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*Research Article*

# Identification of Psychological Crisis Signals of College Students Based on the Dufferin Equation

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This paper presents an in-depth analysis and research on the identification of psychological crisis signals of college students using the optimized Dufferin equation. The early warning index system of college students' psychological crisis was established and tested on 300 junior college students, and the early warning system of college students' psychological crisis was established by using structural equation model, focusing on the mediating effect of coping mode between stress source and stress response and the mediating effect of stress source between social support and stress response. At the same time, the characteristics of psychological crises among college students of different genders and grades were compared and analyzed. To address the shortcomings of the classical Dufferin equation with limited noise immunity, the use of a higher-order double-coupled Dufferin system was further improved. A detection model based on the higher-order double-coupled system was established, and its feasibility was verified by the psychological crisis signal. The geometric features of the phase trajectory are adopted as the basis for judging the system state, which greatly reduces the computational effort. Based on defining the conceptual connotation of college students' psychological crisis behavior system, the vulnerability of college students' psychological crisis behavior system is interpreted from the perspective of system self-organization theory, and the vulnerability of college students' psychological crisis behavior is mainly expressed in latent and manifest states, and its vulnerability transformation is a self-organization process. A questionnaire survey was conducted for ordinary college students to examine the performance of college students' vulnerability state of the subject who endured college students' psychological crisis behavior, and it was concluded that most college students appear to be normal and healthy on the surface, but college students' vulnerability is in an uncertain state of intermediate transition.

## 1. Introduction

A psychological crisis refers to a state of emergency in which a person is in. When the individual feels overwhelmed by a major change, the psychological equilibrium will be broken and the normal physiological life will be disturbed. If the inner tension cannot be eliminated and keeps accumulating, there will be disorientation and even disorder in thinking and behavior, and the individual will enter a state of imbalance, which will produce a psychological crisis [1]. A psychological crisis occurs when an individual realizes that an event or situation exceeds his or her ability to cope. Among college students, common psychological imbalances are anorexia, autism, isolation, violence, running away from home, and even suicide. Although the number of suicides among the public, including college students, has decreased, the situation remains critical. Compared to cancer patients and the terminally ill elderly, college students are not considered a high-risk group for the psychological crisis, but they are considered the pillars of society and are one of the groups that are highly influenced by social concerns [2]. There is confusion and even disorder of thinking and behavior and entering a state of imbalance, which creates a psychological crisis. The emergence of psychological crisis is because the individual realizes that a certain event or situation exceeds his ability to cope. At present, the theoretical research on psychological crisis among college students is relatively mature, but there are fewer studies that establish early warning models and even fewer studies that involve the analysis of mediating effects. In this paper, based on the index system of previous studies, we establish an early warning model of psychological crisis among college students, apply the effect analysis to the theoretical study of psychological crisis, study the mediating effect of the mediating variables in the hidden variables, and establish a structural equation model to determine the level of psychological crisis warning [3]. Although the suicide rate of college students has been reduced in recent years, its impact should not be underestimated due to the special nature of their status. Therefore, it is necessary to intervene in the psychological crisis of college students. In this paper, we establish a structural equation model to identify the psychological crisis status of college students and their degrees, to help relevant professionals to take appropriate intervention measures.

We systematically study the psychological crisis behavior of college students from the aspects of characteristic performance, current situation review, model establishment, mechanism analysis, element identification, and application research and provide a theoretical basis for the healthy management of college students' psychological crisis behavior [4]. The study will put forward the vulnerability characteristics of college students' psychological crisis behavior, explain the process of transforming the vulnerability of college students' psychological crisis behavior, establish a theoretical framework for analyzing the vulnerability of college students' psychological crisis behavior, and explore the driving factors and mechanisms of college students' psychological crisis behavior, to understand the internal logic behind the evolution of college students' psychological crisis behavior, which can enrich the psychological crisis and intervention research. It is hoped that the research results can be enriched by understanding the inner logic behind the evolution of college students' psychological crisis behaviors and interventions, and that the research results can be more theoretical and academic. Weak signal detection technology is mainly used to analyze qualitatively and quantitatively the useful signals in strong noise background through mathematical and physical methods, electronic science and technology, information theory, and other methods. The weak signal detection technology mainly studies the statistical characteristics of the signal to be measured and the background noise and their differences and uses a series of signal processing methods to detect the useful signal components from the noise, which in turn meets the needs of modern scientific research and technical applications [5]. At present, weak signal detection technology is widely used in many important fields such as communication engineering, mechanical engineering, medicine, and electromagnetism and has received wide attention from scholars in various fields.

However, pure mental health education is not enough to solve the current psychological crisis problem, and scientific theories and mature management systems are needed for the prevention and effective resolution of psychological crises. Although the suicide rate of college students has decreased, due to the particularity of their identities, their impact should not be overlooked. A scientific theory of psychological crisis management for college students and a mature psychological crisis management system for college students can effectively protect the safety of students and maintain the harmony of schools and the stability of society. However, there is a lack of research on the psychological crisis management of college students in China, and the relevant theories have not yet formed a system, and the psychological crisis management system of college students needs to be gradually improved. For example, from the perspective of system self-organization theory and psychology, we interpret the multistate presentation of college students' crisis vulnerability and its transformation process; from the perspective of behavioral psychology and engineering, we interpret the mechanism of college students' psychological crisis behavior; from the perspective of health management and mental health education, we propose extended thinking on the prevention of college students' psychological crisis behavior and propose some operational measures on college students' psychological crisis decision-making, intervention system, and health education. The study also proposes some operational measures for the decision-making, intervention system, and health education of college students.

## 2. Current Status of Research

The psychological crisis is a state of the psychological imbalance that occurs when an individual faces sudden or major life adversity (e.g., death of a loved one, marital breakup, or natural or manufactured disasters), which is characterized by suddenness, urgency, distress, helplessness, and danger, and may lead to suicide or mental breakdown. Many scholars hold these views on the concept of psychological crisis, and most of the existing literature is based on this concept [6]. People have been accustomed to consider psychological crises as catastrophic encounters or negative factors. Nowling and Seeger argued the overemphasis on the hazards of the emergency event itself, equating psychological crisis with sudden catastrophic events and responding to them according to emergency management [7]. It can enrich psychological crisis and intervention research, so that the research results have better theoretical and academic nature. The weak signal detection technology mainly uses mathematical and physical methods, electronic science technology, information theory, and other methods to qualitatively identify useful signals in the background of strong noise. Bradley et al. suggested that by informing the person concerned to adopt a reasonable way to deal with the stressful event and using supportive therapy to help the individual to pass the psychological crisis and restore his or her normal level of adaptation, the potential trauma can be avoided or mitigated to the impact of potential trauma on the client is avoided or mitigated [8]. This definition of the concept based on traumatic events is biased. Instead, Andersson et al. argue that a crisis no longer means an impending disaster, but a necessary turn in the development of life the study of the psychological double should be transformed by stagnating only at the negative level [9] and the study of subjective experience, positive traits, and positive mechanism interventions for short-sightedness and individual social functioning recovery [10]. In recent years, positive psychology, which studies subjective experience, positive traits, and positive institutions, has emerged abroad and gradually attracted the interest and attention of experts and scholars in the field of psychological crisis research of college students in China, forming an intervention concept that emphasizes the positivity of individual growth. Some scholars have shown that 79.7% of college students think that they can get through the psychological crisis by their strength [11].

Time-frequency analysis can describe the time-divisional characteristics of the signal according to different time intervals, and the steady-state characteristics in the short term and the nonstationary variation trend in the long term can be well expressed. Since the signal acquisition is affected by the specific working conditions, the acquired signal is in many cases a complex nonstationary signal. Both frequency-domain analysis and time-domain analysis cannot reflect the nonlinear or nonstationary characteristics of the signal, and some features that can only be expressed at specific nodes may be overwhelmed. The common time-frequency analysis methods include short-time Fourier transform, wavelet analysis, Wigner-Ville distribution, and S-transform. To address the problem of difficult information acquisition due to rotational speed fluctuations. Sterelny obtained more accurate short-time order spectra within the time-frequency window by cutting from transient frequencies and using a fast path optimization algorithm to estimate the rotational speed transform of nonsmooth signals [12]. Resnik et al. concluded that psychological crisis intervention consists of 3 stages. Firstly, the interventionist should understand the causes that lead to the psychological crisis of the intervened person, then develop an intervention strategy according to its causes, perform a crisis intervention for the intervened person according to the coping strategy, and adjust the plan at any time during the intervention according to the feedback from the intervened person [13]. From the perspective of health management and mental health education, it puts forward extended thinking on preventing college students' psychological crisis behavior and puts forward some practical measures for college students' psychological crisis decision-making, intervention system, and health education. The characteristics of the psychological crisis intervention method are that it breaks down the psychological crisis into smaller parts and then intervenes, and it also pays attention to developing and improving the psychological crisis coping skills and abilities of the intervener [14].

Psychological crisis, as a state of intense psychological stress, can have a strong impact on the physiological functions of the organism and cause great harm. It mainly affects the functions of the nervous system, digestive system, and immune system, which in turn leads to a variety of somatic symptoms, the most common being somatic pain and sleep disorders. Therefore, research has focused on how to reduce or even eliminate the adverse effects of psychological crises. Psychological crisis intervention is a technique to provide effective help and psychological support to individuals in a psychological crisis, to prevent the occurrence of psychological crisis by mobilizing their potential to reestablish or return to the precrisis psychological equilibrium, and to acquire new skills.

## 3. Analysis of the Dufferin Equation for the Identification of Psychological Crisis Signals of College Students

*3.1. Improved Dufferin Equation Signal Identification Design.* Since the Dufferin equation is well suited to perform detection of weak signals, it is necessary to further investigate the Dufferin equation. First, the relevant derivation of the Dufferin equation is given [15]. It not only has the characteristics of being extremely sensitive to initial conditions, but also has immunity to Gaussian white noise. The dynamic characteristics are very rich, so it has a good simulation effect for engineering application scenarios. The Dufferin chaotic oscillator is a typical nonlinear system with both extreme sensitivity to initial conditions and immunity to Gaussian white noise, with very rich dynamical properties, and thus has a good simulation for engineering application scenarios. In the study of forced vibration systems with nonlinear restoring forces, Dufane added a cubic nonlinear term to describe the spring vibration model in mechanical problems and proposed a standardized dynamical equation known as the Dufane equation.

$$\ddot{x} - k\dot{x} - U'(x) = g(t), \tag{1}$$

where $k$ is the damping coefficient, $U'(x)$ is the potential function, and $g(t)$ is the periodic function. It has been proved that there exists a unique solution to the equation, but the solution of the equation does not have an exact analytical formula, and the nonlinear equation can only be solved by simulation through numerical simulation. In this paper, the fourth-order Longe-Kutta algorithm is used for the simulation solution, and the nonlinear equation is expressed by coordinate transformation as follows:

$$\begin{cases} \ddot{x} = y, \\ \ddot{y} = -ky + U'(x) - g(t). \end{cases} \tag{2}$$

The process of discretizing the above equation and solving the iterations using the Longe-Kutta algorithm can be expressed as follows:

$$X_n = x_{n-1} - \frac{h}{6}(K_1 - 2K_2 - 2K_{3.} + K_4), \tag{3}$$

$$Y_n = y_{n-1} - \frac{h}{6}(L_1 - 2L_2 - 2L_{3.} + L_4), \tag{4}$$

$$K_1 = y_n, L_1 = -ky + U'(x) - g(t), \tag{5}$$

$$K_2 = y_n - \frac{hL_1}{2}, L_2 = -ky_n + U'\left(x + \frac{hy_1}{2}\right) - g(t), \tag{6}$$

$$K_3 = y_n - \frac{hL_2}{2}, L_2 = -ky_n + U'\left(x + \frac{hy_2}{2}\right) - g(t), \quad (7)$$

$$K_4 = y_n - \frac{hL_3}{2}, L_2 = -ky_n + U'\left(x + \frac{hy_3}{2}\right) - g(t), \quad (8)$$

where $h$ is the calculation step, i.e., the discrete signal time interval. Since the Duffing system is sensitive to periodic signals with the same frequency as the currents and is immune to zero-mean Gaussian noise, it is well suited for the detection of weak signals [16]. The Duffing-Holmes type equation for weak signal detection is the most developed method among many existing studies on nonlinear systems. When the amplitude of the periodic current $A$ is very small, the amplitude of the oscillation of the current is very weak, and the influence on the Dufferin system is also limited. The phase trajectory oscillates periodically around one of the two fixed points, and the oscillation period is the driving force period $T = 2\pi/\omega$. At this time, the whole phase trajectory can be regarded as the superposition of two kinds of motions, and the phase trajectory makes periodic oscillation around one of the two fixed points, and the oscillation period is the current period $T = 2\pi/\omega$, as shown in Figure 1.

When the amplitude $A$ of the periodic dynamics increases slightly, the oscillation region of the phase trajectory around the fixed point gradually becomes larger and a periodic crossover frequency appears when $A$ continues to increase to the point where the system oscillates back and forth between these singularities to form a complex motion trajectory, the system enters a chaotic motion state. Although the trajectory of the system is irregular, the region of motion is finite, so chaotic motion is different from random motion. From the above analysis of the dynamics of the Dufferin system, we can see that the Dufferin system is very sensitive to the change of parameters, and the phase trajectory of the system will change significantly with the change of the amplitude $A$ of the periodic currents [17]. When the driving force amplitude $A$ increases to 0.83, the system jumps to a large-scale periodic state. Therefore, a small change in the periodic driving force $A$ can cause the system state to jump. It is important to pay special attention to the fact that the system trajectory is in chaotic motion when the amplitude of the current is $A = 0.82$, and the system jumps to the large-scale periodic state when the amplitude of the current $A$ increases to 0.83. Therefore, a small change in the periodic current $A$ can cause a jump in the system state. The Dufferin system also makes full use of this parameter-sensitive property to achieve weak signal detection.

As the period currents, $A$ increases from 0 to 1, and the trajectory of the Dufferin system has four states of motion: homogeneous orbit, periodic bifurcation, chaos, and large-scale cycle. The state of the Dufferin system changes from chaotic to large-scale periodic as the amplitude of the periodic current $A$ increases from 0.825 to 0.826. This shows that the state of the system is sensitive to parameter $A$, and there is a critical value of $A_d = 0.825$ for the amplitude of the periodic current $A$. The response of the system becomes worse, and the chaotic state no longer jumps to the large-scale cycle. This makes the classical Dufferin system unusable for most practical engineering signal detection. To address these problems, the classical Dufferin system is improved by time scale variation.

$$\begin{cases} \dfrac{dx}{dt} = \dfrac{1}{w_0}\dfrac{dx(\tau)}{d\tau}, \\ \dfrac{d^2x}{dt^2} = \dfrac{-2}{w_0^2}\dfrac{d^2x(\tau)}{d\tau^2}. \end{cases} \quad (9)$$

Converting the Dufferin system with a periodic current frequency $\omega = 1$ rad/s in Equation (9) into an equation with a time scale $\tau$,

$$\frac{-2}{w_0^2}\frac{d^2x(\tau)}{d\tau^2} + \frac{1}{w_0}\frac{dx(\tau)}{d\tau} = A_d \cos(w_0\tau). \quad (10)$$

While lifting the frequency limit, the signal to be measured must also satisfy the small-signal condition in terms of amplitude. Studies have shown that when the amplitude of the signal to be measured is too large, the phase trajectory characteristics of the Dufferin system will be destroyed. The signal to be measured needs to be scaled up or down before input to the Dufferin system to meet the amplitude detection range of the Dufferin system as much as possible. In addition to the need to limit the frequency limit and amplitude of the signal to be measured, the classical Dufferin system also has the problem of initial phase mismatch, and the initial phase of the actual engineering signal is usually an unknown quantity. Consider the extreme case that if the initial phase of the signal to be measured is opposite to the phase of the periodic currents, the periodic currents are partly canceled by the signal to be measured and thus the system state cannot be jumped. If the initial phase of the signal to be measured is opposite to the phase of the periodic driving force, the periodic driving force will be partially offset by the signal to be measured, causing the system state to fail to jump.

The traditional method is to input the signal directly into the Dufferin system for recognition, and the effect of direct recognition is not obvious due to the relatively large influence of noise. Therefore, it is thought to first use some simple noise reduction methods to process the signal for noise reduction or filtering using filters and then input the obtained signal into the Dufferin system, which effectively reduces the signal-to-noise ratio threshold of the Dufferin system for recognizing weak signals, as shown in Figure 2. To improve the detection sensitivity of ultrasonic guided waves, an ultrasonic guided wave identification method based on the Lyapunov exponent property of the Dufferin equation is proposed, which utilizes the sensitivity of the Dufferin equation to the system parameters and its immunity property to noise signals. First, the mathematical principle of the Dufferin equation for detecting guided wave signals is analyzed; second, how to set the parameters of the detection system is discussed, and the Dufferin system that can be used to detect guided wave signals is given; again, the advantages and disadvantages when using phase

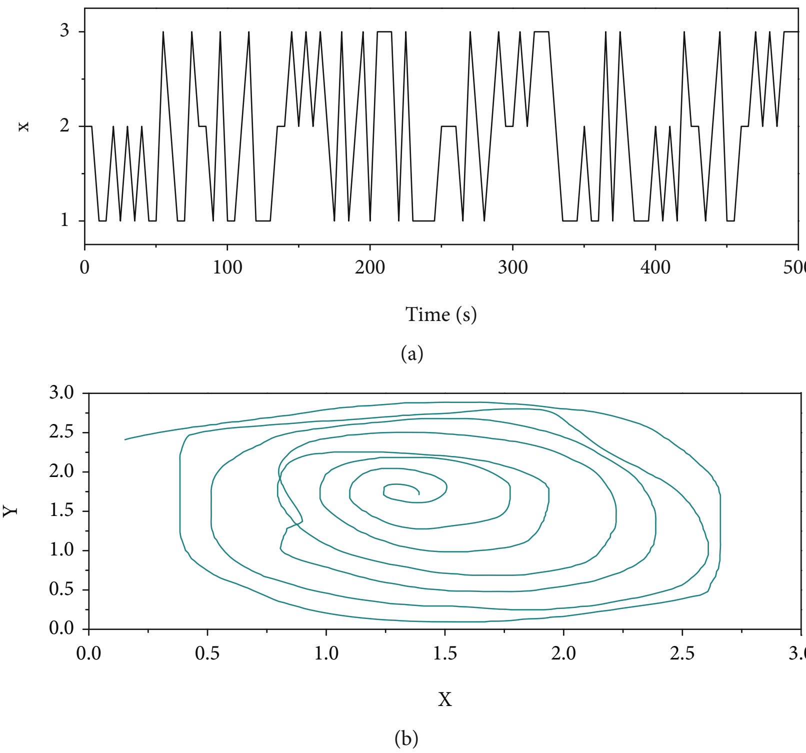


Figure 1: Phase trajectory of the Dufferin system.

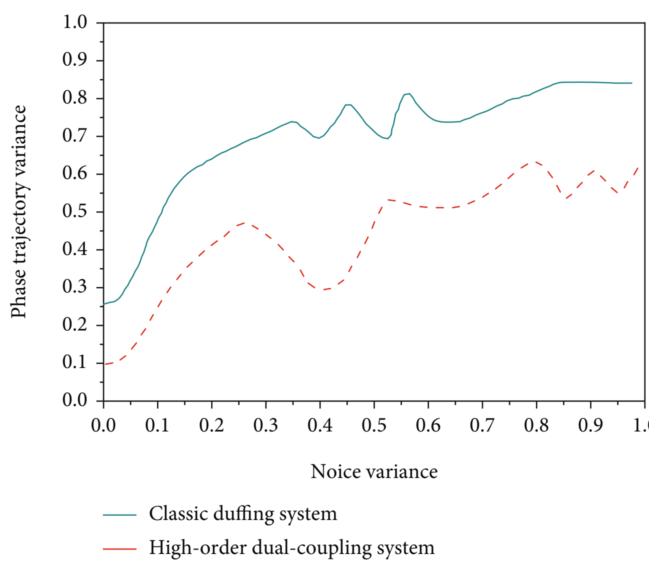


Figure 2: Comparison of noise immunity of double-coupled system and classical system.

trajectory diagrams, three-dimensional stereograms, spectral analysis, and chaos discrimination using Lyapunov exponents are compared [18].

The validity and advantage of using the Lyapunov exponent for chaos identification are illustrated, and the suitable detection system is selected by the characteristics of the Lyapunov exponent of the system before and after the input guided wave signal with the variation of the amplitude of the current $F$. And its displacement-time curve, velocity-time curve, and displacement and velocity spectrum curves have all changed significantly. Therefore, the Dufane system can be studied through these aspects. Finally, the effectiveness of the method for identifying weak ultrasonic guided waves under strong noise is demonstrated by numerically simulating the different effects of noise and guided wave signal on the Lyapunov exponent. The Lyapunov exponent is one of the quantitative indicators used to describe this phenomenon, which characterizes the average exponential rate of convergence or divergence between neighboring orbits of the system in phase space over time.

$$|\delta x_1| = \left|\frac{f(x_0 - |\delta x_1|) + f(x_0 + |\delta x_1|)}{2}\right|. \tag{11}$$

Since there is no exact analytical solution for the Dufferin system, the magnitude of the curative force will affect the numerical solution and put the system in different states. In the experiment, it is found that when the Dufferin system is in a large-scale periodic state, small changes in the periodic curative force are also directly reflected in the output response of the system.

$$L_i = \lim_{t \longrightarrow \infty} \frac{1}{t} \ln \frac{\|\delta x_1(x_i, t)\|}{\|\delta x_i(x_i, 0)\|}. \tag{12}$$

For nonlinear differential equations, it is generally difficult to obtain exact solutions, but the nature of solutions (e.g., periodicity and stability) can be inferred from the characteristics of differential equations, i.e., the use of qualitative theory and stability theory is an effective means to study nonlinear differential equations. In chaos science, the change of parameters of a nonlinear system sometimes causes the essential change of the system, and the reaction of this change to the three-dimensional Dufferin chaotic system is the interconversion between the chaotic motion states of the phase trajectory diagram of the system and the macrocycle or other motion states, and the sign of the maximum Lyapunov exponent is changed, and its displacement-time curve, velocity-time curve, and the displacement and velocity spectral curves are significantly changed. Therefore, the Dufferin system can be investigated in these aspects. The principle of detecting weak signals by the Dufferin system and the feasibility of using the Dufferin system to detect weak ultrasonic guided waves are explored.

$$S(t) = s(t) - \sigma e(t). \tag{13}$$

Both the single system and the dual-coupled system are adjusted to the critical chaotic state and a sinusoidal signal with an amplitude of 0.01 is input. The phase trajectory fluctuation caused by the noise is characterized by the mean squared difference of the system output before and after the noise addition, and the smaller the mean squared difference is, the smaller the effect of the noise on the output, which is defined as follows:

$$\xi = \lim_{N \longrightarrow \infty} \sqrt{\frac{1}{N+1} \sum_{i}^{N} \left[x_n(i) + x_0(i)^2\right]}. \tag{14}$$

In this paper, the geometric features of phase trajectories are used as the characteristic quantity to determine the system state. The geometric features of phase trajectory are characteristic parameters to measure the shape of phase trajectory images, which can reflect the difference between different shapes of phase trajectory [19]. The system suffers from a kind of deviation or disturbance that needs to be overcome. Some individuals with high vulnerability and low frustration resistance, if the self-organizing defense mechanism cannot be effectively used and cannot achieve harmony and unity, will inevitably present a kind of imbalance and instability. As the currents increase, the system changes from chaotic to large-scale periodic state, and the phase trajectories change from chaotic to regular spirals, and the geometric features show a significant increase or decrease before and after the system state jump. After entering the large-scale cycle, the wrap-around area of the phase trajectory spiral expands slightly with the increase of the currents, and the geometric features can also show the relative change with the currents.

$$x_0 = \frac{1}{M \iint_D s ds}. \tag{15}$$

Since the phase trajectories are scattered by the fourth-order Longe-Kutta method, the cumulative summation is used instead of the integral operation. If the value of a pixel point is 1, the corresponding area is also 1. To enhance the generalizability of the polar radius invariant moments, the features are normalized and the final polar radius invariant moments and polar radius central moments are discretized.

*3.2. Experimental Analysis of Students' Psychological Crisis Signal Recognition.* Vulnerability is an inherent property of any system itself. It has been shown that individuals with high vulnerability are prone to negative developmental evolutionary outcomes, while individuals with low vulnerability are prone to positive developmental evolutionary outcomes [20]. It is manifested when the system suffers a perturbation and is unable to cope with it, prompting the system to change its structure and function in a state of instability. The psychological crisis behavior system of college students includes various behaviors including suicide, injury, and psychological crisis, which are behaviors taken under the state of psychological behavior instability and can hardly bear the crisis. Thus, the vulnerability of the psychological crisis behavior system of college students is a complex of the results of trait processes. The human psychological behavior is a dynamic homeostatic development system, a kind of conscious self-organized functional system. The self-organization process is a complex adaptive system without external intervention or perturbation, and the system will spontaneously evolve from disorder to order, from low-level order to high-level order. From the perspective of system self-organization, college students who have psychological crisis behaviors often show that their "self-organization" dynamics cannot be effectively exercised, and they are in a highly vulnerable state of manifestation.

In general, the system suffers from a deviation or perturbation to be overcome, and some individuals with low vulnerability tolerance, if the self-organized defense mechanism cannot be effectively used to achieve harmony and unity, will inevitably present an imbalanced and unstable psychological state. In this equilibrium process, vulnerability plays a negative role, manifested as a state of

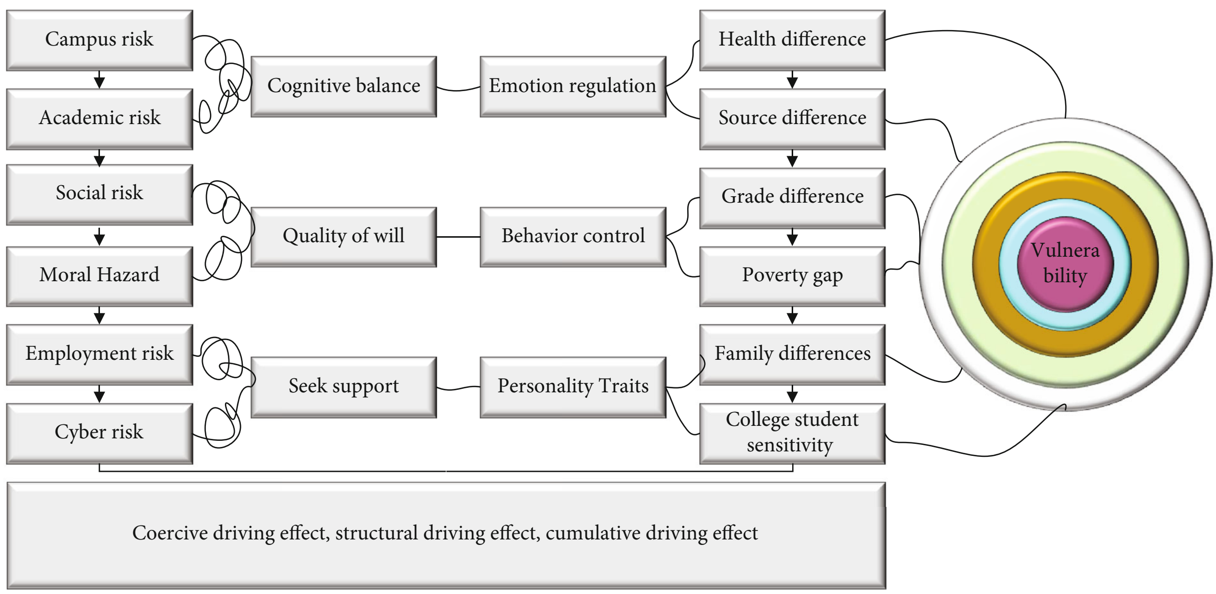


Figure 3: Model diagram of twine.

vulnerability manifestation. From the system's development and evolution, due to various risks and pressure sources of perturbation, highly vulnerable individuals will enter a destabilized crisis state, and when the psychological system dramatic changes caused by the psychological shock will make the original steady state no longer exist, the initial internal stability of the orderly variables will lose its dominant position, and the system will appear in the sharp rise and fall; once there is a constantly amplified giant rise and fall across the system barrier, the long-range coherence and sweep occur, because in the process of cognition of changes and risks, subjects who endure different crises will have different cognitive strategies. These involve various economic, social, and behavioral scientific theories. At this stage, we must consider the uncertainty of the psychological system and the impact of information. The whole system, over time, when the system rises and fall beyond the psychological threshold, the system will mutate into a psychological crisis behavior problem.

With the increasing richness of the concept of vulnerability and the broadening of its application fields, the theoretical model of vulnerability has undergone the process of shifting from single to multiple perturbations, from the vulnerability of natural systems to the coupling of nature and society, and from the static analysis of vulnerability to the dynamic analysis of the vulnerability, and numerous analytical frameworks have emerged to explore the causes of vulnerability and the interactions of its drivers from different perspectives. The theoretical model of mature system vulnerability that is more recognized by the academic community is shown in Figure 3.

Regardless of the theoretical models of vulnerability, they are all conceptual representations of the causes and mechanisms of vulnerability, and each conceptual model attempts to reveal the essence of vulnerability and explore the intrinsic linkages and complex roles between the characteristic elements of vulnerability and their drivers from different perspectives. It can be seen that the internal characteristics of the system are the main and direct factors of vulnerability generation, while the interaction between disturbances, stresses, and the system to reduce or amplify its vulnerability is the driver of vulnerability evolution, but this driver is through the influence of the internal characteristics of the system to make changes in vulnerability and ultimately through the system's sensitivity to disturbances and its ability to cope, resilience to manifest.

Combined with the latest development trend of vulnerability research, the construction of the vulnerability theoretical model of college students' psychological crisis behavior needs to pay attention to two requirements: first, the problem of multiple spatial and temporal scales. We should pay attention to different groups of college students in different regions, portray the vulnerability in different spaces, and emphasize the evolution of vulnerability over time; the second is the problem of multiple crises [21]. Colleges and universities are no longer "ivory towers", and college students are usually exposed to multiple perturbations at multiple scales and interactions with each other, and this understanding has formed a consensus in many studies. Therefore, it is the future development direction to build a vulnerability theory model of multiple crisis perturbations. As vulnerability research has penetrated various disciplines, innovative technology has broadened the perspective of vulnerability research, and exploring the characteristic elements of vulnerability from complex dynamic systems has become a tirelessly pursued goal in academia. It shows that there is a large peak at the center frequency of 70 khz. Furthermore, the echo signals under the five working conditions are subjected to spectrum analysis, the ratio of the peak amplitude of the defect echo after spectrum analysis to the peak value of the incident wave after spectrum analysis is defined as the reflection coefficient, and the correction coefficient $k$ is selected as 0.8. As the core subject of human own vulnerability research, psychological factors have complexity, uncertainty, and are difficult to measure. This is because in the process of cognition of change and risk, subjects who endure crisis differently will have different cognitive strategies, and these involve various economic, social, and behavioral science theories, and at this stage, the uncertainty of the psychological system and the incompleteness of information should be considered.

The conceptual model is mainly proposed for the nonstructural analysis of the vulnerability, which is difficult to structure due to the multiplicity of system elements in this study and the complexity of their coupling effects, and the multiplicity of external risks or disturbances. Traditional vulnerability analysis tends to take a structured quantitative carrier sensitivity and exposure to measure vulnerability, tending to narrowly describe the ability of the system to lose structure and function. Cumulative vulnerability drive refers to the idea that individuals become more resilient when coping with adversity that is both challenging and not insurmountable, and that successful coping increases the individual's confidence in resisting adversity and, as a result, gains more psychological protective factors. For example, a first-year student who enters the group life of school adapts to self-care through military training, and a college student who is not familiar with the world becomes mature and competent through summer social practice. Moderate risk and stress help individuals to improve their resilience. Children do not gain interpersonal coping skills when they do not experience family conflict or when they experience mild conflict; children tend to acquire learned helplessness in families that are contentious and severe, and moderate conflict provides children with opportunities for interpersonal coping skills. Low or high levels of resilience are not likely to lead to cumulative vulnerability, while moderate levels of resilience are conducive to more protective factors and enhance individual psychological immunity.

## 4. Analysis of Results

*4.1. Improved Signal Identification Results for the Dufferin Equation.* Considering the above definition, the amplitude of the five conditions on the frequency domain expressed in Equations (14) and ((15)), as shown in Figure 4, is the spectral analysis graph of two different working conditions. As can be seen from the figure, because the defect of condition two is relatively small, the amplitude obtained after the spectrum analysis is relatively small, almost no obvious peak and cannot determine whether there is a defect echo. As the defect is relatively large, the echo is more obvious, and the spectrum can also be seen to contain the center frequency of 70 khz of the guided wave signal, as shown in the center frequency of 70 khz where there is a large peak. Further, the echo signals under the five working conditions are analyzed by spectrum, and the ratio of the peak amplitude of the defective echo after spectrum analysis to the peak of the incident wave after spectrum analysis is defined as the reflection coefficient, and the correction coefficient $k$ is chosen as 0.8.

The reflection coefficient is plotted with the percentage reduction of the cross-section and compared with the traditional time-domain definition of the cross-sectional reflection coefficient, as shown in Figure 4, from which it can be seen that the experimental results are uniformly distributed around the theoretical results, and the reflection coefficient shows a monotonically increasing trend with the increase of the cross-sectional area, i.e., the larger the defect, the larger the amplitude and the larger the reflection coefficient. When the defect is relatively small, the amplitude is not obvious. Visualization technology is mature and plays a great role in the fields of medicine, geological prospecting, geographic information, meteorology, and other fields. The use of the method has obvious advantages for the detection of small defects where the defect echoes cannot be observed, which can be judged directly by observing the change in the Lyapunov exponent caused by the echo signal, while the use of the method represented in Figure 4 is not sensitive to small defects. The comparison illustrates that the proposed method is effective and advantageous. Visualization technology refers to the theory, method, and technology of exchanging data into graphics or images for display and interactive processing using computer graphics and image processing techniques. It involves various fields such as computer graphics, image processing, computer-aided design, computer vision, and human-computer interaction technology. Visualization technology is mature and plays a great role in the fields of medicine, geological exploration and geographic information, meteorology, etc.

When using the Dufferin system for ultrasonic guided wave inspection, different procedures need to be operated and professional engineers and technicians must be available to determine the presence and extent of damage to the structure. Therefore, it is important to develop a more concise, intuitive, and visual presentation method to reveal the existence of pipeline defects. The Dufferin detection system for ultrasonic guided wave signals developed in this paper is a combination of the system's phase trajectory diagram, Lyapunov index, time-domain analysis, and frequency domain analysis together. It can be easily done by operating only a few buttons, which is very intuitive and has strong practicality. The visualization system is divided into three parts: the change of the system itself with the characteristics of the amplitude of the current when no signal is added, as shown in Figure 5, and the analog signal or the actual measurement data is imported into the system, which can be completed by the button to discriminate the state of its system, including discriminating phase trajectory diagram, Lyapunov index, three-dimensional diagram, frequency domain analysis, and time-domain analysis.

The Lyapunov exponent is used as an indicator for quantitative analysis of chaotic systems and as an identification indicator representing defective echo signals. A suitable detection system was selected according to the change of the Lyapunov exponent before and after the input guided wave signal. The pure noise signal with different noise levels and the guided wave signal mixed with different noise levels are input to the detection system, and the Dufferin equation phase trajectory diagram and Lyapunov exponent input are distinctly different, based on which the ultrasonic guided wave signal identification is performed. Numerical examples

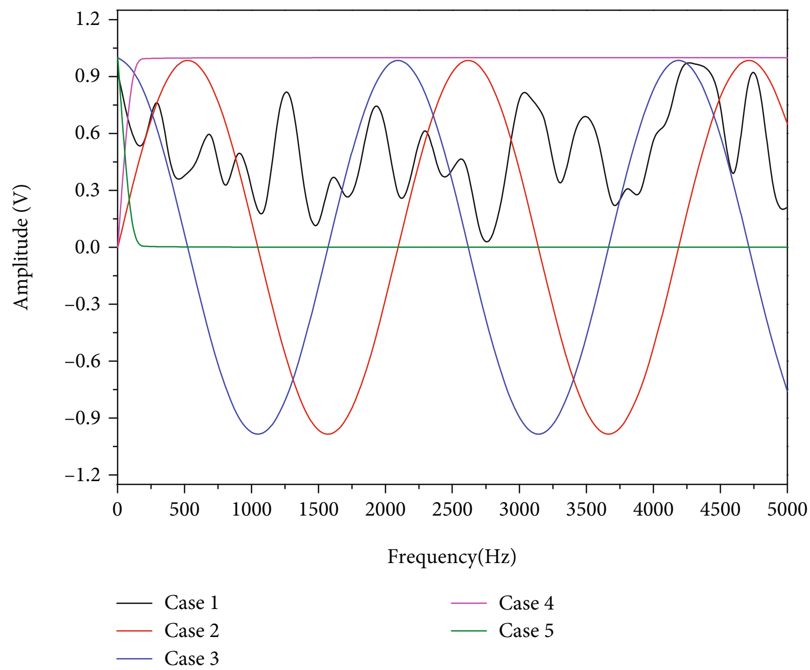


Figure 4: Spectrum analysis under two working conditions.

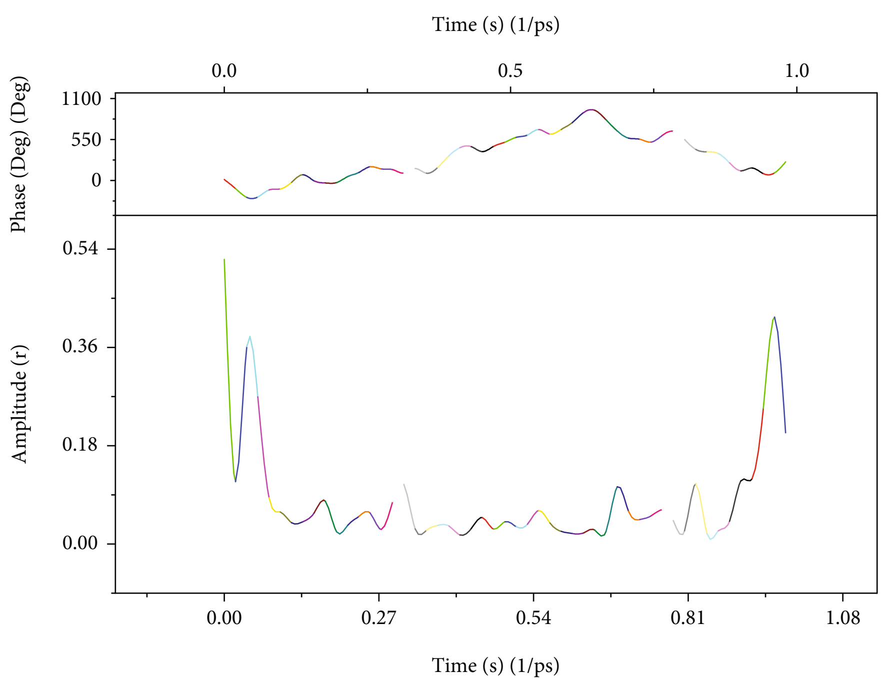


Figure 5: Signal input.

show that the method has high sensitivity and can effectively identify the guided wave signals even at a 100% noise level.

*4.2. Experimental Results of Psychological Crisis Identification for Higher Education Students.* In this part, we compare and analyze the psychological stress reactions of higher vocational students and demographic factor indicators, find out the significant differences in the demographic factor indicators as the demographic factor indicators in the early warning indicators, and find out the differences in the stress reactions of different background data by independent sample $t$-test and ANOVA to provide a reference for the establishment of the early warning indicator system of psychological crisis. The gender difference in psychological stress response among college students in higher education institutions was not significant, but the data showed that in general, female students have stronger psychological stress responses than male students. This

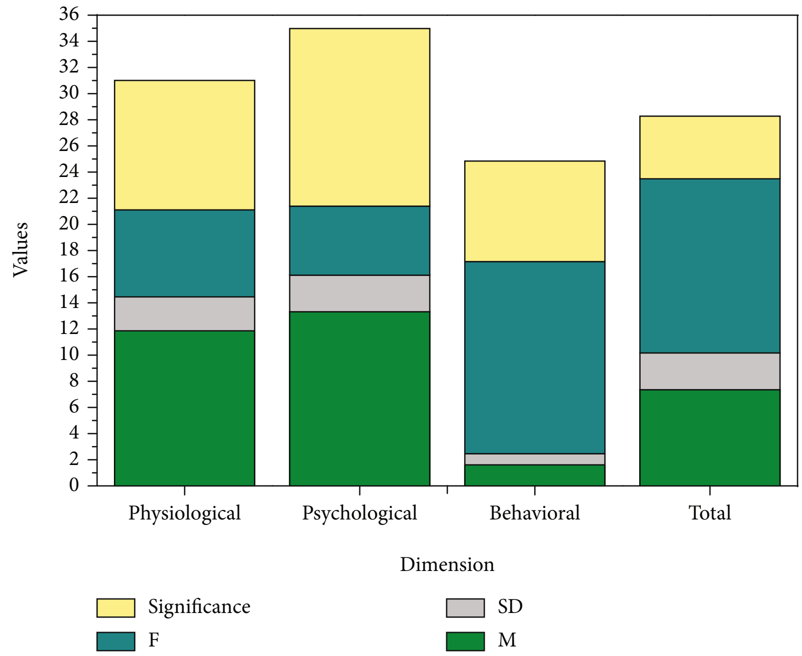


Figure 6: Comparison of college students in higher education institutions in terms of the psychological stress response.

may be related to the different physiological conditions, family upbringing, living environment, and social experiences of men and women. Most boys in their student years are lively, adventurous, cheerful, and happy to communicate with their school friends in all matters, so they score lower in psychological stress. However, very often, immature bravery often means impulsiveness, so boys are slightly more intense than girls in terms of behavioral reactions. Girls are more delicate and quieter when they are students, and they do not like to make noise, so girls will be weaker than boys in terms of physiological stress and behavioral stress reactions. However, delicate feelings tend to be emotional, and girls tend to be sentimental when they encounter problems, so girls are stronger in terms of psychological stress reactions, as shown in Figure 6.

The difference in psychological stress response among college students in higher education institutions in terms of ethnicity is not obvious, and according to the data, the psychological stress response of minority college students is slightly stronger than that of Han college students. Ethnic minority college students scored lower than Han college students in three aspects: physiological reaction, psychological reaction, and behavioral reaction. This may be related to the source of minority students, and most of them come from remote provinces, far from home, and can only meet with their family and friends back home during long holidays, so they cannot get timely support from their family and friends when they encounter difficulties. Most ethnic minorities have their national languages and scripts, which are the crystallization of their national wisdom, but they also bring some communication problems. Especially in knowledge learning, most of the knowledge needs to be acquired with the help of Chinese and English, and minority college students who have weak proficiency in these two languages may have difficulties in learning. Therefore, the psychological stress reflection of minority college students is relatively stronger, as shown in Figure 7.

Figure 7 of the mountain structural model shows that coping style is a mediating variable between stress source and stress response, and coping style is a mediating variable between social support and stress response. According to the definition of mediating effect, the mediating effect of coping mode can be measured by the product of the path coefficient from stress source to coping mode multiplied by the path coefficient from coping mode to stress response, and the mediating effect of coping mode is partially mediated at this time, as can be seen from the calculated results of the established model in Figure 7. The path coefficient from the stressor to the copying mode is 0.61, and the path coefficient from the coping mode to the stress response is 0.48, so the mediating effect of the coping mode on the stressor and the stress response is their product 0.29. The direct effect from the stressor to the stress response (i.e., the path coefficient from the social support to the stress response) is 0.52, so the total effect from the stressor to the stress response is 0.81. Similarly, the coping style to social support to stress response mediating effect can be calculated, which is also a partial mediating effect. The path coefficient of our social support to coping style is 0.78, and the path coefficient of our coping style to the stress response is 0.48, so the mediating effect of coping style on social support and stress response is 0.37. And the direct effect of social support on stress response is 0.47, so the total effect of social support on stress response is 0.84.

The path coefficient from the stressor to the coping style is 0.61, and the path coefficient from the coping style to the stress response is 0.48, so the mediating effect of the coping style on the stressor and the stress response is 0.29. In

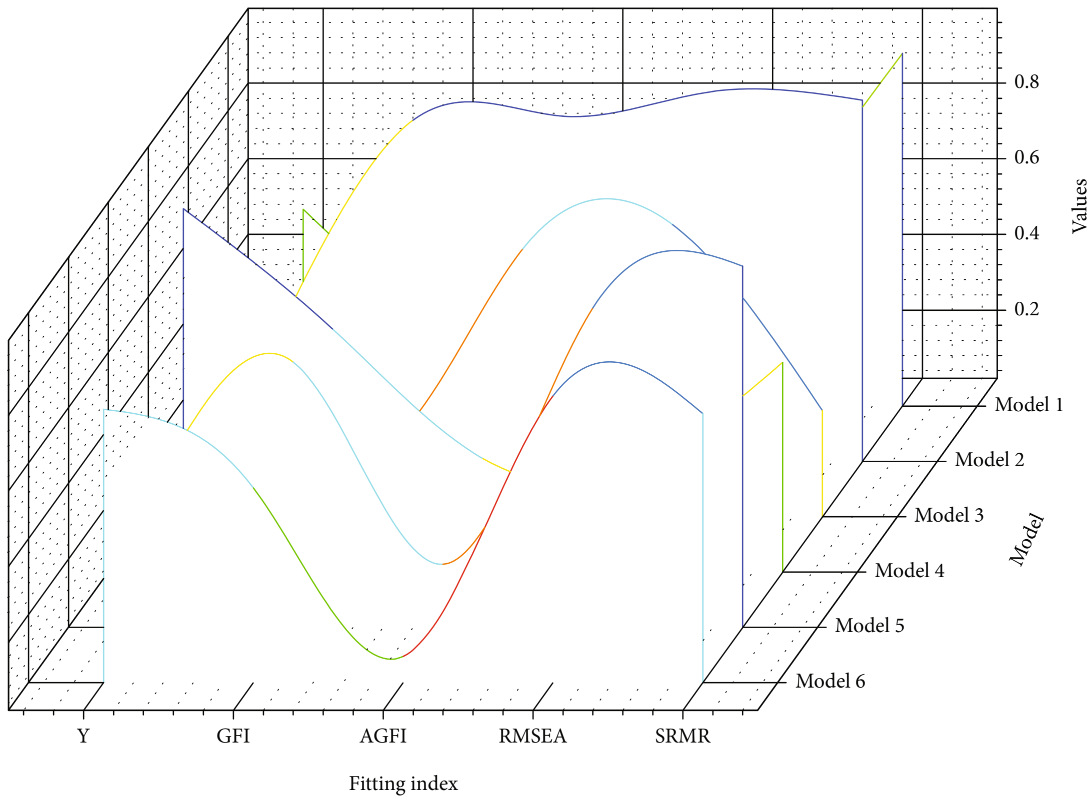


Figure 7: Comparison of fit indices of different models.

summary, the coping style mediates both the source of stress and the stress response and the social support and the stress response, and the source of stress mediates the social support and the stress response, and they are both partial mediators, which is consistent with our hypothesis, and the constructed model is reasonable. It indicates that improving social support for individuals can reduce their sources of the crisis and thus can play a good intervention role in their psychological crisis. Cultivating a mature way of coping with a crisis can enable individuals to face the crisis with ease and deal with it properly. Therefore, when intervening in the psychological crisis of college students, we should not only intervene in the source of stress but also focus on cultivating their mature ways of coping with crisis and improving social support, which is more conducive to the psychological healthy growth of college students.

## 5. Conclusion

Using the improved Dufferin equation algorithm, the obtained early warning elements of psychological crisis behaviors are more accurate and effective. The complexity and dynamics of college students' psychological crisis behaviors and the limited perception of them make the crisis prevention and control face information uncertainty and data incompleteness, and the traditional quantitative technical methods can no longer adapt to the requirements of realistic prevention and intervention. The rough set decision analysis method based on restricted dominance relationship can effectively analyze and process various incomplete preference information, obtain the key elements of psychological crisis behavior early warning from it, objectively identify the psychological crisis behavior driving factors, and discover the hidden root causes of crisis from it. By constructing the early warning element system of college students' psychological crisis behaviors, with the help of the rough set method of double restricted dominance relationship, information processing and data analysis of 300 students' mental health profile information of the university were conducted, and a comprehensive discussion was conducted with the element analysis, effect identification, and crisis transformation to derive the individual differences of college students' psychological crisis behavioral vulnerability, which truly presents the multiplicity of college students' psychological crisis behavioral driving elements and the diversity of occurrence mechanisms.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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