Early Warning and Physical Education Intervention of Psychological Crisis among College Students Based on Artificial Neural Network

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Abstract

The development of modern society has complicated the learning and living environment of college students, which induces significant psychological problems. However, most scholars focus on quantitative evaluation based on objective survey and statistical analysis, or contrastive experiments based on predesigned intervention methods. Few of them consider the interaction between influencing factors, and judge the degree of psychological crisis reliably. To solve the problem, this paper introduces artificial neural network (ANN) to the early warning and physical education (PE) intervention of psychological crisis among college students. Based on a reasonable index system, the psychological crisis of college students was studied with the structural equation, considering the interaction effect between influencing factors. Next, a bidirectional long short-term memory (BiLSTM) network was constructed for the analysis on the psychological crisis of college students, and the degree of psychological crisis of college students was evaluated, with the aid of emotional labeling attention mechanism. Finally, the effect of PE intervention on psychological stress easement of college students was discussed in details. The proposed method was proved valid through experiments.

Keywords: artificial neural network (ANN); psychological crisis among college students; early warning of psychological crisis; physical education (PE) intervention

1. Introduction

The development of modern society has complicated the learning and living environment of college students. The complex environment induces various stressful events, which increase the stress and negative emotions among college students. As a result, many college students face psychological problems like irritability and anxiety (Guo, He, & Guo, 2014; Hazarika, Mousavi, & Rea, 2020; Kim, Liu, & Shan, 2017; Pramana, Jagadhita, & Turnip, 2021; Wang, 2020). To ensure the healthy physical and mental development of college students in China, it is necessary to regulate their psychological problems by effective early warning and intervention of psychological crisis (Cheng, Huang, & Chiu, 2014; Fang, 2020; Li, 2013; Li et al., 2013).

Based on the scales of clinical diagnosis, the traditional screening and early warning methods for psychological crisis of college students have large errors, low efficiency, and poor timeliness (Deroche et al., 2012; Guo, Liu, & Liu, 2018; Heazlewood et al., 2011; Nagelli et al., 2019; Sidong, 2013; Wu & Huang, 2012). Based on the big data of social media, Liu et al. (2021) analyzed the psychological crisis of college students by predicting and judging their emotional changes, stressful events, and personality traits. Panqiu (2018) introduced the education of positive psychological quality into the forecast of psychological crisis among college students, and proposed countermeasures like proactive prevention, whole-process monitoring, and active intervention. Sadovnikova et al. (2018) explored the psychological problems of college students brought by traveling difficulty amidst rising learning stress and COVID epidemic, integrated the time view theory, which advocates

a balanced view of time, to regular intervention of college students' psychological crisis, and improves the intervention effect by building a flexible mind to counter negative emotions.

The psychological crisis of college students comes from various reasons. The traditional intervention mechanism has obvious defects, such as strong limitations, and significant lags (Chang & Xinyi, 2017; Katou, 2013; Pacula et al., 2014; Xiong, 2020). Anagondahalli and Turner (2012) applied mindfulness-based cognitive therapy (MBCT) to prevent the extreme behaviors of college students in psychological crisis, making the intervention more feasible and self-operable.

The cultivation of physical education (PE) talents is greatly affected by the psychological conditions of the students (Bauer & Kratschmar, 2015; Min-gang & Dan-dan, 2015; Tan, 2016). Beida and Bao (2011) classified college students by sources, compared the psychological states of PE majors and other majors, and analyzed the psychological differences between colleges students of different majors, interpersonal relationships, employment prospects, emotions, family backgrounds, and economic conditions.

On the early warning and intervention of college students' psychological crisis, the existing studies mostly carry out quantitative evaluation based on objective surveys, and statistical analysis, or conduct comparative tests based on the pre-designed intervention methods, failing to consider the interplay between influencing factors (Guan, Ma, & Yang, 2011; Huang, 2021). Some theories have emerged for applying data mining to the early warning of college students' psychological crisis, but few researchers have put these theories into practice. Some scholars even mix

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psychological crisis early warning system with psychological crisis intervention system, which threatens the reliability of the judgement for the degree of psychological crisis.

Through the above analysis, this paper introduces artificial neural network (ANN) (Guo, 2020; Huang et al., 2020; Widyaningrum et al., 2020) to the early warning and PE intervention of psychological crisis among college students. Section 2 builds up a reasonable index system, and analyzes the psychological crisis of college students based on the structural equation, considering the interaction effect between influencing factors. Section 3 constructs a bidirectional long short-term memory (BiLSTM) network for the analysis on the psychological crisis of college students, and describes the flow of judging the degree of psychological crisis of college students, under the emotional labeling attention mechanism. Section 4 analyzes the effect of PE intervention on psychological stress easement of college students. The proposed method was proved valid through experiments.

2. College Students' Psychological Crisis Analysis Based on Structural Equation and Interaction Effect

Figure 1 shows the proposed evaluation index system of psychological crisis among college students, which contains five criteria: causes, coping attitudes, stress responses, influence interventions, and symptoms. The causes of psychological crisis among college students are summarized as future pressure, major emergencies, interpersonal pressure, and economic pressure. The coping attitudes of college students to psychological crisis are negative, positive, or slack. The stress responses of college students to psychological crisis can be divided into mental response, physiological response, cognitive response, and behavioral response. The colleges students in psychological crisis can be intervened from three aspects: family, relatives and friends, and education environment. During psychological crisis, college students mainly have four symptoms: depression, anxiety, hostility, and paranoia.
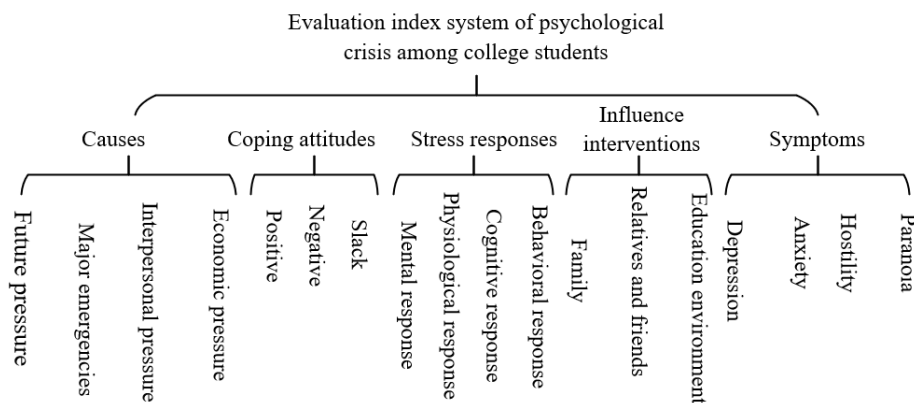

Figure 1. Evaluation index system of psychological crisis among college students

Based on the above evaluation indices, this paper sets up a structural equation model (SEM), consisting of a measurement equation and a structural equation. The indices were taken as latent variables to analyze interaction effect, and to obtain the analysis results on college students' psychological crisis. Next, a BiLSTM was established for analyzing the psychological crisis of college students. The network was coupled with the emotional label attention mechanism to judge the degree of psychological crisis of college students.

Let ε and σ be the error terms of exogenous variable a and endogenous variable b, respectively; δ and γ be the vectors made up of exogenous latent variables and endogenous latent variables, respectively; Γ_a be the relationship between an exogenous observable variable and an exogenous latent variable; Γ_b be the relationship between an endogenous observable variable and an exogenous latent variable. Then, vector A composed of exogenous observable variables can be expressed as:

$$A = \Gamma_a\delta + \varepsilon \qquad (1)$$

Vector B composed of endogenous observable variables can be expressed as:

$$B = \Gamma_b\gamma + \sigma \qquad (2)$$

Let Φ be the mutual influence between endogenous latent variables; Ψ be the influence of an exogenous latent variable on an endogenous latent variable. The unexplained part of the vector γ of endogenous latent variables in the structural equation was treated as the residual term of the equation, and combined into a vector η. Then, the relationship between latent variables can be described by a structural equation:

$$\gamma = \Phi\gamma + \Psi\delta + \eta \qquad (3)$$

The SEM was defined under the following assumptions:

(1) The means of ε and σ are both 0, i.e., $MV(\varepsilon)=0$, and $MV(\sigma)=0$;

(2) The mean of η is 0, i.e., $MV(\eta)=0$;

(3) ε and σ are not correlated with δ and γ, and ε is not correlated with σ, i.e., $cov(\varepsilon, \delta)=0$, $cov(\sigma, \gamma)=0$, and $cov(\varepsilon, \sigma)=0$;

(4) η is not correlated with δ, ε, or σ, i.e., $cov(\eta, \delta)=0$, $cov(\eta, \varepsilon)=0$, and $cov(\eta, \sigma)=0$.

Let ψ be the covariance matrix between exogenous latent variables, i.e., $MV(\delta\delta')=\psi$; Ω_ε be the covariance matrix of ε, i.e., $MV(\varepsilon\varepsilon')=\Omega_\varepsilon$; Ω_σ be the covariance matrix of σ, i.e., $MV(\sigma\sigma')=\Omega_\sigma$; Θ be the covariance matrix of η, i.e., $MV(\eta\eta')=\Theta$. Solving the covariance on both sides of formula 1:

$$cov(a) = MV\big((\Gamma_a\delta + \varepsilon)(\Gamma_a\delta + \varepsilon)'\big) = MV\big((\Gamma_a\delta + \varepsilon)(\delta'\Gamma_a' + \varepsilon')\big) = \Gamma_a MV(\delta\delta')\Gamma_a' + MV(\varepsilon\varepsilon') = \Gamma_a\psi\Gamma_a' + \Omega_\varepsilon \qquad (4)$$

The covariance matrix of exogenous variable a can be given by:

$$\sum_{aa}(\phi) = \Gamma_a MV(\gamma\gamma')\Gamma'_a + \Omega_\varepsilon \qquad (5)$$

Similarly, the covariance matrix of endogenous variable b can be given by:

$$\sum_{bb}(\phi) = \Gamma_b MV(\gamma\gamma')\Gamma'_b + \Omega_\sigma \qquad (6)$$

Suppose $J\text{-}\Phi$ is reversible. Formula 3 can be transposed into:

$$\gamma = (J - \Phi)^{-1}(\Psi\delta + \eta) = \widehat{\Phi}(\Psi\delta + \eta) \qquad (7)$$

Solving formula 7:

$$MV(\gamma\gamma') = MV\left[\left(\widehat{\Phi}(\Psi\delta + \eta)\right)\left(\widehat{\Phi}(\Psi\delta + \eta)\right)'\right] =$$
$$MV\left[\left(\widehat{\Phi}(\Psi\delta + \eta)\right)\left(\widehat{\Phi}(\Psi' + \eta)\right)\widehat{\Phi}'\right] = \widehat{\Phi}[\Psi MV(\delta\eta')\Psi' + MV(\delta\eta')]\widehat{\Phi}' = \widehat{\Phi}(\Psi\psi\Psi' + \Theta)\widehat{\Phi}' \qquad (8)$$

Combining formula 8 with the covariance matrix of b:

$$\sum_{bb}(\phi) = \Gamma_b \widetilde{\Phi}(\Psi\psi\Psi' + \Theta)\widetilde{\Phi}'\Gamma_b' + \Omega_\sigma' \qquad (9)$$

The covariance matrix of a and b can be expressed as:

$$\sum_{ba}(\phi) = MV(ba') = MV[(\Gamma_b\gamma + \sigma)(\Gamma_a\delta + \varepsilon')] =$$
$$MV[(\Gamma_b\gamma + \sigma)(\delta'\Gamma_a' + \varepsilon')] = \Gamma_b MV(\gamma\delta')\Gamma_a' + MV(\sigma\varepsilon') =$$
$$\Gamma_b MV(\gamma\delta')\Gamma_a' = \Gamma_b MV(\widehat{\Phi}(\Psi\delta + \eta)\delta')\Gamma_a' =$$
$$\Gamma_b \widehat{\Phi}\Psi MV(\delta\delta')\Gamma_a' = \Gamma_b \widehat{\Phi}\Psi\psi\Gamma_a' \qquad (10)$$

Similarly, it can be deduced that:

$$\sum_{ab}(\phi) = MV(ab') = \Gamma_a\psi\Psi\widehat{\Phi}\Gamma_b' \qquad (11)$$

The covariance matrix of $(b', a)'$ can be expressed as:

$$\Sigma(\phi) = \begin{pmatrix} \sum bb(\phi) & \sum ba(\phi) \\ \sum ab(\phi) & \sum aa(\phi) \end{pmatrix} =$$
$$\begin{pmatrix} \Gamma_b \widehat{\Phi}(\Psi\psi\Psi' + \Phi)\widehat{\Phi}'\Gamma_b' + \Omega_\sigma & \Gamma_b\widehat{\Phi}\Psi\psi\Gamma_a' \\ \Gamma_a\psi\Psi'\widehat{\Phi}\Gamma_b' & \Gamma_a\psi\Gamma_a' + \Omega_\varepsilon \end{pmatrix} \qquad (12)$$

Formula 12 shows that the SEM of the degree of psychological crisis among college students involves parameter matrices like Γ_a, Γ_b, Φ, Ψ, ψ, Θ, Ω_ε and Ω_σ. Solving the model is equivalent to the estimation of these parameters.

Suppose δ_1 is an exogenous latent variable containing four observable variables a1, a2, a3 and a4, δ_2 is an exogenous latent variable containing three observable variables a5, a6 and a7, δ_3 is an exogenous latent variable containing four observable variables a8, a9, a10 and a11, δ_4 is an exogenous latent variable containing three observable variables a12, a13 and a14, δ_5 is an exogenous latent variable containing four observable variables a_{15}, a_{16}, a_{17} and a_{18}, and γ is an endogenous latent variable containing four observable variables b_1, b_2, b_3 and b_4. It is assumed that δ_1, δ_2, δ_3, δ_4 and δ_5 interact with each other, and their independent and interaction terms both affect γ. The 10 interaction terms can be obtained by product operation of the five independent terms of δ_1, δ_2, δ_3, δ_4 and δ_5.

Assuming that all indices have been decentralized, the observable variable corresponding to each secondary index can be measured by:

$$\begin{cases} a_1 = \delta_1 + \varepsilon_1 \\ a_2 = \mu_2\delta_1 + \varepsilon_2 \\ a_3 = \mu_3\delta_1 + \varepsilon_3 \\ a_4 = \mu_4\delta_1 + \varepsilon_4 \end{cases} \qquad (13)$$

$$\begin{cases} a_5 = \delta_2 + \varepsilon_5 \\ a_6 = \mu_6\delta_2 + \varepsilon_6 \\ a_7 = \mu_7\delta_2 + \varepsilon_7 \end{cases} \qquad (14)$$

$$\begin{cases} a_8 = \delta_3 + \varepsilon_8 \\ a_9 = \mu_9\delta_3 + \varepsilon_9 \\ a_{10} = \mu_{10}\delta_3 + \varepsilon_{10} \\ a_{11} = \mu_{11}\delta_3 + \varepsilon_{11} \end{cases} \qquad (15)$$

$$\begin{cases} a_{12} = \delta_4 + \varepsilon_{12} \\ a_{13} = \mu_{13}\delta_4 + \varepsilon_{13} \\ a_{14} = \mu_{14}\delta_4 + \varepsilon_{14} \end{cases} \qquad (16)$$

$$\begin{cases} a_{15} = \delta_5 + \varepsilon_{15} \\ a_{16} = \mu_{16}\delta_5 + \varepsilon_{16} \\ a_{17} = \mu_{17}\delta_5 + \varepsilon_{17} \\ a_{18} = \mu_{18}\delta_5 + \varepsilon_{18} \end{cases} \qquad (17)$$

The four observable variables b_1, b_2, b_3 and b_4 of the degree of psychological crisis among college students can be measured by:

$$\begin{cases} b_1 = \upsilon_{b1} + \gamma + \sigma_1 \\ b_2 = \upsilon_{b2} + \mu_{b2}\gamma + \sigma_2 \\ b_3 = \upsilon_{b3} + \mu_{b3}\gamma + \sigma_3 \\ b_4 = \upsilon_{b4} + \mu_{b4}\gamma + \sigma_4 \end{cases} \qquad (18)$$

Let Σ be the sum of interaction terms; β_1, β_2, β_3, β_4 and β_5 be the main effect coefficients; β_6 be the interaction effect coefficient. Then, the structural equation can be established as:

$$\gamma = \beta_1\delta_1 + \beta_2\delta_2 + \beta_3\delta_3 + \beta_4\delta_4 + \beta_5\delta_5 + \beta_6 \sum_{i,j=1,i\neq j}^{5}(\delta_i\delta_j -) + \eta \qquad (19)$$

If the SEM has no mean, then the four observable variables b_1, b_2, b_3 and b_4 can be measured by:

$$\begin{cases} b_1 = \gamma + \sigma_1 \\ b_2 = \mu_{b2}\gamma + \sigma_2 \\ b_3 = \mu_{b3}\gamma + \sigma_3 \\ b_4 = \mu_{b4}\gamma + \sigma_4 \end{cases} \qquad (20)$$

The corresponding structural equation can be given by:

$$\gamma = \beta_1\delta_1 + \beta_2\delta_2 + \beta_3\delta_3 + \beta_4\delta_4 + \beta_5\delta_5 + \beta_6 \sum_{i,j=1,i\neq j}^{5}\left(\delta_i\delta_j - MV(\delta_i\delta_j)\right) + \eta \qquad (21)$$

3. BiLSTM-Based Analysis of Psychological Crisis among College Students

The LSTM controls the index information flow of the current network with one memory cell MU, and three gates, namely, an input gate EN, a forget gate YW, and an output gate EX. Let $g_{\tau-1}$ be the state of the memory cell at the previous moment; EN_τ be the input of the index information; Q_{YW} be the matrix multiplication of the forget gate; r_{YW} be the bias of the forget gate function; ζ be the sigmoid function. Then, the forget gate of the LSTM can operate by the following mechanism:

$$YW_\tau = \zeta(Q_{YW}[g_{\tau-1}EN_\tau] + r_{YW}) \qquad (22)$$

Let T be tanh function; Q_{MU} be the matrix multiplication of the input gate; r_{MU} be the bias of the input gate function. Then, the input gate of the LSTM can operate by the following mechanism:

$$I_\tau = \zeta(Q_I[g_{\tau-1}EN_\tau] + r_I) \qquad (23)$$
$$MU_\tau = T(Q_{MU}[g_{\tau-1}EN_\tau] + r_{MU}) \qquad (24)$$
$$MU_\tau^* = YW_\tau * MU_{\tau-1} + I_\tau * MU_\tau \qquad (25)$$

Let Q_{EX} be the matrix multiplication of the output gate; r_{EX} be the bias of the output gate function. Then, the output gate of the LSTM can operate by the following mechanism:

$$EX_\tau = \zeta(Q_{EX}[g_{\tau-1}EN_\tau] + r_{EX}) \qquad (26)$$
$$g_\tau = EX_\tau * T(MU_\tau) \qquad (27)$$

Our research and experimental dataset not only contains the data of psychological crisis evaluation for college students, but also covers the texts on the interviews and comments on motional confession of college students about their psychological stress and emotions (hereinafter referred to as the IC texts for short). The sentence vectors of the above texts constitute an unlabeled training set, which is suitable for training large, unlabeled corpus. Figure 2 provides the structure of psychological crisis analysis model for college students.
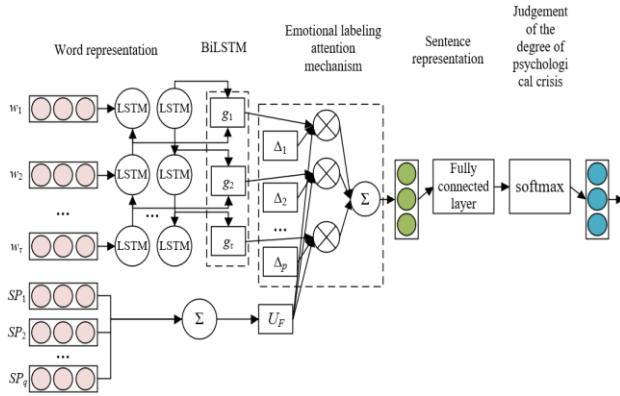
Figure 2. Structure of psychological crisis analysis model for college students

Suppose the longest IC text has m semantic units, which are converted into a series of word vectors w_l after neural network training. There are many emotional labels in the set of training sentence vectors. Each emotional label has a unique semantic code. During neural network training, the code is defined as a special word vector SP_i. Then, the word vector matrix GD^Q of an IC text obeying sequential distribution can be expressed as:

$$GD^Q = w_1 \oplus w_2 \oplus \ldots \oplus w_l \qquad (28)$$

Similarly, the emotional labels can be stitched into an emotional space matrix GD^F of the same dimensions as GD^Q, that is, $[SP_1, SP_2, \ldots, SP_q]$:

$$GD^F = SP_1 \oplus SP_2 \oplus \ldots \oplus SP_q \qquad (29)$$

If the text has fewer than m semantic units, full zero vectors of different lengths can be added to the end of GD^Q to ensure the dimensional consistency between all word vector matrices. GD^Q and GD^F can be connected into a complete IC text vector matrix GD:

$$GD = GD^F + GD^Q \qquad (30)$$

Our research focuses on the effect of emotional labels on text. Therefore, the emotional features were extracted from the target text, and added to the emotional label attention mechanism. Then, GD^Q was used to replace GD as the input of the proposed neural network for the extraction of psychological stress and emotional eigenvectors of college students.
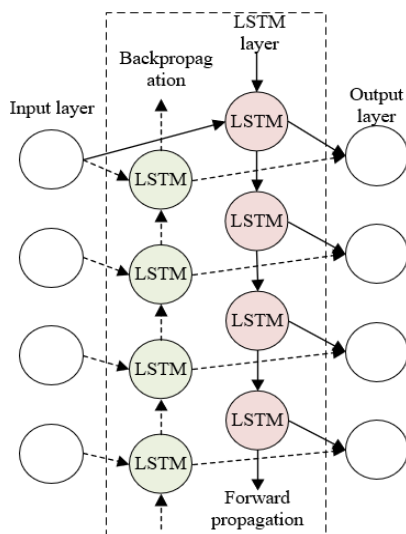

Figure 3. Structure of BiLSTM

In our psychological crisis analysis model for college students, the LSTM obtains GD^Q information from two opposite directions (forward and reverse directions), and keeps the inputs in the two directions consistent. Figure 3 shows the structure of the designed BiLSTM. The final output of the network is the deep word vector feature DH of the class for the degree of psychological crisis among college students:

$$DH = \begin{pmatrix} DH_1 \\ DH_2 \\ \vdots \\ DH_n \end{pmatrix} \qquad (31)$$

The word vector U_F with emotional label can be defined as:

$$U_F = \sum_{p=1}^{i} SP_p \qquad (32)$$

Text sentence combined with emotional label can be expressed as:

$$HQ = \sum_{p=1}^{l} \Delta_p DH_p \qquad (33)$$

where, Δp is the degree of importance of the p-th word in the emotional labeled text sentence to the judgement of the degree of psychological crisis among college students, i.e., the attention weight of the p-th word in the text sentence. This index helps to accurately determine whether emotional label enhances or weakens the emotion. The weight of emotional label can be calculated by:

$$\Delta_p = \frac{e^{IM(DH_p, U_F)}}{\sum_{j=1}^{l} e^{IM(DH_p, U_F)}} \qquad (34)$$

Let ω_R and ω_D be weight matrices; r be the bias. The degree of importance of a word in the emotional labeled text can be measured by:

$$IM(g_p, U_F) = U^T T(\omega_R g_p + \omega_D U_F + r) \qquad (35)$$

Formula 35 shows that, during the processing of emotional label attention mechanism, the final output vector HQ of the emotional label attention mechanism layer can be derived from Δp.

Figure 4 explains the evaluation flow of psychological crisis among college students under emotional labeling attention mechanism.
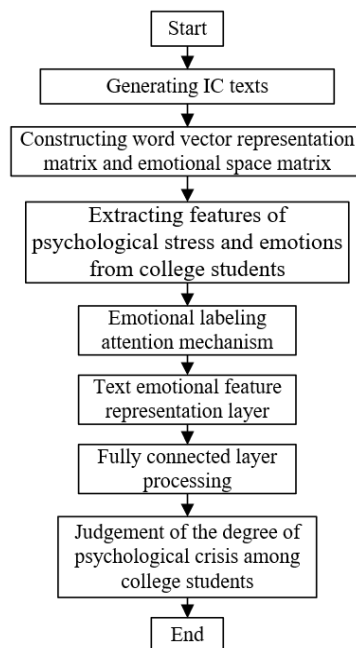

Figure 4. Evaluation flow of psychological crisis among college students under emotional labeling attention mechanism

Four target classes b_i were designed for the psychological crisis among college students: healthy, poor, disorderly, and ill. This paper classifies the degree of psychological crisis with the normalized index function softmax, which maps each element in HQ to (0, 1), and classifies the elements according to the probabilities of belonging to the four target classes. Let i be the number of actual classes of objects. Then, the probability distribution of membership can be calculated by:

$$GV_i(b) = \frac{e^{b_i}}{\sum_{j=1}^{l} e^{b_i}}, i = 1,2,3,\dots,l \tag{36}$$

To ensure the accurate classification of the degree of psychological crisis among college students, the error between the predicted and actual probabilities for an object to belong to a class can be measured by the cross-entropy loss function:

$$K = -\sum_{e \in E} \sum_{s=1}^{S} GV_s^H(e) \log(GV_s(e)) \tag{37}$$

4. Effect of PE Intervention on Psychological Stress Easement of College Students

To further explore the relationship between psychological stress easement and PE intervention, a stochastic effect model was adopted to test the longitudinal time effect of PE intervention on psychological stress.

The stochastic effect model was constructed to observe and describe the changes in psychological stress of the college students. On the first layer of the model, the independent variable is PE intervention intensity (PEI), and the dependent variable is the psychological stress easement (PSE):

$$PSE = \alpha_0 + \alpha_1(TIME) + \alpha_2(PEI) + \theta \tag{38}$$

Suppose α_0, α_1 and α_2 consist of a fixed effect θ_0, θ_1 and θ_2, and a random effect λ_0, λ_1 and λ_2, respectively. Taking time as the control variable, the second layer of the model can be constructed as:

$$\alpha_0 = \theta_0 + \lambda_0 \tag{39}$$

$$\alpha_1 = \theta_1 + \lambda_1 \tag{40}$$

$$\alpha_2 = \theta_2 + \lambda_2 \tag{41}$$

To explain the difference in the emotional trend of psychological stress easement among college students, the low-level or high-level explained variable of PEI could be introduced to the second layer of the model. Suppose PE intervention intensity PEI_L is the independent variable, and psychological stress easement PSE_L is the dependent variable of the first layer. Under the regulation of low PEI, the model can be constructed as:

$$PSE_L = \alpha_{L-0} + \alpha_{L-1}(TIME_L) + \alpha_{L-2}(PEI_L) + \theta_L \tag{42}$$

where,

$$\alpha_{L-0} = \theta_{L-0} + \theta'_{L-0}(PEI_L) + \lambda_{L-0} \tag{43}$$

$$\alpha_{L-1} = \theta_{L-1} + \lambda_{L-1} \tag{44}$$

$$\alpha_{L-2} = \theta_{L-2} + \theta'_{L-2}(PEI_L) + \lambda_{L-2} \tag{45}$$

Under the regulation of high PEI_L, the model can be constructed as:

$$PSE_H = \alpha_{H-0} + \alpha_{H-1}(TIME_H) + \alpha_{H-2}(PEI_H) + \theta_H \tag{46}$$

where,

$$\alpha_{H-0} = \theta_{H-0} + \theta'_{H-0}(PEI_H) + \lambda_{H-0} \tag{47}$$

$$\alpha_{H-1} = \theta_{H-1} + \lambda_{H-1} \tag{48}$$

$$\alpha_{H-2} = \theta_{H-2} + \theta'_{H-2}(PEI_H) + \lambda_{H-2} \tag{49}$$

5. Experiments and Results Analysis

Table 1 presents the correlation coefficients between the five primary indices for psychological crisis among college students, namely, causes, coping attitudes, stress responses, influence interventions, and symptoms. The correlation coefficients between the indices fell in 0.345-0.562, a sign of medium correlation. The correlation coefficients between each index and total score fell in 0.613-0.785, indicating high correlations. Therefore, our evaluation index system has high structural validity.

Table 1

Correlation coefficients between primary indices

Latent variable	δ_1	δ_2	δ_3	δ_4	δ_5	Total score
δ_1	1.000					
δ_2	0.562	1.000				
δ_3	0.507	0.543	1.000			
δ_4	0.376	0.371	0.476	1.000		
δ_5	0.345	0.413	0.462	0.475	1.000	
Total score	0.785	0.753	0.735	0.657	0.613	1.000

Table 2

Recognition of psychological crisis among college students before and after the introduction of emotional labeling attention mechanism

System	Level of psychological crisis	P (%)	R (%)	F (%)
Pre-introduction	Healthy	74.62	78.91	75.41
	Poor	77.93	77.86	75.72
	Disorderly	75.87	78.37	72.37
	Ill	81.87	80.37	79.37
Post-introduction	Healthy	85.21	86.49	86.63
	Poor	85.76	81.28	87.09
	Disorderly	82.09	85.74	83.25
	Ill	81.23	80.34	81.32

Table 2 compares the recognized levels of psychological crisis among college students before and after the introduction of emotional labeling attention mechanism. The comparison reveals that the recognition accuracy of psychological crisis varied with the emotional labels. Before the mechanism was introduced, the ill-level psychological crisis was recognized relatively accurately (80%). After the mechanism was introduced, all four classes of psychological crisis were recognized with an accuracy surpassing 80%. Therefore, our psychological crisis analysis model, which integrates emotional labeling attention mechanism, performs better than the ordinary psychological crisis analysis model, which does not consider emotional labels.

Table 3

Index scores of target college students and Chinese college student norm

Latent variables	Target college students	Norm	t	p
δ_1	2.31±0.57	2.09±0.54	4.572	0.000
δ_2	2.02±0.65	1.82±0.65	1.237	0.231
δ_3	1.93±0.67	1.82±0.65	3.723	0.000
δ_4	1.87±0.60	1.79±0.65	4.256	0.000
δ_5	1.80±0.53	1.82±0.65	4.429	0.804

Table 3 compares the index scores of target college students with those of Chinese college student norm. It can be seen that the target college students received high scores on causes, coping attitudes, and stress responses, suggesting that they are very likely to have psychological crisis in these three aspects. The target college students differed greatly in coping attitudes and stress responses from the norm, that is, they face more severe psychological crisis than the national average in these two aspects.

Table 4

Index scores of college students in different grades

Latent variables	Grade 1	Grade 2	Grade 3	t	p
δ_1	1.32±0.32	1.50±0.39	1.22±0.39	3.651	0.027
δ_2	2.25±0.78	2.30±0.27	2.25±0.47	1.023	0.364
δ_3	2.01±0.63	2.02±0.63	2.01±0.63	0.067	0.932
δ_4	1.97±0.65	1.96±0.62	1.84±0.65	0.834	0.431
δ_5	1.81±0.50	1.87±0.50	1.79±0.53	1.036	0.356
Total score	17.32±4.65	16.54±4.46	16.69±4.66	0.842	0.439

Table 5

Criteria level scores of test group and control group

Latent variables	Target college students	Norm	p	Latent variables	Target college students	Norm	p
a_1	1.73±0.43	1.65±0.56	0.427	a_{10}	1.32±0.48	1.43±0.56	0.511
a_2	1.54±0.42	1.52±0.47	1.000	a_{11}	1.56±0.44	1.58±0.49	0.416
a_3	2.07±0.76	2.04±0.81	0.763	a_{12}	2.17±0.78	2.11±0.04	0.673
a_4	1.84±0.52	1.79±0.57	0.386	a_{13}	1.46±0.53	1.42±0.56	0.311
a_5	1.75±0.51	1.62±0.63	0.375	a_{14}	1.88±0.55	1.64±0.68	0.453
a_6	1.72±0.53	1.68±0.72	0.637	a_{15}	1.71±0.56	1.62±0.77	0.533
a_7	1.71±0.42	1.42±0.67	0.784	a_{16}	1.74±0.44	1.53±0.61	0.241
a_8	1.57±0.48	1.71±0.53	0.752	a_{17}	1.67±0.48	1.79±0.11	0.236
a_9	1.74±0.56	1.72±0.62	0.863	a_{18}	1.75±0.51	1.81±0.63	0.866

As shown in Figure 5 and Table 5, statistical t-test confirms the significant differences between the test group and the control group on all 10 psychological crisis symptoms. Therefore, the test group greatly outshines the control group in psychological stress easement, after taking four more physical exercises per week (a total of 120min). This means PE intervention simultaneously promotes physical and mental health, improve body functions, stimulate the secretion of endorphin, and enhance subjective physiological comfort, thereby accelerating the recovery from psychological crisis.

After the PE intervention, great changes took place in the total score, and the criterial level scores of psychological crisis

Table 4 compares the index scores of college students in different grades. Except for causes, there was no significant difference in any other index between college students in different grades. Whichever the grade, the college students scored high on coping attitudes, stress responses, and influence intervention. Therefore, the college students tend to suffer from psychological crisis in these three aspects. The total score indicates that psychological crisis is most likely to occur among grade 1 students, followed in turn by grade 3 students, and grade 2 students.
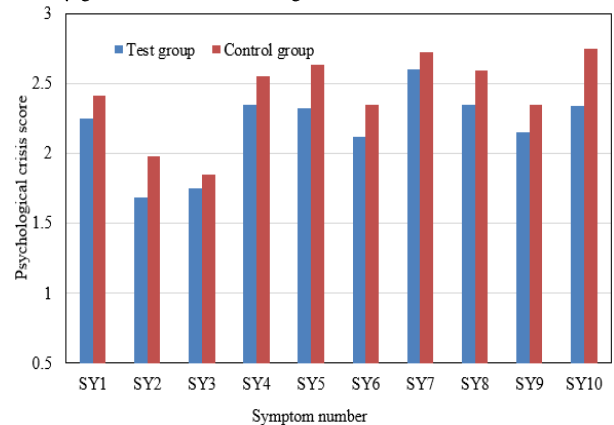

Figure 5. Psychological crisis scores of test group and control group

The target college students were divided into a test group (receiving PE intervention) and a control group. Their psychological crisis level was evaluated against 10 symptoms, namely, depression, anxiety, and hostility. Figure 5 compares the psychological crisis scores of test group and control group. Table 5 compares the scores of each criterion between the two groups.

evaluation. On the distribution of symptom scores, 4 and 5 college students in the test group had poor to disorderly symptoms, while 11 and 8 in the control group had these two symptoms. Hence, the psychological crisis scores of the test group are generally lower than those of the control group. In addition, the test group differed significantly from the control group in mean psychological health score, anxiety, and somatization, and very significantly in hostility. Therefore, it is clearly demonstrated that the test group significantly outperforms the control group in overall psychological health, anxiety, somatization, and hostility, thanks to the four additional physical exercises per week (a total of 120min).

Table 6

Influence of PE intervention on psychological crisis of college students

Dependent variable		Fixed effects				Random effects	
Psychological stress easement of college students		Coefficient	Standard error SE	T value		Variance SD	Chi-square x^2
	θ_0	1.75	0.08	35.62	λ_0	0.07	267.35
	θ_1	0.00	0.03	-0.13	λ_1	0.00	152.93
	θ_2	0.37	0.05	5.36	λ_2	0.09	202.76

Table 6 shows the influence of PE intervention on psychological crisis of college students. On the fixed effects, the PE intervention intensity significantly promoted the psychological stress easement of college students, while the time variable had no impact on the latter factor. Therefore, the psychological stress easement of college students does not change linearly with the elapse of time, but increases with the PE intervention intensity. On the random effects, the intercepts of different college students change significantly, which signifies the prominent individual difference in psychological stress easement of college students under the same intensity of PE intervention. Thus, it is necessary to find the causes of the individual difference.

Table 7

Regulation of low PEI on psychological crisis of college students

Dependent variable		Fixed effects				Random effects	
Psychological stress easement of college students		Coefficient	Standard error SE	T value		Variance SD	Chi-square x^2
	$\theta_{L\text{-}0}$	1.72	0.02	38.54	$\mu_{L\text{-}0}$	0.07	245.84
	$\theta'_{L\text{-}0}$	-0.24	0.03	-6.72			
	$\theta_{L\text{-}2}$	0.35	0.04	5.43	$\mu_{L\text{-}2}$	0.06	194.38
	$\theta'_{L\text{-}2}$	-0.13	0.05	-1.15			

Next, the PE intervention intensity PEI was introduced to create new random effects models. Table 7 illustrates the regulation of low PEI on psychological crisis of college students. The results show that a low PEI had no significant effect on the psychological stress easement of college students. Every unit of increment in low PEI led to 0.19 unit of decrease in psychological stress among college students, that is, the influence curve of low PEI on psychological stress easement has a small slope. The introduction of low PEI changed the residual variation of the intercept from 0.069 to 0.031. Therefore, low PEI does not significantly regulate the influence of PE intervention on the psychological stress easement of college students.

Table 8

Regulation of high PEI on psychological crisis of college students

Dependent variable		Fixed effects				Random effects	
Negative emotions		Coefficient	Standard error SE	T value		Variance SD	Chi-square x^2
	$\theta_{H\text{-}0}$	1.75	0.02	38.72	$\mu_{H\text{-}0}$	0.07	247.05
	$\theta'_{H\text{-}0}$	-0.16	0.03	-4.89			
	$\theta_{H\text{-}2}$	0.37	0.05	5.27	$\mu_{H\text{-}2}$	0.06	192.37
	$\theta'_{H\text{-}2}$	-0.24	0.06	-2.31			

Table 8 displays how high PEI regulates psychological crisis of college students. It can be seen that the high PEI negatively predicted the psychological stress easement of college students. Every unit of increment in high PEI led to 0.25 unit of decrease in psychological stress among college students, that is, the influence curve of high PEI on psychological stress easement has a large slope. The introduction of high PEI changed the residual variation of the intercept from 0.085 to 0.042. Therefore, high PEI does significantly regulate the influence of PE intervention on the psychological stress easement of college students.

The above experiments show that, in this research, the psychological stress, negative emotions, and PEI of college students were tracked and measured in daily life. The random survey can capture the real situation of college students, and better judge their psychological stress, state of negative emotions, and PE intervention effect. The research results were basically consistent with those of previous studies: PE intervention has a close relationship with emotional response, and PE intervention can regulate the emotions of each individual. Some studies have suggested that, to manage the emotions of an individual, multiple factors could be adopted to regulate the negative emotions under individual psychological stress. Thus, this paper holds that the influence of psychological stress on negative emotions varies with college students, because the individuals perceive psychological stress differently.

5 Conclusions

This paper introduces the ANN to the early warning and PE intervention of psychological crisis among college students. Firstly, an evaluation index system was established for psychological crisis among college students, and used to construct the structural

equation for psychological crisis analysis. The interaction effect between influencing factors was analyzed in details. Next, a BiLSTM was proposed, the judgement flow of psychological crisis level was clarified, based on emotional labeling attention mechanism. Finally, the authors analyzed the influence of PE intervention on psychological stress easement of college students. Through experiments, the correlation coefficients between the selected evaluation indices were summarized, which reflects the good structural validity of the proposed evaluation index system. Further, the psychological crisis scores and criteria level cores were compared between the test group and the control group. The comparison confirms that PE intervention promotes the psychological stress easement of college students, and the high PEI significantly regulates the influence of PE intervention on the psychological stress easement of college students.

Our results not only enrich the relevant research, but also provide some constructive suggestions. On the one hand, the suggestions help competent department of education, colleges, and PE teachers to focus on improving students' psychological health, and carrying out more pertinent PE activities. On the other hand, the suggestions enable college students to get involved in PE activities, and enhance their psychological health through these activities.

This paper achieves some results in tracking the psychological health and PE of college students. But there are several limitations to be solved: Firstly, the subjects are limited to college students. The research range will be expanded in future. Secondly, the PE activities were measured subjectively. The future work will combine subjective measurement with objective measurement, and evaluate the level of physical literacy of the subjects.

References

Anagondahalli, D., & Turner, M. M. (2012). Predicting psychological ripple effects: The role of cultural identity, in-group/out-group identification, and attributions of blame in crisis communication. *Risk Analysis: An International Journal, 32*(4), 695-712. https://doi.org/10.1111/j.1539-6924.2011.01727.x

Bauer, C., & Kratschmar, A. (2015). Designing a music-controlled running application: A sports science and psychological perspective. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 1379-1384). ACM Digital Library. https://doi.org/10.1145/2702613.2732736

Beida, T., & Bao, X. (2011). Psychological intervention mechanism in public crisis information communication. In *2011 IEEE 2nd International Conference on Software Engineering and Service Science* (pp. 776-779). IEEE. https://doi.org/10.1109/ICSESS.2011.5982451

Chang, Q., & Xinyi, L. (2017). Psychological crisis of college students in a computer network environment. *AGRO Food Industry Hi-Tech, 28*(1), 1963-1966. https://www.teknoscienze.com/tks_issue/vol_281

Cheng, W.-Y., Huang, P.-H., & Chiu, M.-C. (2014). Integrating Physiological and Psychological Techniques to Measure and Improve Usability: an Empirical Study on Kinect Applying of Health Management Sport. *International Journal of Industrial Engineering: Theory, Applications, and Practice, 21*(6), 304-316. https://doi.org/10.23055/ijietap.2014.21.6.1208

Deroche, T., Stephan, Y., Woodman, T., & Le Scanff, C. (2012). Psychological mediators of the sport injury—perceived risk relationship. *Risk Analysis: An International Journal, 32*(1), 113-121. https://doi.org/10.1111/j.1539-6924.2011.01646.x

Fang, L. (2020). The Prevention and Analysis of College Students' Psychological Crisis Based on Data Mining Technology. In *International conference on Big Data Analytics for Cyber-Physical-Systems* (pp. 1505-1509). Springer. https://doi.org/10.1007/978-981-33-4572-0_218

Guan, H. J., Ma, G. S., & Yang, S. H. (2011). Research on college students' psychological crisis prevention and control system based on network technology and multi-system agent. *Advances in Information Sciences and Service Sciences, 3*(3), 11-18. https://doi.org/10.4156/aiss.vol3.issue3.2

Guo, J., Liu, S., & Liu, X. (2018). Construction of visual cognitive computation model for sports psychology based on knowledge atlas. *Cognitive Systems Research, 52*, 521-530. https://doi.org/10.1016/j.cogsys.2018.07.028

Guo, N., He, Y., & Guo, X. S. (2014). Research on analytic hierarchy process-based sports events impacts on university students' psychological health. *BioTechnology: An Indian Journal, 10*(7), 2184-2191. https://www.tsijournals.com/articles/research-on-analytic-hierarchy-processbased-sports-events-impacts-on-university-students-psychological-health.pdf

Guo, Q. (2020). Detection of Head Raising Rate of Students in Classroom Based on Head Posture Recognition. *Traitement du Signal, 37*(5), 823-830. https://doi.org/10.18280/ts.370515

Hazarika, B., Mousavi, R., & Rea, A. (2020). The effectiveness of institutional structures to minimize concerns in fantasy sports sites: Psychological contract violation mitigation. *Human Systems Management, 39*(2), 277-292. https://doil.org/10.3233/HSM-190709

Heazlewood, I., Walsh, J., Climstein, M., Burke, S., Kettunen, J., Adams, K., & DeBeliso, M. (2011). Sport psychological constructs related to participation in the 2009 world masters games. *World Academy of Science, Engineering and Technology, 7*, 2027-2032. https://www.researchgate.net/profile/Joe-Walsh/publication/289701117

Huang, S. (2021). Analysis of psychological teaching assisted by artificial intelligence in sports training courses. *Journal of Applied Science and Engineering, 24*(5), 743-748. https://doi.org/10.6180/jase.202110_24(5).0008

Huang, W., Li, N., Qiu, Z., Jiang, N., Wu, B., & Liu, B. (2020). An Automatic Recognition Method for Students' Classroom Behaviors Based on Image Processing. *Traitement du Signal, 37*(3), 503-509. https://doi.org/10.18280/ts.370318

Katou, A. A. (2013). The link between HR practices, psychological contract fulfilment, and organisational performance in Greece: An economic crisis perspective. *Journal of Industrial Engineering and Management (JIEM), 6*(2), 568-594. https://doi.org/10.3926/jiem.501

Kim, Y., Liu, Y., & Shan, Z. (2017). Beyond touchdown: College students' sports participation, social media use, college attachment, and psychological well-being. *Telematics and Informatics, 34*(7), 895-903. https://doi.org/10.1016/j.tele.2017.03.006

Li, J. (2013). Psychological analysis and suggestions given on sports consumption of urban residents in Shannxi Province. *BioTechnology: An Indian Journal, 8*(5), 653-658. https://www.tsijournals.com/articles/psychological-analysis--suggestions-given-on-sports-consumption-of-urban-residents-in-shannxi-province.pdf

Li, M. L., Deng, Y. L., Yu, R. H., Zhang, J., & Wen, H. (2013). Time series analysis of sports activity's influence on psychological health based on ARIMA model. *International Journal of Applied Mathematics and Statistics, 45*(15), 272-279. https://www.researchgate.net/publication/289341068

Liu, J., Shi, G., Zhou, J., & Yao, Q. (2021). Prediction of college students' psychological crisis based on data mining. *Mobile Information Systems, 2021*, 9979770. https://doi.org/10.1155/2021/9979770

Min-gang, G., & Dan-dan, B. (2015). Study on the Influence of Children's Sports Dance on Their Physical Fitness and Psychological Behavior Problems. *International Journal of Simulation--Systems, Science & Technology, 16*(3), 18.11-18.15. https://doi.org/10.5013/IJSSST.a.16.3A.18

Nagelli, C. V., Webster, K. E., Di Stasi, S., Wordeman, S. C., & Hewett, T. E. (2019). The association of psychological readiness to return to sport after anterior cruciate ligament reconstruction and hip and knee landing kinematics. *Clinical Biomechanics, 68*, 104-108. https://doi.org/10.1016/j.clinbiomech.2019.05.031

Pacula, M., Meltzer, T., Crystal, M., Srivastava, A., & Marx, B. (2014). Automatic detection of psychological distress indicators and severity assessment in crisis hotline conversations. In *2014 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)* (pp. 4863-4867). IEEE. https://doi.org/10.1109/ICASSP.2014.6854526

Panqiu, J. (2018). Research on College Students' Psychological Crisis Intervention in the Context of Big Data. In *Proceedings of the 2018 International Conference on Big Data and Education* (pp. 33-37). ACM Digital Library. https://doi.org/10.1145/3206157.3206173

Pramana, E., Jagadhita, D., & Turnip, S. (2021). Youth Ambassadors for Disaster Preparedness: Using Psychological First Aid in Times of Crisis. *IOP Conference Series: Earth and Environmental Science, 673*(1), 012053. https://doi.org/10.1088/1755-1315/673/1/012053

Sadovnikova, N. O., Sergeeva, T. B., Kotova, S. S., Khasanova, I. I., & Pesterev, A. O. (2018). Foundation of Psychological Support in the Emotional Experience of Professional Identity Crisis by Teachers. *Eurasian Journal of Analytical Chemistry, 13*(1b), em76. https://doi.org/10.29333/ejac/101791

Sidong, C. (2013). Algorithm of distributed mining community structure used in sports psychology based on local information. *Journal of Digital Information Management, 11*(3), 248-255. https://www.dline.info/fpaper/jdim/v11i3/15.pdf

Tan, C. (2016). Dynamic Evaluation of Sports Games Teaching on College student's Psychological Health and Basketball Skills based on Network Big Data. *International Journal of Signal Processing, Image Processing and Pattern Recognition, 9*(2), 225-238. https://www.earticle.net/Article/A270129

Wang, Y. (2020). Data Analysis of Psychological Measurement of Intelligent Internet-assisted Sports Training based on Bio-Sensors. In *2020 International Conference on Smart Electronics and Communication (ICOSEC)* (pp. 474-477). IEEE. https://doi.org/10.1109/ICOSEC49089.2020.9215348

Widyaningrum, H. K., Hasanudin, C., Fitrianingsih, A., Novianti, D. E., Saddhono, K., & Supratmi, N. (2020). The Use of Edmodo Apps in Flipped Classroom Learning. How is the Students' Creative Thinking Ability? *Ingénierie des Systèmes d Inf., 25*(1), 69-74. https://doi.org/10.18280/isi.250109

Wu, C., & Huang, H. (2012). Evaluation and research on sports psychology based on BP neural network model. *AISS: Advances in Information Sciences and Service Sciences, 4*(10), 355-363. https://doi.org/10.4156/aiss.vol4.issue10.42

Xiong, W. (2020). Identification and early warning of college students' psychological crisis based on big data. In *Data Processing Techniques and Applications for Cyber-Physical Systems (DPTA 2019)* (pp. 23-28). Springer. https://doi.org/10.1007/978-981-15-1468-5_4