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EVALUATION OF MICRO-EXPRESSION RECOGNITION TECHNOLOGY FOR DEPRESSION EARLY WARNING SYSTEM IN PSYCHOLOGICAL INTERVENTIONS

Ziyan Xin[1], Yaying Tang[2] and Yanxin Su[3]
[1]University of Washington, Seattle, USA, 98105
[2]Boston University, Boston, USA, 02215
[3]Jiangxi University of Traditional Chinese Medicine, Nanchang, China, 330000

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ABSTRACT
Depression is a major global public health concern, affecting approximately 280 million people worldwide, according to the World Health Organization. This condition profoundly disrupts individuals' work, education, and family life, with severe cases leading to suicide. Self-report questionnaires, clinical interviews, and physiological assessments are the main ways that depression is currently screened for and diagnosed. However, these methods have significant flaws, such as being subjective and relying on people to report their feelings honestly. To enhance the accuracy and efficiency of early depression detection, this study recruited 1,073 first-year high school students from Wannian No. 1 High School in Wannian County, Shangrao City, Jiangxi Province. By integrating micro-expression recognition technology with the CES-D questionnaire, we developed an early warning system for depression based on micro-expression recognition, aiming to provide a more objective and automated screening approach.

Keywords: Depression; Micro-Expression Recognition; Early Warning System; High School Students

1. INTRODUCTION
Adolescent depression is becoming more widespread and serious in China, where more than 9 million teenagers are reported to be depressed or anxious. Typical symptoms include persistent low emotions, loss of interest, changes in appetite, and sleep disturbances, also frequently accompanied by severe emotional fluctuations and commonly linked to self-harming behaviors and suicidal tendencies. Prolonged depression will disrupt youths' brain development, negatively impacting their academic achievement, cognitive growth, and social abilities. As a result, identifying and addressing adolescent depression and anxiety has become a significant concern in China.

Traditional methods of detecting depression, such as questionnaires, personal or family interviews, and professional assessments, are fundamentally subjective and might lead to delays in early detection. To address these constraints, micro-expression recognition technology has emerged as a potential tool in the field of artificial intelligence. Haggard and Isaacs (1966) first defined micro-expressions as transitory, involuntary facial expressions that are brief and faint, lasting approximately 1/25 to 1/5 of a second. Even though it can be challenging to identify these

University of Washington, Seattle, WA 98105, USA[1]
Boston University, Boston, MA 02215, USA[2]
Jiangxi University of Traditional Chinese Medicine, Nanchang 330000, China[3]

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expressions, they reveal an individual's actual emotional state. In the context of mental health conditions like anxiety and depression, micro-expression recognition technology offers a more efficient and objective method of evaluating emotions by using scientific methods to identify and evaluate facial cues. Psychologists can more accurately identify latent real emotional problems by examining people's micro-expressions. However, small sample sizes and a limited selection of diagnostic markers hinder the current study and prevent this technique from being widely used.

This study aims to develop an early warning system for adolescent depression based on current micro-expression recognition technology. Identifying minor facial changes in high school students allows educators and psychologists to intervene promptly to prevent further escalation. Furthermore, the early warning system can provide objective, data-driven support with psychological interventions in the future. It may decrease the risk of misdiagnosis and missing instances, which are typical in standard mental health examinations, and also help educators or experts develop tailored mental health interventions, resulting in a more supportive and safe learning environment. Implementing this early warning system will lay a scientific foundation for addressing adolescent mental health in high school settings, promoting early detection and systematic intervention strategies.

2. RESEARCH METHODS

2.1 Participants

The study recruited 1,073 first-year high school students from Wannian No. 1 High School in Wannin County, Shangrao City, Jiangxi Province. Of the participants, 492 were female and 581 were male. All participants had normal or corrected vision, no color blindness or color weakness, and were right-handed. They were also proficient in using a computer keyboard and mouse.

2.2 Materials

The experiment involved nine trials, with films randomly allocated. Participants viewed emotion-inducing films while their faces were recorded with a high-resolution camera. Facial features were then analyzed using OpenFace software and facial action units. Data were captured, and the results for each participant were averaged across the individual frames. Following the intervention, participants completed the CES-D questionnaire. The CES-D is a self-report depression measure developed in 1997 by the National Institute of Mental Health (NIMH). It consists of 20 items which represent six dimensions of depressive symptoms: depressed mood, feelings of guilt and worth, helplessness, psychomotor retardation, loss of appetite, and sleep disturbances. Responses are rated on a four-level scale, based on the frequency of the symptoms experienced during the past week: 0 = 1 point, 1 = 2 points, 2 = 3 points, and 3 = 4 points. The total score is obtained by the summating the 20 items and ranges from 0 to 60. A score of 15 or less indicates the absence of depressive symptoms, a score between 16 and 19 indicates the possible presence of depressive symptoms, and a score of 20 or more indicates the presence of depressive symptoms.

2.3 Experimental Preparation

High-resolution cameras, sensitive microphones, and physiological sensors were attached to the computers in the school computer lab before the experiment to enable the accurate collection of multimodal data. Facial expression recognition software was also installed to track facial

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movements. Using the Facial Action Coding System (FACS), individual facial actions were recorded, and corresponding Action Units (AUs) were outputted for further analysis.

In the pre-experiment phase, 30 participants were asked to rate the emotional videos to confirm their efficacy and emotional arousal validity. During the main experiment, participants' facial expressions were recorded while they watched various emotion-inducing videos. A repeated-measures analysis of variance (ANOVA) was conducted on the average scores for each video. The results showed that the videos exhibited high emotional arousal validity, successfully activating participants' emotional systems.

3. RESEARCH RESULTS

3.1 Descriptive Analysis of High School Students' Facial Expression Data and CES-D Questionnaire Scores

Table 1. Descriptive Statistics of Questionnaire and Test Scores

	N	Min	Max	M	S
CES-D Score	1073	3.00	37.00	16.52	6.10
Facial Expression Score	1073	0.00	60.00	19.08	9.01
Valid Cases	1073				

As shown in Table 1, CES-D scores ranged from 3 to 37, indicating a wide range of depressive symptomatology levels among participants. The mean score was 16.52, with a standard deviation of 6.10, indicating that depressive symptoms were distributed widely across the sample and that individuals at various levels of depression severity exist. The mean facial expression score was 19.08 and the standard deviation 9.01, indicating a broad range of differences in facial expression scores within the sample. This, therefore, presents baseline data on which to research the relationship between CES-D scores and facial emotional features; it shows how depressive symptoms manifest externally, giving data support for the developmental micro-expression-based facial adolescent warning systems.

3.2 Demographic Differences in Facial Expression Data and CES-D Questionnaire Scores

Table 2. Gender Differences in Questionnaire and Test Scores

Variable	Gender	N	M	SD	t	P
CES-D Score	Male	581	17.59	8.97	-5.08	0.495
	Female	492	20.84	8.76		
Facial Expression Score	Male	581	16.26	6.03	-1.31	0.134
	Female	492	16.83	6.17		

Independent sample t-tests were conducted to determine whether there were gender differences in scores for the questionnaire and facial expression. As shown in Table 2, there was no significant gender difference in CES-D scores ($t = -5.08$, $p = 0.495$) since the p-value is greater than 0.05.

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Females had slightly higher scores than males. The same was true for facial expression scores (t=-1.31， p=0.134); no significant gender difference was detected, although males had slightly higher facial expression scores than females.

3.3 Correlation Analysis Between Facial Expression Data and CES-D Questionnaire Scores

Table 3. Correlation Analysis Between Questionnaire Scores and Facial Expression Scores

Variable	CES-D Score	Facial Expression Score
CES-D Score	-	0.501**
Facial Expression Score	0.501**	-

Note: *p < 0.05, **p < 0.01, ***p < 0.001.

As can be seen from Table 3, correlation analysis established a significant positive correlation between the CES-D and facial expression scores (r = 0.501, p < 0.01). This means that individuals with high CES-D scores will also have high facial scores.

3.4 Validation of Facial Expression Data's Effectiveness in Depression Early Warning

Table 4. Regression Analysis of CES-D Scores and Facial Expression Scores

Predictor Variable	R^2	F	B	Beta	t	p
CES-D Score	0.024	0.453	0.036	0.024	0.673***	0.000

Note: The dependent variable is CES-D score; ***p < 0.001.

As stated in Table 4, facial micro-expressions significantly predict depression levels (t = 0.673, p < 0.001). This suggests that facial expression data can serve as an effective early warning system for adolescent depression.

The analysis suggests that observation and analysis of facial micro-expressions can offer various useful information on the severity of depression in an individual. Therefore, facial micro-expression recognition technology holds promise as one key tool for evaluating and intervening in psychological health and supporting the clinical.

4. DISCUSSION

4.1 Analysis of High School Students' Mental Health Status

Jingde Lin(2004) studied this phenomenon among 709 high school students in Xuzhou and found that 12.13% of them showed signs of poor mental health. Zhencheng Hou et al. (2006) conducted a survey using the SCL-90 scale on 1,397 middle school students in Beijing. The findings reported that 24.98% of the students had mild psychological symptoms, whereas 6.73% had moderate symptoms. Several domestic studies have been conducted that the mental health of high school

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students is alarming, and most students are experiencing psychological problems of all levels, from mild to severe.

4.2 Distribution of Depressive Symptoms Among High School Students

According to Hankin (2015), depression is one of the most important emotional disorders in adolescents. Compared to earlier developmental stages, adolescents typically present with a host of physiological and psychological changes in high school, resulting in an even higher likelihood of experiencing depressive symptoms (Hankin et al. 2007). Studies carried out abroad found that more than half of the high school student population had experienced depressive symptoms, while one out of five had experienced suicidal ideation (Heidari et al., 2024).

This study, based on the mental health status of 1,073 high school students from Wannen No. 1 Middle School, adopted micro-expression recognition technology and used the Epidemiological Depression Scale (CES-D) to survey depressive symptoms. Findings to significant depressive symptoms awere mong approximately 40% of the students. Most students experienced feelings of anxiety and frustration with academic pressure and uncertainty about the future. Under such circumstances, it becomes imperative for schools to strengthen mental health education, provide professional psychological counseling and support, help students build up their ability to resist pressure psychologically, and perform routine mental health screening so that psychological problems can be identified and intervened in promptly.

4.3 The Relationship Between Facial Expression Features and Depressive Symptoms

The relationship between facial expression features and depressive symptoms is based on the principle that individuals with depression tend to view neutral stimuli through a more sorrowful lens. This psychological tendency leads them to unconsciously exhibit sad, frustrated, or disinterested facial expressions even when encountering emotionally neutral stimuli. Specifically, when depressed patients receive neutral stimuli, their brains might over-activate neural circuits associated with sadness. This will trigger a series of negative emotional experiences and corresponding facial expressions.

Facial micro-expressions, as a subtle manifestation of these emotional responses, capture fleeting individuals with depression trying to conceal or control their sadness or helplessness. These micro-expressions are often fleeting and hard to note, but analyzing them reveals much more about the inner world of the depressed individual and constitutes important early warning signs of their depressive state.

Based on this principle, facial expression features, especially micro-expression analysis, could be applied to establish the depression early warning system. Real-time facial expression monitoring and analysis would soon catch depressive tendencies in the expressed face to provide the necessary support for subsequent evaluation and intervention. Thus, it allows earlier treatment and care for those with depression.

4.4 Accuracy and Sensitivity of the Warning System

The early warning system for depression, based on micro-expression recognition technology, exhibits a high level of performance in respect of both accuracy and sensitivity. Research data

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point to an accuracy of more than 85% for the system, while the sensitivity is equally as compelling at above 90%, detecting potential depressive patients. These figures do not only represent the promising detection of early depression with micro-expression recognition technology but also the application value of the system itself in mental health. Therefore, it alerts facial micro-expressions in real time and could fast identify emotional changes in the vast population, giving timely support in making further interventions and treatments. In brief, the micro-expression-based early warning system for depression really holds promise as a new and effective tool in modern mental health management since its high accuracy and sensitivity have immensely increased the efficiency of early identification and intervention in cases of depression.

4.5 Specificity and False Positive Rate of the Warning System

The micro-expression-based depression early warning system shows good results regarding specificity and the false positive rate. Specificity refers to the ability of the system to identify non-depressed individuals, and this particular system achieved over 80% specificity, distinguishing normal emotional states from depressive symptoms and thereby reducing the misjudgment of healthy individuals. Usually, the false positive rate of this system is lower than 15%, which indicates that incidents where a healthy individual is misidentified as depressed are quite rare; hence, this significantly enhances the usefulness and credibility of this system for clinical purposes.

The specificity of the system is relatively high, and the false-positive rate is low, which ensures the accuracy of this system in screening for depression and helps build trust among the user group in the system's outcomes. By analyzing micro facial expressions in detail, the proposed system will catch the smallest changes in emotional expression and, therefore, minimize mistakes and contribute significantly to the early identification and intervention of mental health problems in individuals.

4.6 Stability and Reliability of the Warning System

The depression early warning system based on micro-expression recognition technology shows strong advantages in the stability and reliability of its warning results. By analyzing large-scale sample data, the system can continuously monitor users' facial micro-expressions under various environmental conditions, ensuring accurate recognition across different emotional states. Research indicates that the micro-expression recognition algorithm has been optimized multiple times and possesses high robustness, effectively reducing interference caused by factors such as lighting changes, angle differences, or facial obstructions, thus maintaining consistency in warning results.

The system continuously learns and adjusts through machine learning models, improving its prediction accuracy over time. This adaptive ability enables the system to better accommodate individual differences, accurately capturing each user's emotional trends and enhancing the reliability of depression symptom prediction. Additionally, long-term operational data shows a significant correlation between the system's warning results and clinical assessment outcomes, further validating its effectiveness in clinical applications.

5. CONCLUSION

5.1 The Effectiveness of the System in Adolescent Education and Psychological Intervention

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Taking 1,073 high school students from Wannen No. 1 Middle School as an example, the depression early-warning system, utilizing micro-expression recognition technology, is capable of monitoring students' facial expressions and subtle emotional fluctuations, promptly identifying potential signs of depression. For widespread application in education and psychological intervention for development at Wannen No. 1 Middle School, this technology allows capturing and analyzing students' micro-expressions to categorize them as normal, mildly, moderately, or severely depressed. Because of this, students showing significant depressive tendencies were intercepted and given the proper counseling service.

Through the implementation of the depression early-warning system, the psychological well-being of students at Wannen No. 1 Middle School has improved significantly, and depressive symptoms among students have been effectively alleviated. In addition to helping identify depressive symptoms, the system has also heightened the school's awareness of students' mental health issues and improved intervention efficiency, providing strong support for students' healthy development.

5.2 The Significant Role and Importance of the System in Managing Adolescent Mental Health

The depression early-warning system based on micro-expression recognition technology plays a crucial role in managing adolescent mental health. This system is not just a simple detection tool; it is capable of keenly identifying subtle emotional fluctuations in each student. By detecting early signs of emotional disturbances, it issues precise warnings at the initial stages of abnormal emotional changes, enabling early identification and intervention, effectively preventing the worsening of mental health issues.

This system considerably revolutionizes how students' psychological well-being is monitored, minimizing the subjectivity embedded in traditional depression assessments yet enhancing both detection efficiency and accuracy. It allows schools to conduct timely and targeted interventions with greater speed and efficacy. Acting as a very strong first line of defense, such a system would help catch mental health issues early and prevent them from escalating.

In the application of the micro-expression recognition technology-based depression early-warning system, school student mental health can be insured much more scientifically and effectively and thus provide much better support for comprehensive development and healthy growth.

6. RECOMMENDATIONS AND STRATEGIES FOR MANAGING ADOLESCENT MENTAL HEALTH

Collaborative efforts from individuals, families, schools, and the society are necessary to help adolescents maintain their mental health.

Individual Level: Adolescents need to enhance self-regulation, emotionally regulate, and build mental resilience. This means that when they experience psychological problems or when something distressing happens that they cannot sort out, seeking assistance from professional counselors will be required. Managing academic pressure involves not adding unnecessary pressure on oneself but setting learning objectives and plans in line with one's capabilities and

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circumstances. When misunderstandings with peers occur, the adolescent should be reflective; if it is due to his/her actions, he/she should quickly work to remedy the situation.

Family Level: Families should build the children's emotional support by providing an atmosphere of positive communication, whereby everything the youths think and express is heard. Changes in psychological states will be observed, expectations will be set reasonably, and children will not be forced into doing anything. Families can also do activities together to make their parent-child relationships better and give the child more security and acceptance.

School Level: Schools should have a whole-school approach to mental health education. Adolescents learn the fundamental skills of emotional regulation and stress management through regular mental health courses and awareness-raising campaigns. In addition, schools should offer professional psychological counseling services accessible to students who can provide individualized assistance in coping with challenges posed both by academic and personal life.

Societal Level: An understanding of psychological issues results from a greater awareness of mental health problems in adolescents among members of society. That would help reduce the stigma about mental health. Besides, several public outreach programs should be conducted in which students actively participate in enhancing their awareness of mental well-being.
Better mental health outcomes for teenagers can be fostered by addressing mental health on several levels and creating a more understanding and supportive environment.

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