hidden layer activation function was a hyperbolic tangent, the number of units in the output layer was 2, the output layer activation function was Softmax, and the error function was Cross-entropy. The scaled conjugate gradient approach was used to optimize the model's hyperparameters.

2.3. Performance Evaluation of the Models

The MLP ANN model was evaluated using performance metrics including Accuracy, Balanced accuracy, Sensitivity, Specificity, Positive predictive value (PPV), Negative predictive value (NPV), F-score, and Area under the curve (AUC) with an appropriate 95% confidence interval (CI).

2.4. Data Analysis

IBM SPSS Statistics 26.0 program was used for all analyzes in the study. The compliance of continuous variables to the normal distribution was evaluated using the Shapiro Wilk test. The comparison of continuous variables that do not provide the assumption of normal distribution between two independent groups (Death Event: Survived and Died) was performed with the Mann Whitney U test, and descriptive statistics were presented as median (min-max). In the analysis of categorical variables, the Pearson chi-square test was used, and descriptive statistics were presented as frequency (%). The significance level was accepted as 0.05.

3. RESULTS

The statistical analysis findings of the variables included in the data set are presented in Table 2. In the table, statistically significant p values are presented in bold.

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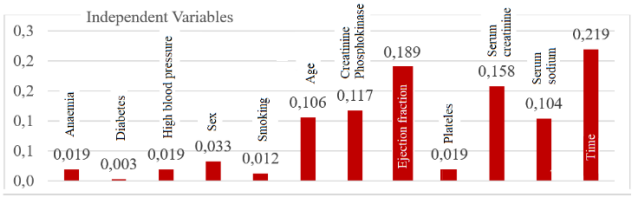

Figure 1. The importance values of possible risk factors associated with heart failure.

When the table is examined, it is seen that Age, Ejection Fraction, Serum Creatinine, Serum Sodium, Time, and Smoking variables are statistically significantly different between the groups. Table 3 shows the classification matrices for the MLP ANN model's training and testing measures.Table 4 shows the performance metrics results obtained from the MLP ANN model for classifying hearth failure in the test step.

TABLE 2
STATISTICAL COMPARISONS OF VARIABLES

Variables		Death Event		p-value
		Survived (n=203)	Dead (n=96)	
Age [Median (Min-Max)]		60(40-90)	65(42-95)	**<0.001**
Creatinine Phosphokinase [Median (Min-Max)]		245(30-5209)	259(237-861)	0.684
Ejection Fraction [Median (Min-Max)]		38(17-80)	30(14-70)	**<0.001**
Platelets [Median (Min-Max)]		263000(25100-850000)	258500(47000-621000)	0.425
Serum Creatinine [Median (Min-Max)]		1(0.5-6.10)	1.3(0.6-9.40)	**<0.001**
Serum Sodium [Median (Min-Max)]		137(113-148)	136(116-146)	**<0.001**
Time [Median (Min-Max)]		172(12-285)	45(4-241)	**<0.001**
Gender n(%)	Female	71(35.00%)	34(35.40%)	0.941
	Male	132(65.00%)	62(64.60%)	
Anemia n(%)	Absence	120(59.10%)	50(52.10%)	0.252
	Presence	83(40.90%)	46(47.90%)	
Diabetes n(%)	Absence	118(58.10%)	56(58.30%)	0.973
	Presence	85(41.90%)	40(41.70%)	
High blood pressure n(%)	Absence	137(67.50%)	57(59.40%)	0.170
	Presence	66(32.50%)	39(40.60%)	
Smoking n(%)	Absence	137(67.50%)	66(68.75%)	0.827
	Presence	66(32.50%)	30(31.25%)	

TABLE 3
CLASSIFICATION MATRICES OF TRAINING AND TESTING STEPS

Training Step

		Reference		Total
		Survived	Dead	
Predicted	Survived	127	11	138
	Dead	23	56	79
	Total	150	67	217 (72.6%)

Testing Step

		Reference		Total
		Survived	Dead	
Predicted	Survived	61	4	65
	Dead	1	16	17
	Total	62	20	82 (27.4%)

TABLE 4
CLASSIFICATION PERFORMANCE METRICS OF THE MLP ANN MODEL

Performance Metrics	Value (95% CI)
Accuracy (%)	93.9 (88.7 – 99.1)
Balanced Accuracy (%)	89.2 (82.5 – 95.9)
Sensitivity (%)	98.4 (91.3 – 1.00)
Specificity (%)	80.0 (56.3 – 94.3)
PPV (%)	93.8 (85.0 – 98.3)
NPV (%)	94.1 (71.3 – 99.9)
F1-score (%)	96.1 (91.9 – 1.00)
AUC	0.925

Table 5 and Figure 1 show the significance values of the input variables in the data set obtained from the MLP ANN model, respectively.

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TABLE 5
THE IMPORTANCE VALUES OF THE INPUT VARIABLES

Independent Variables	Importance
Anemia	0,019
Diabetes	0,003
High blood pressure	0,019
Sex	0,033
Smoking	0,012
Age	0,106
Creatinine phosphokinase	0,117
Ejection fraction	0,189
Platelets	0,019
Serum creatinine	0,158
Serum sodium	0,104
Time	0,219

4. DISCUSSION

Heart failure is one of the most common cardiovascular diseases in the world, the last stage of all heart diseases, a health problem with increasing prevalence and incidence. The incidence of heart failure continues to increase in our country and worldwide, and mortality rates are still at very high levels. Individuals' survival and lifespans are increasing as a result of advances in cardiovascular disease care. As a result, monitoring and treating patients with heart failure is becoming increasingly relevant, and it continues to be a fertile ground for new research and innovations[10], [11].

Researchers successfully use various artificial neural networks to conduct difficult diagnostic tasks in medical applications, such as classifying diseases such as heart disease and diabetes. The ability of ANNs to process a large amount of data during the training phase and reduce the necessary diagnostic time is the reason for their success [12], [13]. The most abstracted type of ANNs is the single-layer perceptron (SLP), which has only two input and output layers [14]. It has been shown that SLPs are incapable of handling nonlinearly separable patterns effectively [15]. In this regard, multilayer perceptron (MLP) NNs have been proposed, which employ one or more hidden layers in the ANNs to avoid the drawbacks of SLPs. As a result, the MLP edition of ANNs is the most widely used [16]. MLP's learning speed, nonlinearity, parallelism, fault tolerance, robustness to noise, and excellent generalization capacity are just a few of its main features [13].

The MLP model, which is one of the ANN models, was applied to the open-source data set "Heart Failure" in this analysis. The MLP ANN model was used to estimate various factors (explanatory variables) that may be correlated with heart failure (dependent variable), and performance metrics were obtained. The model's accuracy, balanced accuracy, sensitivity, specificity, PPV, NPV, F1-score, and AUC values were 93.9%, 89.2%, 98.4%, 80.0%, 93.8%, 94.1%, 96.1%, and 0.925, respectively, according to the experimental results. The results of a study using the same data set were obtained using a variety of machine learning models, with the "Random Forest" model reporting the highest accuracy of 0.74 [8]. Another study using the same data set stated that the accuracy was 0.86 [17]. When this study is compared with the other two studies using the same data set, it is seen that the accuracy value obtained with the MLP ANN model used in this study is higher than the others with 93.9%.

Consequently, in the analysis with the heart failure data collection, the MLP ANN model generated very positive results. Moreover, this model has gained important information in identifying risk factors that may be associated with heart failure. Thus, it has been understood that the relevant model will provide reliable information about any disease to be used in preventive medicine practices.

REFERENCES

[1] Loehr, L. R., Rosamond, W. D., Chang, P. P., Folsom, A. R., & Chambless, L. E. (2008). Heart failure incidence and survival (from the Atherosclerosis Risk in Communities study). *The American journal of cardiology*, *101*(7), 1016-1022.

[2] Lindenfeld, J. O. A. N. N., Krause-Steinrauf, H., & Salerno, J. U. D. I. T. H. (1997). Where are all the women with heart failure?. *Journal of the American College of Cardiology*, *30*(6), 1417-1419.

[3] Maestre, A., Gil, V., Gallego, J., Aznar, J., Mora, A., & Martín-Hidalgo, A. (2009). Diagnostic accuracy of clinical criteria for identifying systolic and diastolic heart failure: cross-sectional study. *Journal of evaluation in clinical practice*, *15*(1), 55-61.

[4] Gil, V., Merino, J., García, M., Jordán, A., & Guerrero, L. (2006). Validity of Framingham criteria as a clinical test for systolic heart failure. *Revista clinica espanola*, *206*(10), 495-498.

[5] Öztemel, E. (2003). Yapay sinir ağları. *PapatyaYayincilik, Istanbul*.

[6] Haykin, S. (1999). A comprehensive foundation on neural networks.

[7] Ayşe, A. R. I., & Berberler, M. E. (2017). Yapay sinir ağları ile tahmin ve sınıflandırma problemlerinin çözümü için arayüz tasarımı. *Acta Infologica*, *1*(2), 55-73.

[8] Chicco, D., & Jurman, G. (2020). Machine learning can predict survival of patients with heart failure from serum creatinine and ejection fraction alone. *BMC medical informatics and decision making*, *20*(1), 1-16.

[9] Orhan, U., Hekim, M., & Özer, M. (2010, April). Discretization approach to EEG signal classification using Multilayer Perceptron Neural Network model. In *2010 15th National Biomedical Engineering Meeting* (pp. 1-4). IEEE.

[10] Bleumink, G. S., Knetsch, A. M., Sturkenboom, M. C., Straus, S. M., Hofman, A., Deckers, J. W., ... & Stricker, B. H. C. (2004). Quantifying the heart failure epidemic: prevalence, incidence rate, lifetime risk and prognosis of heart failure: the Rotterdam Study. *European heart journal*, *25*(18), 1614-1619.

[11] Mosterd, A., & Azadas, A. W. (2007). Epidemiología clínica de la insuficiencia cardíaca. *Heart*, *93*, 1137-1146.

[12] Heidari, A. A., Faris, H., Aljarah, I., & Mirjalili, S. (2019). An efficient hybrid multilayer perceptron neural network with grasshopper optimization. *Soft Computing*, *23*(17), 7941-7958.

[13] Faris, H., Aljarah, I., & Mirjalili, S. (2016). Training feedforward neural networks using multi-verse optimizer for binary classification problems. *Applied Intelligence*, *45*(2), 322-332.

[14] Hu, Y. C. (2014). Nonadditive similarity-based single-layer perceptron for multi-criteria collaborative filtering. *Neurocomputing*, *129*, 306-314.

[15] Ojha, V. K., Abraham, A., & Snášel, V. (2017). Metaheuristic design of feedforward neural networks: A review of two decades of research. *Engineering Applications of Artificial Intelligence*, *60*, 97-116.

[16] Chen, J. F., Do, Q. H., & Hsieh, H. N. (2015). Training artificial neural networks by a hybrid PSO-CS algorithm. *Algorithms*, *8*(2), 292-308.

[17] KUCUKAKCALİ, Z. T., ÇİÇEK, İ. B., GÜLDOĞAN, E., & ÇOLAK, C. (2020). Assessment of Associative Classification Approach for Predicting Mortality by Heart Failure. *The Journal of Cognitive Systems*, *5*(2), 41-45.

BIOGRAPHIES

Mehmet Onur Kaya received his BSc from Fırat University in 2009. He received his MSc degree from Fırat University Applied Statistics in 2011 and his PhD degree from Bursa Uludağ University Biostatistics Department in 2016. His research interests are clinical biostatistics, meta-analysis, data mining, expert systems, artificial intelligence, bioinformatics and statistical shape analysis. He joined the Fırat University Biostatistics and Medical Informatics Department as an Assistant Professor in 2017 and is still a faculty member. He is engaged in teaching and research activities in artificial intelligence, data mining, statistical shape analysis and meta-analysis.

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A Web-Based Software for Reporting Guidelines of Scientific Research

Burak Yagin, Fatma Hilal Yagin, Harika Gozde Gozukara Bag, Cemil Colak

Inonu University, Faculty of Medicine, Department of Biostatistics and Medical Informatics, Malatya, Turkey. (e-mail: {burak.yagin, hilal.yagin, harika.gozukara, cemil.colak}@inonu.edu.tr

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Corresponding author: Fatma Hilal Yagin
✉ hilal.yagin@inonu.edu.tr
☎ +90 422 3410660

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ABSTRACT

Aim: It is very important to use accurate reporting guidelines when reporting a study in cognitive science and health. This study aims to develop a web-based tool that leads to a reporting guideline that includes checklists and flowcharts for relevant research by type of research designs (qualitative, descriptive, experimental, and methodological studies, etc.)

Materials and Methods: The current study covers qualitative research, systematic review/meta-analysis, case presentations, case series, correlational (ecological), case-control, cross-sectional, cohort, randomized clinical trial, non-randomized clinical trial, field studies (for there are reporting guideline for primary protection measures), health care research (animal experiments, etc.), validity studies, consistency studies, simulation studies. For this purpose, the researcher is asked which epidemiological research design is useful and is directed to the reporting guideline for the relevant research type. During the development of the software, the DASH Library in the Python programming language was used.

Results: The Scientific Research Guidelines Software developed in this study can improve the reporting quality of the studies by guiding researchers to the correct reporting guide. The web-based software developed can be accessed at http://biostatapps.inonu.edu.tr/BAKY/. The software has English and Turkish language options.

Conclusion: Scientific Research Guidelines Software allows researchers to clearly state what they do and what they don't do in their study, how they do it, and what they find as a result. Besides, this software provides access to guides where they can learn about the meaning, strengths, and weaknesses of the study being done.

1. INTRODUCTION

GIVEN the large and growing volume of published articles, readers often find research reports that do not provide a clear and transparent explanation of methods and adequate reporting of results. If authors do not provide sufficient detail about the conduct of their work, they leave readers with an incomplete picture of the work done and its findings. Insufficiently reported studies can lead to misinterpretation and misapplication in clinical settings. It also provides misleading evidence that can be used to develop new research based on published studies. Therefore, funds allocated to support research may not be optimally used [1].

Since the early 1990s, research groups of major medical journal editors and content experts have developed reporting guidelines to help to improve the reporting quality of their articles in the healthcare field. Reporting guidelines are developed to report a particular type of epidemiological research. A reporting guideline line usually consists of a guiding checklist, flowchart, or clear text for authors. Carefully developed reporting guidelines provide authors with a minimal set of items that should be addressed when reporting a study. For example, PRISMA is a reporting guideline developed for Systematic reviews and Meta-Analysis. PRISMA was developed by a team of 29 people with meticulous work and includes a 27-item checklist and a four-step flow chart. Initial reviews of reporting guidelines show that their use is associated with improved reporting quality [2].

Research reporting guidelines allow authors to properly write their research and give them the specific guidance they need during the reporting phase. Editors often advise authors to report on their work, but these recommendations tend to be vague and short, or too broadly long and daunting. For

example, BMJ's recommendations for reporting are currently more than 20,000 words (http://resources.bmj.com/bmj/authors) [2, 3].

The development of more than 80 reporting guidelines to report different types of epidemiological investigations may result in uncertainty and misapplication. In addition, authors may not know where to access these guidelines and referees do not know how to use them. These guidelines contain recommendations that allow researchers to clearly say what they did and did not do in their study, how they did it, and what they found as a result of the research, thus allowing an honest discussion about the meaning of the study, its strengths and weaknesses [4, 5]. Also, these guidelines often include a checklist of items that should be clearly communicated in the study and a flowchart showing what happened to the participants at each stage of the study [2].

The aim of this study is to develop a web-based tool that guidelines you to a reporting guideline that includes checklists and flow charts for the relevant research according to the research type (qualitative, descriptive, experimental, and methodological studies, etc.). Scientific research guidelines software can be accessed free of charge at http://biostatapps.inonu.edu.tr/BAKY/. It has two language options, English and Turkish.

2. REPORTING RULES

Reporting guidelines are very important for studies in cognitive science and health. Guidelines and checklists help individuals meet certain standards by providing a set of rules or principles that guidelines best behavior in a particular area. The World Health Organization submitted the checklist in 2008 and piloted its implementation in eight different hospitals around the world. The results of this study showed that the implementation of the checklist had a significant decrease in postoperative complication rates and surgical death. These results show that the implementation of the checklist can lead to significant improvements [6].

In recent years, many reporting guidelines have been developed. These guidelines usually contain the minimum information required for a complete and clear explanation of what was done and what was found during research, and specifically address issues that may have biased the research. Most internationally accepted reporting guidelines reflect the consensus of journal editors and experts in a particular field and also drawn on relevant evidence. Some journals already use these guidelines and require authors to report their work according to the relevant guidelines. Although studies evaluating the effects of using reporting guidelines on the quality of health research are still rare, studies have shown very promising results. However, to achieve an improvement in health research reporting globally, everyone involved in publishing research findings should have at least a basic knowledge of good research reporting principles and existing reporting guidelines. This applies not only to researchers and authors of research articles but also to journal editors and reviewers.

2.1.1.1. Scientific Research Guidelines Software

The Scientific Research manuals software was developed using the DASH Library in the Python programming language. The web-based software developed provides reporting guidelines for the following types of health research. The developed software is published at the website of https://biostatapps.inonu.edu.tr/.

2.1.1.2. Qualitative Researches

It is a type of research in which qualitative data collection methods such as observation, interview, and document analysis are used, and a process is followed to reveal perceptions and events realistically and holistically in the natural environment. The reporting guideline used in the software for qualitative research can be accessed at https://insights.ovid.com/pubmed?pmid=24979285 [7].

2.1.1.3. Systematic Review/Meta-Analysis

A systematic review, meta-analysis and meta-synthesis studies synthesize the results of research on the same subject and are research methods developed to summarize. While summarizing quantitative research results in meta-analyses Qualitative research results are summarized in meta-syntheses. In systematic reviews, the results of many studies conducted by experts in the field with similar methods are synthesized. In order to perform a meta-analysis, a systematic review process must be done beforehand. However, when the findings of the studies included in the systematic review are not appropriate, meta-analysis is not performed [8]. In meta-synthesis, the findings of qualitative research conducted in a specific field are evaluated and interpreted. New inferences are made by revealing similar and different aspects of these studies [9].

Different reporting guidelines should be used according to the types of systematic reviews, meta-analysis and meta-synthesis studies. In systematic reviews and meta- analyses, “Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA)” is most frequently used [8, 10]. The reporting guideline used in the software for Systematic Reviews and Meta-Analyzes can be accessed http://www.prisma-statement.org/. In meta-synthesis studies, the quality of the research is generally evaluated with the "Critical Appraisal Skills Program (CASP) Tool as a Screening Tool" [11]. The reporting guideline used in the software for meta-synthesis studies can be https://casp-uk.b-cdn.net/wp-content/uploads/2018/03/CASP-Qualitative-Checklist-2018_fillable_form.pdf. When Cochrane meta-analysis is done from randomized controlled studies, "Cochrane Central Register of Controlled Trials" (CENTRAL) should be used [11,12]. The reporting guideline used in the software for Cochrane Meta-Analysis from Randomized Controlled Trials can be https://core.ac.uk/download/pdf/145317582.pdf. Quality of Reporting of Meta-analysis (QUOROM) is used in systematic reviews and meta-analyses of randomized controlled trials [13]. The reporting guideline used in the software for systematic reviews and meta-analyses of randomized controlled trials can be https://www.thelancet.com/pdfs/journals/lancet/PIIS0140673699041495.pdf. Systematic Reviews and Meta-Analyzes of Observation Studies in Epidemiology (MOOSE) can be used for systematic reviews and meta-analysis of epidemiological observational studies [14]. The reporting guideline used in the software for Systematic Reviews and Meta-Analysis of Observational Studies can be https://www.ijo.in/documents/14MOOSE_SS.pdf.

2.1.1.4. Case Report

It is a report in which the findings, clinical course, and prognosis of a single case with an unexpected clinical disease are described, and previously reported cases are discussed, generally to indicate the place of the presented case in the general disease. The reporting guideline used in the software for Case Presentations Research is available at https://www.care-statement.org/checklist [15].

2.1.1.5. Case Series

It enables the identification of symptoms and findings and the definition of the case. It helps to better understand the spectrum and natural history of the disease. It is useful for clinical education. The reporting guideline used in the software for Case Series Research is available at https://www.neuropt.org/docs/default-source/research/csm-case-study-abstract-guidelines.pdf?sfvrsn=13325343_0 [16].

2.1.1.6. Correlational (Ecological) Studies

Ecological studies assess the overall disease frequency in a range of populations and look for a correlation with average exposure in populations. These studies are unique in that the analysis is not based on data on individuals. Rather, data points are average exposure levels and overall disease frequency in a range of populations. Therefore, the observation unit is not a person; instead, it is a whole population or group. The reporting guideline used in the software for Correlational (Ecological) Research can be accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4902742/ [17].

2.1.1.7. Case-Control Studies

A study comparing people with a particular interest outcome ('cases') with people from the same population source but without that outcome, to examine the relationship between outcome and previous exposure (for example, an intervention). This design is particularly useful when the result is rare. The reporting guideline used in the software for Case-Control Research can be accessed at https://www.strobe-statement.org/index.php?id=available-checklists [18].

2.1.1.8. Cross-Sectional Studies

These are the studies in which the prevalence of the disease of interest in the society is investigated, results are obtained generalizable to the whole society, and the whole society or a representative sample is examined. The reporting guideline used in the software for Cross-sectional Research can be accessed at https://www.strobe-statement.org/index.php?id=available-checklists [18].

2.1.1.9. Cohort Studies

Cohort studies are analytical epidemiological studies planned to determine the relationship between a health problem and the reason thought to cause this health problem. The reporting guideline used in the software for Cohort Studies can be accessed at https://www.strobe-statement.org/index.php?id=available-checklists [18].

2.1.1.10. Randomized Clinical Trials

It is a study design that randomly assigns individuals to an experimental group or a control group. While the study is being conducted, the only expected difference between the control and experimental groups in a randomized controlled study (RCT) is the study outcome variable. The reporting guideline used in the software for the Randomized Clinical Trial can be accessed at http://www.consort-statement.org/consort-2010 [19].

2.1.1.11. Non-Randomized Clinical Trials

It is a clinical trial in which participants are not assigned to different treatment groups by chance. Participants can choose the group they want to be included in, or they can be assigned to groups by researchers. The reporting guideline used in the software for Non-Randomized Clinical Trial can be accessed at https://www.cdc.gov/trendstatement/ [20].

2.1.1.12. Field Studies (For Primary Protection Measures)

Fieldwork is a research activity that takes place in the researcher context rather than an office or lab. The range of possible fieldwork methods and activities is very wide. Fieldwork also varies greatly in terms of how the researcher interacts (or does not) with the participants. The reporting guideline used in the software for Field Studies (For Primary Protection Measures) can be accessed at https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1000052 [21].

2.1.1.13. Health Care Research (Animal Experiments etc.)

Health research refers to many types of scientific research that aim to test ideas, answer questions, improve treatment options, and increase knowledge about human health. The reporting guideline used in the software for Health Care Research (Animal Experiments etc.) can be accessed at https://arriveguidelines.org/ [22,23].

2.1.1.14. Validity Studies

Indicates whether a scale measures what it aims to measure and its generalizability. It indicates that the phenomenon or judgment considered to be measured is measured correctly. A valid measurement means that the measuring tool is measuring the features it plans to measure. The reporting guideline used in the software for Validity Studies can be accessed at https://www.bmj.com/content/351/bmj.h5527 [24].

2.1.1.15. Consistency Studies

In Consistency Studies, when the measurements, observations, and examinations made in any research are repeated on the same people under the same conditions, the same observers will obtain the same results. If there is no observer variation, it is expected that the measurement results are theoretically the same or very close to each other in the examinations performed with the same method in two serum samples taken simultaneously from the same person. This same / similarity dimension is called the reliability/consistency of the observations. The reporting guideline used in the software for Consistency Studies can be

accessed at https://www.bmj.com/content/351/bmj.h5527 [24].

2.1.1.16. Simulation Studies

Simulation studies are computer experiments that involve generating data by so-called random sampling. An important strength of simulation studies is the ability to understand the behaviour of statistical methods because some "real" (usually some parameters) are known from the data generation process. The reporting guideline used in the software for Simulation Studies can be accessed at https://www.cos.ufrj.br/uploadfile/1368206472.pdf [25].

3. RESULTS

The Scientific Research Guidelines Software developed in this study can improve the reporting quality of the studies by guiding researchers to the correct reporting guide. The web-based software developed can be accessed at http://biostatapps.inonu.edu.tr/BAKY/. The software has English and Turkish language options. The main and research designs menus of Scientific Research Guidelines Software are given in Figure 1.

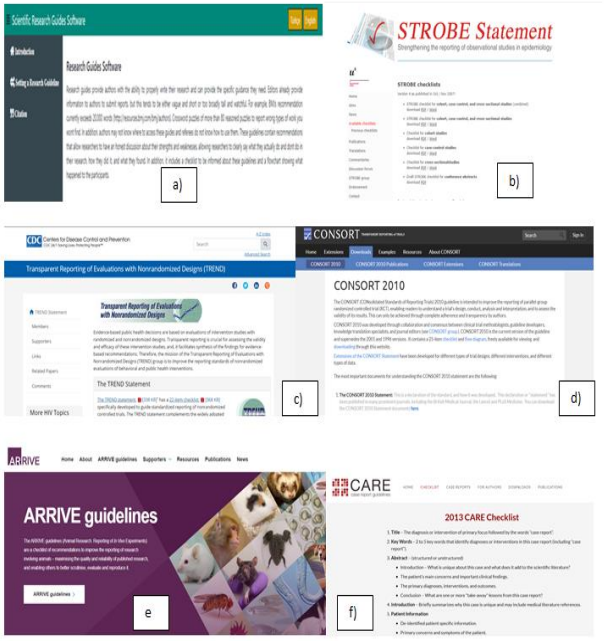

Fig.1. Main menus of Scientific Research Guidelines Software (a: Introduction menu; b: Reporting guidelines for Cohort, case-control, and cross-sectional studies - STROBE; c: Reporting guidelines for Nonrandomized designs - TREND; d: Reporting guidelines for Randomize designs - CONSORT; e: Reporting guidelines for Animal Experiments - ARRIVE; f: Reporting guidelines for Case Report Studies – CARE.

4. CONCLUSIONS

The reliability and robustness of the medical research literature can be greatly improved by empowering authors, editors, and reviewers using tools that provide better reporting and improve the evaluation process. By using research reporting guidelines, clinicians, managers, and other healthcare professionals can make better evidence-based decisions, resulting in a much higher return on investment in health research [26].

More discipline should be taken when publishing research studies if new and effective research evidence/results are desired to improve health. Therefore, the way to provide more accurate and complete research reports is to adhere to scientific reporting rules [27].

It is the joint responsibility of all individuals and institutions involved in the financing, management, and publication of the research to report health research in a complete, accurate, open, and timely manner. Error-free and high-quality scientific research reports contribute to the more efficient use of the obtained research findings in clinical applications and allow the new scientific knowledge obtained and the progress of the care and treatment of patients [21].

Some of the benefits arising from the implementation of Scientific Research guidelines can be expressed as follows [23]:

1. Presentation quality and transparency of research increases,
2. Light up future research with good reporting is kept,
3. With advanced reporting, published research output may be maximized,
4. For the publication and reporting of research a common model is designed.

In addition to the benefits in designing and conducting research in the field of health, the reporting guideline set in the software can be used as an aid in the development of training courses in the design and application of research. The web-based scientific research guideline s software developed can make an important contribution to this process by facilitating global cooperation between researchers, higher education, and publishing communities.

REFERENCES

[1] Simera, I., Moher, D., Hoey, J., Schulz, K. F., & Altman, D. G. (2010). A catalogue of reporting guidelines for health research. European journal of clinical investigation, 40(1), 35-53.
[2] Moher, D., Schulz, K. F., Simera, I., & Altman, D. G. (2010). Guidance for developers of health research reporting guidelines. PLoS medicine, 7(2), e1000217.
[3] Altman, D. G., Simera, I., Hoey, J., Moher, D., & Schulz, K. (2008). EQUATOR: reporting guidelines for health research. Open Medicine, 2(2), e49.
[4] Simera, I., Moher, D., Hirst, A., Hoey, J., Schulz, K. F., & Altman, D. G. (2010). Transparent and accurate reporting increases reliability, utility, and impact of your research: reporting guidelines and the EQUATOR Network. BMC medicine, 8(1), 1-6.
[5] Stevens, A., Shamseer, L., Weinstein, E., Yazdi, F., Turner, L., Thielman, J., ... & Moher, D. (2014). Relation of completeness of reporting of health research to journals' endorsement of reporting guidelines: systematic review. Bmj, 348.
[6] Altman, D. G., & Moher, D. (2005). Developing guidelines for reporting healthcare research: scientific rationale and procedures. Medicina clinica, 125, 8-13.
[7] Al-Busaidi, Z. Q. (2008). Qualitative research and its uses in health care. Sultan Qaboos University Medical Journal, 8(1), 11.
[8] Karaçam, Z. (2013). Sistematik derleme metodolojisi: Sistematik derleme hazırlamak için bir rehber. Dokuz Eylül Üniversitesi Hemşirelik Fakültesi Elektronik Dergisi, 6(1), 26-33.
[9] Polat, S., & Osman, A. Y. (2016). Meta-sentez: Kavramsal bir çözümleme. Eğitimde Nitel Araştırmalar Dergisi, 4(2), 52-64.
[10] Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., ... & Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Annals of internal medicine, 169(7), 467-473.
[11] Maribo, T., Jensen, C. M., Madsen, L. S., & Handberg, C. (2020). Experiences with and perspectives on goal setting in spinal cord injury rehabilitation: a systematic review of qualitative studies. Spinal Cord, 58(9), 949-958.
[12] Kılıçkap, M. (2018). Meta-analizleri nasıl yorumlayalım: Türkiye'de kardiyovasküler risk faktörlerine yönelik yapılan meta-analizlerin metodolojik açıdan değerlendirilmesi. Turk Kardiyol Dern Ars, 46(7), 624-635.
[13] Moher, D., Cook, D. J., Eastwood, S., Olkin, I., Rennie, D., & Stroup, D. F. (2000). Improving the quality of reports of meta-analyses of randomised controlled trials: the QUOROM statement. Oncology Research and Treatment, 23(6), 597-602.

[14] Rajasekhar, A., Lottenberg, R., Lottenberg, L., Liu, H., & Ang, D. (2011). Pulmonary embolism prophylaxis with inferior vena cava filters in trauma patients: a systematic review using the meta-analysis of observational studies in epidemiology (MOOSE) guidelines. Journal of thrombosis and thrombolysis, 32(1), 40-46.
[15] Agha, R. A., Fowler, A. J., Saeta, A., Barai, I., Rajmohan, S., Orgill, D. P., ... & Rosin, D. (2016). The SCARE statement: consensus-based surgical case report guidelines. International Journal of Surgery, 34, 180-186.
[16] Zucker, D. M. (2009). How to do case study research. School of nursing faculty publication series, 2.
[17] Morgan, R. L., Thayer, K. A., Bero, L., Bruce, N., Falck-Ytter, Y., Ghersi, D., ... & Schünemann, H. J. (2016). GRADE: Assessing the quality of evidence in environmental and occupational health. Environment international, 92, 611-616.
[18] Cuschieri, S. (2019). The STROBE guidelines. Saudi journal of anaesthesia, 13(Suppl 1), S31.
[19] Moher, D., Schulz, K. F., & Altman, D. (2001). The CONSORT statement: revised recommendations. JAMA, 285(15), 1987-1991.
[20] Treasure, E. (2004). The TREND statement. Evidence-based dentistry, 5(4), 88-91.
[21] Newton, P. N., Lee, S. J., Goodman, C., Fernández, F. M., Yeung, S., Phanouvong, S., ... & White, N. J. (2009). Guidelines for field surveys of the quality of medicines: a proposal. PLoS medicine, 6(3), e1000052.
[22] Percie du Sert, N., Hurst, V., Ahluwalia, A., Alam, S., Avey, M. T., Baker, M., ... & Würbel, H. (2020). The ARRIVE guidelines 2.0: Updated guidelines for reporting animal research. Journal of Cerebral Blood Flow & Metabolism, 40(9), 1769-1777.
[23] Çolak, C., & Parlakpınar, H. (2012). Hayvan deneyleri: in vivo denemelerin bildirimi: ARRIVE Kılavuzu-Derleme.
[24] Bossuyt, P. M., Reitsma, J. B., Bruns, D. E., Gatsonis, C. A., Glasziou, P. P., Irwig, L., ... & Cohen, J. F. (2015). STARD 2015: an updated list of essential items for reporting diagnostic accuracy studies. Clinical chemistry, 61(12), 1446-1452.
[25] De França, B. N., & Travassos, G. H. (2012). Reporting guidelines for simulation-based studies in software engineering.
[26] Erik von Elm, M. D., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med, 147(8), 573e7.
[27] Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P., ... & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Journal of clinical epidemiology, 62(10), e1-e34.

BIOGRAPHIES

Burak Yağın obtained his BSc. degree in Statistics from Gazi University in 2017. He currently continues his MSc. education in biostatistics and medical informatics from Inonu University. His research interests are cognitive systems, data mining, machine learning, deep learning, and image processing.

Fatma Hial Yağın obtained her BSc. degree in Statistics from Gazi University in 2017. She received MSc. degree in biostatistics and medical informatics from Inonu University in 2020. She currently continues her Ph.D. education in biostatistics and medical informatics from Inonu University. In 2019, she joined the Department of Biostatistics and Medical Informatics at Inonu University as a researcher assistant. Her research interests are cognitive systems, data mining, machine learning, deep learning, and image processing.

Harika Gözde Gözükara Bağ obtained her BSc. degree in Agricultural Engineering from Ankara University in 2000. She received MSc. degree in Biostatistics from the Inonu University in 2004, and a PhD degree in Biostatistics from Hacettepe University in 2011. She is currently working as an Associate Professor at the Department of Biostatistics and Medical Informatics at Inonu University since 2019. She is active in teaching and her research interests are genetics, survival analysis and meta-analysis.

Cemil Çolak obtained his BSc. degree in Statistics from Ondokuz Mayıs University in 1999. He received MSc. degree in Biostatistics from the Inonu University in 2001, and a PhD degree in the Graduate Department of Biostatistics and Medical Informatics of Ankara University in 2005. His research interests are cognitive systems, data mining, reliability, and biomedical system, genetics, and bioengineering. In 2016, he joined the Department of Biostatistics and Medical Informatics at Inonu University as a Professor, where he is presently a professor. He is active in teaching and research in general image processing, artificial intelligence, data mining, and analysis.

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A Web-Based Software for the Calculation of Theoretical Probability Distributions

Fatma Hilal Yagin, Emek Guldogan, Cemil Colak

Inonu University, Faculty of Medicine, Department of Biostatistics and Medical Informatics, Malatya, Turkey. (e-mail: {hilal.yagin, emek.guldogan, cemil.colak}@inonu.edu.tr.

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Corresponding author: Fatma Hilal Yagin
✉ hilal.yagin@inonu.edu.tr
☎ +90 422 3410660

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ABSTRACT

Aim: The aim of this study is to develop a public web-based theoretical probability distributions software (KODY) that can calculate probabilities for discrete and continuous distributions.

Materials and Methods: The Discrete Uniform, Bernoulli, Binomial, Multinomial, Poisson, Geometric, Negative Binomial, Hypergeometric and Zeta (Zipf) distributions from the discrete distributions are explained. Among the continuous distributions, The Continuous Uniform, Beta, Normal, Log-Normal, Exponential, Gamma, Weibull, Rayleigh, Logistics, Pareto, Laplace, Cauchy and Erlang distributions are elucidated. Illustrative examples are presented on hypothetical medical data. The software was developed using the MATH and DASH libraries of the Python programming language.

Results: When making statistical analysis, the feature of the distribution is essential. Because the descriptive and analytical statistical methods to be applied to data with different distributions are also different. Probability distributions of variables are important in the effectiveness of these methods. For this reason, it is an essential step for researchers to determine the probability distributions of their data before starting their studies. It is thought that the software developed in this study will enable researchers to make the necessary calculations in probabilistic estimates regarding the theoretical probability distributions. The developed software can be accessed at http://biostatapps.inonu.edu.tr/KODY/.

Conclusion: The open access web-based software with Turkish/English language options may guide and contribute to researchers in probabilistic estimation processes regarding theoretical distributions. In the later stages of this study, it is foreseen to develop simulation processes based on each probability distribution.

1. INTRODUCTION

THE science of statistics, which developed to determine the factors affecting complex events that occur as a result of the rapid developments in the fields of science and technology, to predict uncertainties and to eliminate the risks caused by uncertainty, has led to the development of probability theory [1].

A random variable is a variable whose discrete or continuous values are random, and a probability distribution for these values can be defined. In other words, this variable shows all possible measurable values in the sample space. Random variables are frequently used in probability calculations in physics, chemistry, engineering, biology, and medical sciences. Properties of probability distributions of random variables in statistical analysis and it is fundamental in choosing the analysis method and interpreting the results. Since these analyzes are based on a specific theoretical distribution, the variable (s) we use in the analysis must fit this theoretical distribution. Theoretical distributions are also a probability distribution [2].

The most important task in applying the probability concept is to find the probability function suitable. Today, many events are different from each other and have a complex structure. Since it would be difficult for a researcher to search for a different probability function for each different event in terms of time, information and possibility, probability functions have been developed in specific patterns related to events that provide certain properties. These probability distributions are divided into two as discrete and continuous probability distributions. Discrete probability distributions describe the possible distributions in the occurrence of a random and countable event. If the element of the set consisting of the possible outcomes of an event takes a value

in a continuous range, this random variable is called a "continuous random variable". Furthermore, the probability distribution of this random variable is called the continuous probability distribution. The discrete sampling space points in the discrete probability function are based on the continuous probability function's continuous sampling space [3].

In the field of health, probability distributions are frequently used in daily life. For example, the estimation of how many patients will apply to the hospital one day, how long the disease will be treated with a particular drug, the probability of a patient being discharged, the probability of dying if the patient is not bypassed, etc. situations are used in daily life.

The aim of this study is to develop a public web-based theoretical probability distributions software (KODY) that can calculate probabilities for comprehensive discrete and continuous distributions. There are calculations for The Discrete Uniform, Bernoulli, Binomial, Polynomial, Poisson, Geometric, Negative Binomial, Hypergeometric and Zeta (Zipf) distributions in the section of discrete probability distributions in software. In the section of continuous probability distributions, there are The Continuous Uniform, Beta, Normal, Log-Normal, Exponential, Gamma, Weibull, Rayleigh, Logistics, Pareto, Laplace, Cauchy and Erlang distributions. The developed software can be publicly accessed at http://biostatapps.inonu.edu.tr/KODY/.

2. MATERIALS AND METHODS

2.1.1.1. Hypothetical examples

The calculation of illustrative examples for the usability and applications of theoretical probability distributions in Medicine and other health fields was carried out with the software proposed in this study.

2.1.1.2. Theoretical Distributions

Any theoretical distribution is a mathematical function defined as $y = f(x)$. y indicates the frequency at which x values occur. $f(x)$ is also called the density function [3].

$f(x)$ has the following properties in case the x variable is continuous.

$$0 \leq f(x) \leq 1 \qquad -\infty \leq x \leq \infty \qquad \int_{-\infty}^{\infty} f(x)dx = 1$$

$f(x)$, If the variable x is discrete, it has the following properties.

$$0 \leq f(x) \leq 1 \qquad a \leq x \leq b \qquad \sum_{a}^{b} f(x) = 1$$

Parameters and related explanations of the software's theoretical probability distributions are given in Tables 1 and 2.

2.1.1.3. Discrete Probability Distributions

The discrete probability function contains a countable infinite number or finite discrete results obtained from the sample space. The discrete probability distributions used in the study are explained below.

2.1.1.4. The Discrete Uniform Distribution

It is one of the simplest of discrete uniform distributions and assumes that each of the random variables has equal probability. If X is a random variable $x1, x2, x3, ..., xk$. If it is assumed that it has equal probabilities with its values, then a discrete uniform distribution is mentioned [4].

2.1.1.5. Bernoulli Distribution

When interested in two results, which are called success and failure in an experiment, this experiment is called the (two-result) Bernoulli experiment or the Bernoulli test. For example; Bernoulli distribution is mentioned in the event that has two-state outcomes such as successful-unsuccessful, intact-broken, positive-negative, dead-alive, patient-healthy. This distribution has repeatability under the same conditions and success does not change from experiment to experiment [5].

2.1.1.6. Binomial Distribution

An experiment that occurs when a Bernoulli experiment with a probability of success is repeated n times (independently) under the same conditions is called the binomial test. The binomial test must fulfill the following conditions:

• The number of subjects in the sample or the number of trials must be constant during the experiment.

• Trials are independent from each other.

• Each attempt has two possible outcomes (desired and undesired event).

• The event probability p of interest in each trial is constant. Therefore, the probability of adverse events is invariant at $q = 1\text{-}p$.

The binomial distribution is a discrete probability distribution. When a random variable has a binomial distribution, it is denoted by $X \sim b(n, p)$. This distribution is frequently used in sampling and quality control areas in statistics [6].

2.1.1.7. Multinomial Distribution

The Multinomial Distribution is a generalized form of the binomial distribution. If there are more than two results in each trial, if the probabilities of similar results in each experiment are equal and all trials are independent from each other, then a multinomial distribution is mentioned [7].

2.1.1.8. Poisson Distribution

This distribution is used in situations where the probability of an event occurring in a given time interval is minimal. The time interval given can be in terms of minutes, days, weeks or years. For example, Poisson distribution can be used for natural disasters or rare diseases that occur in a certain year. If the number of subjects, n, is large and the probability of success p is too small, the binomial distribution approaches the Poisson distribution. In general, when $np \leq 5$, the Poisson distribution can be used instead of the binomial distribution. In addition, there is a condition that n should be greater than 20 [8].

2.1.1.9. Geometric Distribution

X, the number of experiments performed to obtain the first desired result (success or failure) in a Bernoulli experiment repeated n consecutive times, is called a geometric random variable. The distribution of this variable is called the geometric distribution. If the X random variable has a geometric distribution, it is shown in the format $X \sim$ Geo (p).

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What is desired in the geometric distribution is to determine the number of experiments required to achieve the initial success. It is a distribution used for quality control purposes [9].

2.1.1.10. Negative Binomial Distribution

The negative binomial distribution is one of the discrete probability distributions used to calculate the probability of occurrence of the rth success in an event in x trials. The assumptions required for the Bernoulli distribution are also valid for this distribution. This distribution forms the negative binomial regression analysis basis and is used in cases where the dependent variable shows a negative binomial distribution. The negative binomial distribution, which is the generalized form of the geometric distribution, is used to determine the number of experiments required to achieve k successes [10]. Variables with quantitative and discrete data types such as the number of COVİD-19 tests performed, the number of births, the number of cases, and the number of deaths can be given as examples that show a negative binomial distribution.

2.1.1.11. Hypergeometric Distribution

The hypergeometric distribution is the distribution of success numbers for an operation in which n successive objects are pulled in series without substituting them through from a finite population. The hypergeometric distribution should satisfy the following conditions:

- N trials can be repeated under similar conditions.
- Each trial has two possible results.
- Non-refundable sampling is made from the finite population.
- As the sampling is non-refundable, the probability of success (p) varies from experiment to experiment.

Hypergeometric distribution, unlike the binomial distribution, does not require independence and can be sampled without substitution. The unit tested or used in such sampling will become unusable and cannot be replaced. The hypergeometric distribution is used primarily in electronic testing and quality assurance [11].

2.1.1.12. Zeta (Zipf) Distribution

The Zipf distribution is commonly used to provide a close model for the size or rank of an object randomly chosen from certain types of populations. The Zipf random variable has wide applications when a very small number of outcomes occur quite frequently but a very large number of outcomes occur quite rarely [12].

2.1.1.13. Continuous Probability Distributions

If a continuous random variable can take every value in the range (a, b), it is said that this variable has a continuous probability distribution. Continuous Probability Distributions used in the study are explained below.

2.1.1.14. The Continuous Uniform Distribution

Let the range of variability of X Random variable be (a, b). In other words, a is the minimum value that X can have and b let X be the maximum value that it can take.

If the interval (a, b) is proportional to the probability of X, this variable has a continuous uniform distribution [13].

2.1.1.15. Beta Distribution

In probability theory and statistics, the beta distribution is a continuous probability distribution normalized with two positive shape parameters (α and β) in the range [0,1]. Beta distribution has often been applied to model random variables with finite length ranges in various domains or the random behavior of percentages and ratios [14].

2.1.1.16. Normal Distribution

Most of the methods used in practical statistics are based on Normal distribution. This distribution was first discovered in 1733 by Abraham de Moivre (1667-1745) as a distribution in which the sum of variables showing the Binomial distribution converges. The normal distribution has a bell-shaped symmetrical plot. The mean (expected value = E (x)) value for this distribution is denoted by μ. The normal scatter plot is always symmetrical with respect to the μ value. Calculations are made over this value. μ is the largest value on the chart. The continuous random variable X can take all values on the real axis under a normal distribution. So, the range $-\infty < x < +\infty$ is the range of variability. The area under the curve $f(x)$ is always 1 [15].

2.1.1.17. Log-Normal Distribution

If the logarithm X is a normally distributed log$X$~ N ((μ, σ^2) random variable, then the X random variable has a lognormal distribution. The probability density function of the random variable X can be obtained by applying a logarithmic transformation to the probability density function of the normal distribution. The probabilities of the lognormal distribution can be calculated using the standard normal distribution. In a lognormal distribution, the random variable can only take positive values [16].

2.1.1.18. Exponential Distribution

An exponential distribution occurs naturally when modeling the time interval between independent events. Exponential distribution occurs as the time until a particular event occurs. The exponential distribution is the only continuous distribution that has memoryless property. Exponential distribution can be used in modeling lifetimes. It can be used when $\alpha = 1$ in the gamma distribution and the geometric distribution used in discrete situations [17].

2.1.1.19. Gamma Distribution

The gamma distribution is frequently used in engineering, science, and business to model continuous variables with skewed distributions. The importance of the Gamma distribution stems mainly from its relationship with exponential and normal distributions. In this distribution, variables and results are always positive. Gamma distribution occurs naturally when a particular random process is considered over time [18]. For example, patients coming to the hospital need to line up in a network of clinical staff, x-ray machines, operating theaters, and beds, and the time spent on each can be defined by the gamma distribution.

2.1.1.20. Weibull Distribution

The Weibull distribution deals with the time it takes for different systems to fail. The parameters of the distribution provide great flexibility in modeling the system. Here, the error (deterioration) numbers in the system increase, decrease, or remain the same depending on time. The Weibull

distribution is a distribution with positive random variables. The cumulative probability function for the Weibull distribution is a stretched function. Weibull distribution is used to analyze life and survival data because it is very elastic and can be changed easily. Weibull is the most used statistical distribution to determine wind energy potential [19].

2.1.1.21. Rayleigh Distribution

Rayleigh distribution, a special case of the Weilbull distribution, reflects a situation in which the dimensions of a two-dimensional vector (0 origin) are normally distributed. These dimensions must also be independent and have the same variance. In this case, the size of the vector will have a Rayleigh distribution [20].

TABLE 1
PARAMETERS AND DESCRIPTIONS FOR DISCRETE PROBABILITY DISTRIBUTIONS IN THE KODY

Distribution	Parameter	Description
The Discrete Uniform	k Value	Number of random variables
Bernoulli	p Value	Probability of Success
	x Value	Random Variable
Binomial	p Value	Probability of Success
	N Value	Number of Attempts
	K Value	Number of Success
Multinomial	p1 Value	First Probability Value
	p2 Value	Second Probability Value
	p3 Value	Third Probability Value
	N Value	Number of Attempts
	X1 Value	First Random Variable
	X2 Value	Second Random Variable
	X3 Value	Third Random Variable
Geometric	p Value	Probability Value
	Step Value	It is the number of attempts made until the first success is achieved.
Hypergeometric	n Value	Sample Observation Value
	m Value	Number of Members in the Population Value
	N Value	Number of Population Members Value
	k Value	Sample Success Value
Poisson	x Value	Random Variable
	Lambda Value	Average Number of Events in a Range
Negative Binomial	p Value	Probability of Success
	N Value	Number of Trials
	K Value	Number of Success
Zeta (Zipf)	x Value	Random Variable
	s Value	Zeta Distribution Parameter

1.1.1.1. Logistic Distribution

The cumulative distribution function of the logistic distribution is a logistic function, and this function also plays a role in logistic regression and neural networks. Although the logistic distribution curve resembles the normal distribution curve in shape, it is flatter than the normal distribution curve since it has wider tails. The relevant distribution a wide range of applications from growth modeling to logistic regression analysis, from physics to hydrology, from chess score ratings to sports modeling, from logit models to artificial neural networks [21].

1.1.1.2. Pareto Distribution

There are many practical applications of the Pareto distribution in probability theory and statistics. This distribution is a continuous probability distribution or a power theory used where stability is obtained in the distribution of a "small" object to a "large" object. It is first used by Vilfredo Pareto, an Italian economist, to show the wealth distribution of individuals in economies [22].

TABLE 2
PARAMETERS AND DESCRIPTIONS FOR CONTINUOUS PROBABILITY DISTRIBUTIONS IN THE KODY

Distribution	Parameter	Description
The Continuous Uniform	x Value	Random Variable
	a Value	Minimum value of a random variable
	b Value	Maximum value of a random variable
Beta	x Value	Random Variable
	α Value	Shape Parameter
	β Value	Shape Parameter
Log Normal	μ Value	Arithmetic Mean
	Sigma Value	Standard Deviation
	x Value	Random Variable
Normal	μ Value	Arithmetic Mean
	Sigma Value	Standard Deviation
	x Value	Random Variable
Exponential	μ Value	Arithmetic Mean
	x Value	Random Variable
Gamma Distribution	N Value	N Value of Gamma
	x Value	Range Value
	Lamda Value	Ratio Parameter (λ)
Weilbull	Alfa Value	Scale Parameter
	K Value	Shape Parameter (or slope)
	x Value	Random Variable
Rayleigh	Sigma Value	Standard Deviation
	x Value	Random Variable
Logistic	μ Value	Location Parameter
	Sigma Value	Scale Parameter (σ)
	x Value	Random Variable
Pareto	Alfa Value	Location Parameter (α)
	Beta Value	Shape Parameter (β)
	x Value	Random Variable
Laplace	Lamda Value	Scale Parameter (λ)
	X Value	Random Variable
Cauchy	Alfa Value	Location Parameter (α)
	Beta Value	Scale Parameter (β)
	x Value	Random Variable
Erlang	x Value	Random Variable
	λ Value	Rate Parameter
	k Value	Shape Parameter

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1.1.1.1. Laplace Distribution

In probability theory and statistics, the Laplace distribution is a continuous probability distribution named in memory of Pierre-Simon Laplace. It is also referred to as the double exponential distribution since it consists of two exponential distributions, which are glued back to each other and combined by including a position parameter. A random variable with two independent and precisely the same exponential distribution functions as a Laplace distribution. The Laplace distribution is the distribution of the differences between two independent exponentially distributed random variables [23].

1.1.1.2. Cauchy Distribution

The Cauchy distribution plays a unique role in statistical theories. The Cauchy distribution is symmetrical and shows a bell-shaped distribution in the range of $(-\infty,\infty)$. Although the Cauchy distribution does not look very different from the normal distribution, it contains large differences compared to the normal distribution. One of these is that the mean and moment of the Cauchy distribution are absent. The standard Cauchy distribution is the same as the Student *t*-distribution with 1 degree of freedom [24].

1.1.1.3. Erlang Distribution

The Erlang distribution is a generalization of the exponential distribution. While the exponential random variable describes the time between adjacent events, the Erlang random variable describes the time interval between any event and the kth following event [25].

1.1.1.4. Web-Based Software

The theoretical probability distribution software is a web-based platform and can be used free of charge from any device(s) with an internet connection (desktop computer, laptop, mobile phone, etc.). The software was developed using the math and DASH libraries in the Python programming language [26]. The software includes English and Turkish language options. The current software can be accessed at http://biostatapps.inonu.edu.tr/KODY/.

3. RESULTS

The following examples were illustrated for binomial and Poisson distributions in order to demonstrate the working style and principle of the software.

Examples of Discrete Probability Distributions in KODY

An example for Binomial Distribution:

The probability of a successful result of a particular surgery is 80%. What is the probability that 6 out of 10 operated patients will recover? (K: Number of patients recovering after surgery)

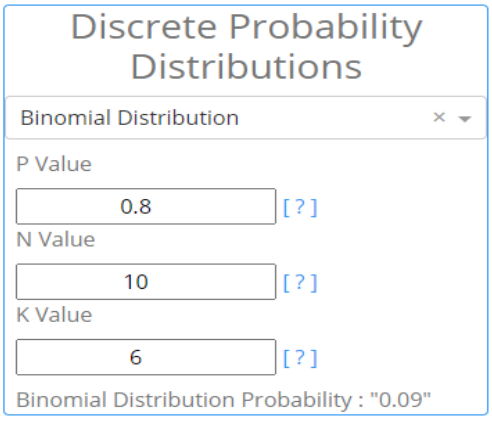

Fig.1. An example for Binominal Distribution

The average number of people who died in a week from a rare disease in a city is 4. What is the probability that three people will die from this disease in a given week?

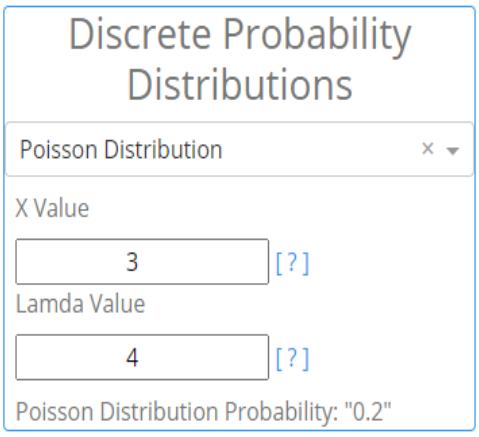

Fig.2. Examples of Poisson Distributions

An example for Normal distribution:

The average length of stay of the patients in Farabi Hospital is = 9 days, σ = 4 days. What is the probability that a randomly selected inpatient will be discharged on the 5th day?

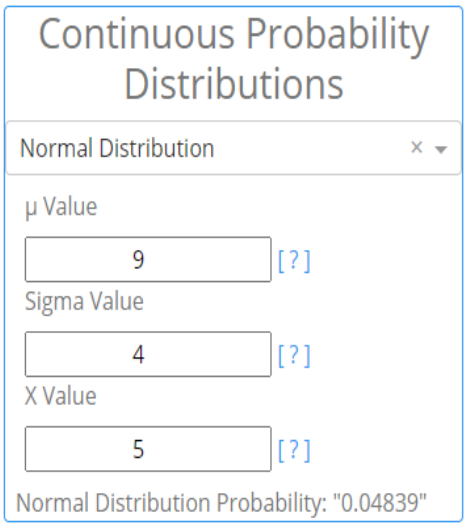

Fig.3. An example for normal distribution

It is known that the operating time (in hours) of electronic devices used in a hospital conforms to an exponential distribution and the average non-defect working

time is calculated to be 24 hours. Accordingly, what is the probability that a randomly selected device will non-defect work for 36 hours maximum?

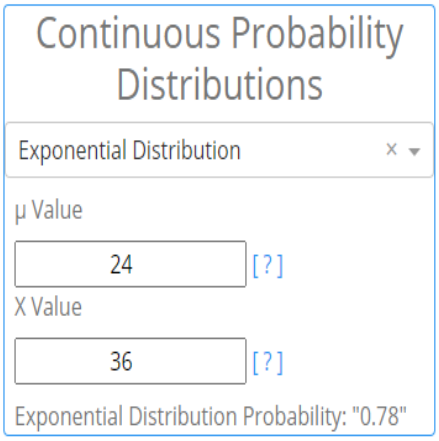

Fig.4. An example for Exponential distribution

4. DISCUSSION

Probability is one of the methods used to generalize the information obtained by examining the frequency of occurrence of an event through examples. The frequency and rate of occurrence of random events in society are called probability. When we look at the health problems examined in society, we observe that different results occur in the units under similar conditions. For this reason, health issues are random events that give different results even under stable conditions. Individuals with health problems have biological variability. Results obtained from health problems arise by chance. Thus, the concepts of probability and probability distributions are essential in medicine [27]. Therefore, in this study, a theoretical probability distribution software that includes probability calculations for comprehensive discrete and continuous probability distributions has been developed using Python programming language.

In virtually every aspect of life, randomness, and uncertainty, which always go synonymously, exist. To this effect, almost everyone, through intuition or experience, has a basic understanding of the term probability. The analysis of probability derives from the study of certain games of chance. Probability is the measure of the chance of an event occurring and, as such, finds applications in uncertain disciplines. Probability theory is used extensively, to name just a few, in a host of fields in science, engineering, medicine, and business. Probability theory is nothing but common sense reduced to calculation, as claimed by Pierre-Simon Laplace, a prominent French scholar. A probabilistic model is required in order to account for uncertainties in a random experiment. As a simplified approximation to an actual random experiment, a probability model provides sufficient details to include all significant aspects of the random phenomenon. Models of probability are generally based on the fact that averages obtained from random experiments in long sequences of independent trials almost always give rise to the same value. In many instances, this property, known as a statistical regularity, is an experimentally verifiable phenomenon. As the relative frequency of the event, the ratio representing the number of times a particular event happens over the number of times the trial has been repeated is defined. When infinity is approached by the number of times the experiment is repeated, the relative frequency of the event, which approaches a limit due to statistical regularity, is called the definition of probability of relative frequency. Note that this limit, based on an a posteriori approach, cannot really exist, because the number of times repeated in a physical experiment can be huge, but always finite [12]. In addition to applying many statistical and data science models, the theoretical distributions are frequently used in the verification of different methods in which hypothesis tests are evaluated for various assumptions or propositions. Knowing the structure of the distribution of the properties studied and predicting the occurrence of the event of interest is widely applied in biomedical research.

When the literature is examined, a web-based tool called MATCH was developed in a study to determine probability distributions about uncertain model parameters. The tool is free to use and includes five methods for extracting univariate probability distributions. These are normal, student-t, scaled beta, gamma, log-normal distributions [28]. When the MATCH tool is compared with the theoretical probability distribution software developed in this study, MATCH tool includes restricted distributions and makes parameter estimation by examining the distributions graphically. But in KODY, probability calculations for The Discrete Uniform, Bernoulli, Binomial, Multinomial, Poisson, Geometric, Negative Binom, Hypergeometric, Zeta (Zipf), The Continuous Uniform, Beta, Normal, Log Normal, Exponential, Gamma, Weibull, Rayleigh, Logistics, Pareto, Laplace, Cauchy and Erlang distributions can be performed quite easily. Probabilities for various theoretical distributions can be calculated in package programs such as Microsoft Excel [29], IBM SPSS Statistics [30], MedCalc [31], Statistica [32]. However, although these distributions are limited in the tools, most of these software are licensed/paid and cannot be easily used by researchers regardless of the platform, since they operate depending on the operating system.

In the literature, various parameters belonging to each probability distribution are used. These parameters are shown in different places in the literature with different symbols and different explanations. For this reason, we added the description of the relevant parameter for each parameter in KODY as tooltip. In this way, researchers will obtain results without error by using these tooltips while performing probabilistic calculations regarding each probability distribution in the software.

As a result, the open-access web-based software with Turkish/English language options may guide and contribute to researchers in probabilistic estimation processes regarding theoretical distributions. In the later stages of this study, it is foreseen to develop simulation processes based on each probability distribution.

REFERENCES

[1] Akdeniz, F. (1995). *Olasılık ve istatistik*. AÜ FF Döner Sermaye İşletmesi Yayınları. Beaumont, G. P. (1983). Introductory applied probability. *JOHN WILEY & SONS, INC., 605 THIRD AVE., NEW YORK, NY 10158, USA, 1983, 200*.

[2] Beaumont, G. P. (1983). Introductory applied probability. *JOHN WILEY & SONS, INC., 605 THIRD AVE., NEW YORK, NY 10158, USA, 1983, 200*.

[3] Ghahramani, S. (2000). *Fundamentals of probability* (Vol. 2). New Jersey:: Prentice Hall.

[4] Sandhya, E., & Prasanth, C. B. (2014). Marshall-Olkin discrete uniform distribution. *Journal of probability, 2014*.

[5] Dai, B., Ding, S., & Wahba, G. (2013). Multivariate bernoulli distribution. *Bernoulli, 19*(4), 1465-1483.

[6] Altham, P. M. (1978). Two generalizations of the binomial distribution. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, *27*(2), 162-167.
[7] Mosimann, J. E. (1962). On the compound multinomial distribution, the multivariate β-distribution, and correlations among proportions. *Biometrika*, *49*(1/2), 65-82.
[8] Consul, P. C., & Jain, G. C. (1973). A generalization of the Poisson distribution. *Technometrics*, *15*(4), 791-799.
[9] Philippou, A. N., Georghiou, C., & Philippou, G. N. (1983). A generalized geometric distribution and some of its properties. *Statistics & Probability Letters*, *1*(4), 171-175.
[10] Fisher, P. (1941). Negative Binomial Distribution. *Annals of Eugenics*, *11*, 182-787.
[11] Harkness, W. L. (1965). Properties of the extended hypergeometric distribution. *The Annals of Mathematical Statistics*, *36*(3), 938-945.
[12] Grami, A. (2019). *Probability, random variables, statistics, and random processes: Fundamentals & applications*. John Wiley & Sons.
[13] Kuipers, L., & Niederreiter, H. (2012). *Uniform distribution of sequences*. Courier Corporation.
[14] Gupta, A. K., & Nadarajah, S. (2004). *Handbook of beta distribution and its applications*. CRC press.
[15] Ahsanullah, M., Kibria, B. G., & Shakil, M. (2014). Normal distribution. In *Normal and Student st Distributions and Their Applications* (pp. 7-50). Atlantis Press, Paris.
[16] Mitchell, R. L. (1968). Permanence of the log-normal distribution. *JOSA*, *58*(9), 1267-1272.
[17] Balakrishnan, N. (1995). AP Basu: The Exponential Distribution: Theory, Method and Applications.
[18] Thom, H. C. (1958). A note on the gamma distribution. *Monthly weather review*, *86*(4), 117-122.
[19] Rinne, H. (2008). *The Weibull distribution: a handbook*. CRC press.
[20] Kundu, D., & Raqab, M. Z. (2005). Generalized Rayleigh distribution: different methods of estimations. *Computational statistics & data analysis*, *49*(1), 187-200.
[21] Balakrishnan, N. (1991). *Handbook of the logistic distribution*. CRC Press.
[22] Arnold, B. C. (2014). Pareto distribution. *Wiley StatsRef: Statistics Reference Online*, 1-10.
[23] Kotz, S., Kozubowski, T., & Podgorski, K. (2012). *The Laplace distribution and generalizations: a revisit with applications to communications, economics, engineering, and finance*. Springer Science & Business Media.
[24] Arnold, B. C., & Beaver, R. J. (2000). The skew-Cauchy distribution. *Statistics & probability letters*, *49*(3), 285-290.
[25] Ibe, O. (2013). *Markov processes for stochastic modeling*. Newnes.
[26] Sanner, M. F. (2004). Using the P ython programming language for bioinformatics. *Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics*.
[27] Grimmett, G., & Stirzaker, D. (2020). *Probability and random processes*. Oxford university press.
[28] Morris, D. E., Oakley, J. E., & Crowe, J. A. (2014). A web-based tool for eliciting probability distributions from experts. *Environmental Modelling & Software*, *52*, 1-4.
[29] Fylstra, D., Lasdon, L., Watson, J., & Waren, A. (1998). Design and use of the Microsoft Excel Solver. *Interfaces*, *28*(5), 29-55.
[30] Nie, N. H., Bent, D. H., & Hull, C. H. (1975). *SPSS: Statistical package for the social sciences* (Vol. 227). New York: McGraw-Hill.
[31] Schoonjans, F. R. A. N. K., Zalata, A., Depuydt, C. E., & Comhaire, F. H. (1995). MedCalc: a new computer program for medical statistics. *Computer methods and programs in biomedicine*, *48*(3), 257-262.
[32] StatSoft, I. N. C. (2001). STATISTICA (data analysis software system), version 6. *Tulsa, USA*, *150*, 91-94.

BIOGRAPHIES

Fatma Hial Yağın obtained her BSc. degree in Statistics from Gazi University in 2017. She received MSc. degree in biostatistics and medical informatics from Inonu University in 2020. She currently continues her Ph.D. education in biostatistics and medical informatics from Inonu University. In 2019, she joined the Department of Biostatistics and Medical Informatics at Inonu University as a researcher assistant. Her research interests are cognitive systems, data mining, machine learning, deep learning, and image processing.

Emek Güldoğan obtained his BSc. degree in Computer Engineering from Middle East Technical University in 2001. He received MSc. degree in biostatistics and medical informatics from the Inonu University in 2005, and Ph.D. degrees in biostatistics and medical informatics from the Inonu University in 2017. He is currently working as an assistant professor of the Department of Biostatistics and Medical Informatics at Inonu University and as the information processing manager at Turgut Özal Medical Center. His research interests are cognitive systems, data mining, machine learning, and deep learning.

Cemil Çolak obtained his BSc. degree in Statistics from Ondokuz Mayıs University in 1999. He received MSc. degree in Biostatistics from the Inonu University in 2001, and a PhD degree in the Graduate Department of Biostatistics and Medical Informatics of Ankara University in 2005. His research interests are cognitive systems, data mining, reliability, and biomedical system, genetics, and bioengineering. In 2016, he joined the Department of Biostatistics and Medical Informatics at Inonu University as a Professor, where he is presently a professor. He is active in teaching and research in general image processing, artificial intelligence, data mining, and analysis.

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