Cluster Analysis of Psychophysiological State Parameters of Middle School Students: Measurement Based on Vibraimage Technology

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Abstract: *This paper explains the concept of cluster analysis in data mining. It analyzes the psychophysiological state parameters of middle school students obtained using Vibraimage technology, as well as discusses the distribution of middle school students in 12 psychological and physiological parameters, which helps explain the current emotional state of middle school students and accurately measures the normal value distribution range of potential emotions using Vibraimage technology.*

Keywords: *vibraimage, middle school student, k-means, cluster analysis, normal.*

Introduction

Emotion is "the experience of changing one's attitude towards objective things and the resulting psychosomatic changes" (Huang Xiting et al., 1991), significantly impacts human behavior and mental health. Emotional changes and development are essential manifestations of adolescent socialization (Sang Biao, Deng Xinmei, 2015). According to current research, they are more prone to substantial emotional fluctuations, and the usage and development of emotion regulation mechanisms is a trend of complexity and nonlinearity (Conradt Elisabeth et al., 2021). Due to the cross-cultural uniformity of the conclusions, scholars have long referred to adolescence as the "stormy period." This metaphor illustrates the complexity and subjectivity of adolescent emotions. For a long time, emotional exams were highly subjective, especially when assessing kids' emotional well-being. Emotional tests have long been highly subjective, and despite the efforts of the questionnaire creators, social praise effects cannot be avoided.

Vibraimage technology offers the possibility to measure emotional states objectively. The video images of subjects in different emotional states have different vibration frequencies and variances. By calculating the inter-frame differences of accumulated muscle activity in different parts of the video images, the subjects' emotions can be objectively assessed. Researchers have previously applied it to emotional state assessment in interpersonal situations and found that strangers elicit more negative emotions, which is a positive finding (Sung Teac Hwang et al., 2014). This paper will used vibraimage

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technology to describe the distribution of each parameter of middle school students more systematically and obtained the normal range of their psychophysiological parameters more accurately.

Materials and Method

1 Subject

A total of 74,011 students were selected from 59 middle schools in Shanxi Province by Convenience Sampling, including 35,029 junior high school students and 38,982 senior high school students. Subjects meet the following criteria unlimited sex, aged 13–18, no recent (within two months) use of psychotropic drugs or confirmed mental illness by self-report or other-feedbacks, and no major life events (such as physical illness, relatives or friends' death) in the past two weeks. All subjects included in the study participated and signed the informed consent form of the test voluntarily.

2 Tool

The equipment includes five laptops and cameras and the VibraMed emotional testing program based on vibraimage technology. All equipment are debugged before using, and the testers are well-trained.

3 Method

The study used vibraimage technology to collect 12 psychophysiological parameters of the subjects, including Aggression, Stress, Tension, Suspicious, Balance, Charm, Energy, Self-Regulation, Inhibition, Neuroticism, Depression, and Happiness. The obtained data were imported into SPSS 22.0 software, and descriptive statistics and significance test of difference were used to describe and evaluate the parametric distribution of the subjects. Finally, cluster analysis was used to divide the data into multiple clusters, and then a normal range for the group represented by the subjects is obtained.

Analysis Results and Evaluation

The subjects selected in this study include junior high school students and senior high school students. To exclude the interference of age factors on the test results, a "coefficient of variation" is introduced ($V = SD/M$, SD represents the standard deviation of the parameters of the subjects, M represents the mean of the parameters of the subjects). The analysis results show no significant statistical difference in the variation rate of each parameter between junior high school students and high school students.

1 Description of the psychophysiological parameters distribution status

The 12 psychophysiological parameters obtained for middle school students were analyzed using descriptive statistical methods. Table 1 below presents the distribution of the mean and extreme values of the measured parameters for middle school students.

Table 1

The mean and extreme value distribution of 12 psychophysiological parameters

Parameter	Norm minimum	Norm maximum	Measured minimum	Measured maximum	Measured average
Aggression	20.00	50.00	17.19	60.52	38.87
Stress	20.00	40.00	7.58	41.70	22.97
Tension	15.00	40.00	9.14	48.09	27.44
Suspicious	30.00	50.00	17.74	41.00	29.17
Balance	50.00	100.00	40.90	85.48	66.76
Charm	40.00	100.00	61.95	92.64	80.79
Energy	10.00	50.00	4.58	65.06	27.01
Self-Regulation	50.00	100.00	53.83	87.02	73.56
Inhibition	10.00	25.00	8.09	26.70	16.12
Neuroticism	0.00	50.00	3.26	63.48	27.44
Depression	20.00	50.00	7.78	37.38	21.21
Happiness	20.00	100.00	14.26	59.32	36.00

The results showed that the minimum values of the other nine parameters were lower than the lower limit of normal, except for the three parameters of Charm, Self-Regulation, and Neuroticism, especially negative emotions. Is it possible to infer the conclusion that "the emotional states of middle school students are generally positive"? The answer is "no". According to the distribution in Table 1, the maximum value of the three negative emotional parameters (Aggression, Stress, Anxiety) and Neuroticism parameters of middle school students exceeds the norm upper limit. Overall, the results show that adolescent subjects represented by middle school students have higher emotional fluctuations, which is consistent with previous research. Figure 1 below shows the differences between the parameters and norm range for middle school students in this study.

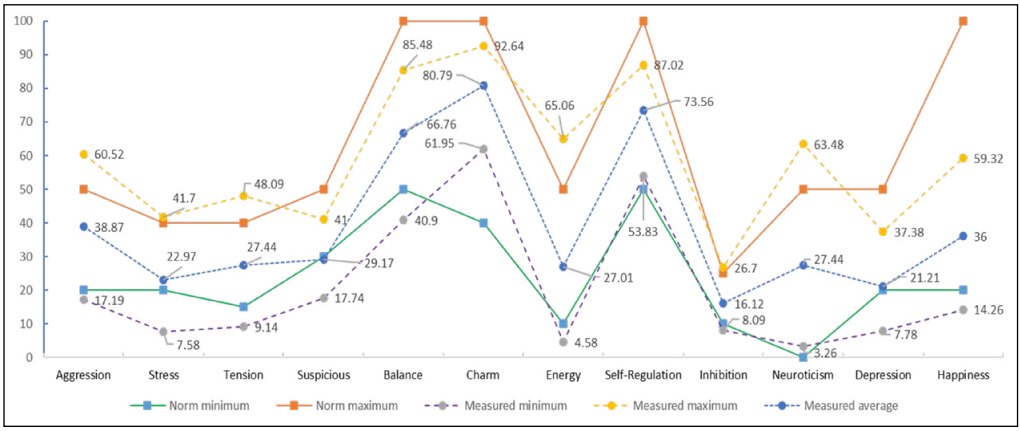

Fig. 1. *Line chart of the difference between each parameter and the normal upper and lower limits*

2 Significance test of the difference between the measurement result and norm

In this study, the measured data and the norm mean were tested for significance of difference. Table 2 presents the comparison results of the two groups' data.

Table 2

The significance test of the difference between the two groups of data

Parameter	Test results (M±SD)	Mean value of norm	t	p
Aggression	38.87±6.53	35.00	161.204	0.000
Stress	22.97±5.24	30.00	–365.065	0.000
Tension	27.44±6.47	27.50	–2.707	0.007
Suspicious	29.17±3.53	40.00	–835.848	0.000
Balance	66.76±7.29	75.00	–307.341	0.000
Charm	80.79±4.51	70.00	650.423	0.000
Energy	27.01±7.28	30.00	–111.529	0.000
Self-Regulation	73.56±4.62	75.00	–84.59	0.000
Inhibition	16.12±2.80	17.50	–134.333	0.000
Neuroticism	27.44±10.24	25.00	64.765	0.000
Depression	21.21±4.51	35.00	–830.755	0.000
Happiness	36.00±6.64	60.00	–984.045	0.000

The results of the significant difference test showed that the subjects' Aggression, Charm, and Neuroticism were significantly higher than the norm, while the Stress, Tension, Suspicious, Balance, Energy, Self-Regulation, Inhibition, Depression, and Happiness were significantly lower than the norm.

3 Subject group division and result analysis

The normality test of the measured psychophysiological parameters shows that each parameter has significant skewness, so it is not suitable to determine the critical value of each parameter according to the law of the standard distribution curve. Therefore, it is necessary to use the K-means clustering algorithm to divide students with similar emotional states into one category.

The optimal number of clusters for mixed data was determined based on the existing research (Duggirala Raja Kishor, 2016). The optimal number of clusters for the data in this study was 3 through binary clustering calculation. Quality is "Fair".

After mathematical model calculation, there are 25,904 students in the first category, 24,378 in the second category, and 23,729 in the third category. The mean and standard deviation of the psychophysiological parameters of the three types of students are shown in Table 3.

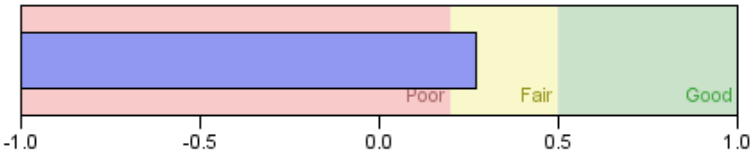

Fig. 2. *Silhouette measurement of cohesion and separation*

Table 3

Psychophysiological parameters of the three types of students

Parameter	first category students		Second category students		Third category students	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Aggression	33.34	4.57	40.05	5.32	43.69	4.81
Stress	24.28	4.94	20.22	4.42	24.38	5.21
Tension	30.12	5.45	22.12	4.81	29.96	5.56
Suspicious	28.79	2.86	26.77	2.71	32.03	2.84
Balance	70.14	5.49	68.14	6.42	61.65	7.08
Charm	80.43	4.53	82.57	3.63	79.34	4.69
Energy	22.06	5.67	30.89	6.63	28.44	6.40
Self-Regulation	75.03	3.86	75.21	3.85	70.27	4.35
Inhibition	15.08	2.13	18.23	2.66	15.09	2.32
Neuroticism	22.35	6.63	37.74	8.15	22.41	6.96
Depression	22.14	4.38	18.88	3.79	22.60	4.42
Happiness	40.81	6.06	35.41	5.38	31.36	4.51

From the clustering results in Table 3, the first type of students had relatively low Aggression, Energy, and Neuroticism, while the Tension and Balance were the highest; the second type of students had the lowest parameters of Stress, Tension, Suspicious and Depression, and the highest parameters of Charm, Energy, Self-Regulation, Inhibition, and Neuroticism; the third type of students had the lowest parameters of Balance, Charm, Self-Regulation, and Happiness, and the highest parameters of Depression. Figure 3 presents the emotional state of the three types of students.

We can divide the subjects into three groups: high, medium, and low, according to the cluster analysis results. The average value of each group is the center of the cluster distribution, which can be used as the basis for formulating the norm of the population. Because the new cluster conforms to the standard normality assumption, the new norm range of the parameter can be derived from it. Table 4 presents the norm ranges of various emotional parameters of middle school students with the 95% confidence interval as an example.

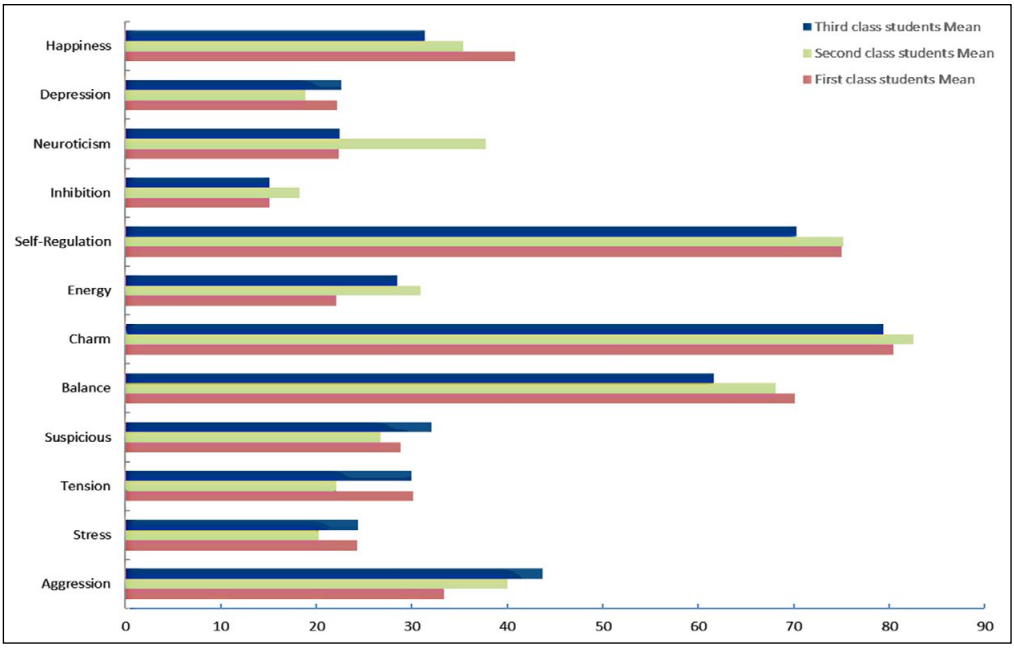

Fig. 3. *Distribution of various psychophysiological parameters of the three types of people*

Table 4

The new cluster center results under the 95% confidence interval

Parameter	Original norm mean	New cluster center		Two-tailed		One-tailed	
		Mean	Standard deviation	Minimum	Maximum	Minimum	Maximum
Aggression	35.00	40.05	5.32	29.62	50.48	27.65	52.45
Stress	30.00	24.28	4.94	14.60	33.96	12.77	35.79
Tension	27.50	29.96	5.56	19.06	40.86	17.01	42.91
Suspicious	40.00	28.79	2.86	23.18	34.40	22.13	35.45
Balance	75.00	68.14	6.42	55.56	80.72	53.18	83.10
Charm	70.00	80.43	4.53	71.55	89.31	69.88	90.98
Energy	30.00	28.44	6.4	15.90	40.98	13.53	43.35
Self-Regulation	75.00	75.03	3.86	67.46	82.60	66.04	84.02
Inhibition	17.50	15.09	2.32	10.54	19.64	9.68	20.50
Neuroticism	25.00	22.41	6.96	8.77	36.05	6.19	38.63
Depression	35.00	22.14	4.38	13.56	30.72	11.93	32.35
Happiness	60.00	35.41	5.38	24.87	45.95	22.87	47.95

Discussion

Compared with the general population, middle school students show impulsiveness, high mood swings, lower physical adaptations (such as Balance, Energy, and Self-Regulation), and lower sensitivity to depression and happiness. Because middle school students are in a period of psychological and physical "upheaval," and the degree of socialization of problems and emergencies is increasing, sometimes they will feel "unable to control" and easily face psychological and physiological conflicts (Li Mengyao, 2021), it psychologically makes middle school students more prone to expressiveness and impulsiveness (Sara L. Bryson, 2020), while physiologically it manifests as exhaustion, somatization, and discomfort. Moreover, middle school students had lower negative emotions (Stress, Tension, and Suspicious) and higher positive emotions about self-satisfaction (Charm). This is related to the self-consciousness development of middle school students. Adolescence is the second "mutation period" developing individual self-consciousness. They are more and more able to recognize their advantages and be more cautious about negative emotions. Research shows that this phenomenon has across-cultures consistency (Nameata et al., 2018; Yeoun Kyoung Hwang et al., 2018; Wei Yuan et al., 2017).

In this study, the cluster analysis algorithm was used to divide all the subjects into three clusters: The first type of students behaves calmly, peacefully, rationally, and happily. Compared with the other two types of students, they are most likely to feel anxious. What needs to be paid attention to is that prolonged tension and anxiety will cause students' physical and mental fatigue, which will intensify the balance parameter decline, so relevant institutions need to pay attention to this, such as carrying out physical exercise, strengthening the popularization of mental health, alleviating anxiety. The second type of student has the best emotional state, the least negative emotional experience, and high self-regulation ability. However, their neuroticism level is the highest, indicating that they are susceptible to emotions and are more prone to emotional fluctuations than the other two types of students. The teacher can carry out emotional counseling for such students and learn positive cope emotions skills. In comparison, the third type of students needs the most attention because they experienced less positive emotions and were likely to be in a state of depressive mood.

With the help of vibraimage technology, the researchers completed the emotional evaluation of middle school students of different grades and genders. Through sampling tests, description, evaluation, and cluster analysis, the position of middle school students within the norm is further refined. We will carry out more ecological validity and cross-cultural consistency model research in the next stage.

References:

1. Conradt Elisabeth, Crowell Sheila E., Cicchetti Dante, Vogel Alecia C. et al. (2021) The Trajectory of Emotion Dysregulation in Positive and Negative Affect Across Childhood Predicts Adolescent Emotion Dysregulation and Overall Functioning, Development and Psychopathology, 2021 (5). DOI: 10.1017/S0954579421000705

2. Duggirala Raja Kishor, N. B. Venkateswarlu (2016) A Novel Hybridization of Expectation-Maximization and K-Means Algorithms for Better Clustering Performance, International Journal of Ambient Computing and Intelligence (IJACI), 2016 (2). DOI: 10.4018/IJACI.2016070103
3. Fino Edita, Mema Denis, Treska Valbona (2022) The Interpersonal Dimension of Pandemic Fear and the Dual-Factor Model of Mental Health: The Role of Coping Strategies. Healthcare, 2022 (2). DOI: 10.3390/HEALTHCARE10020247
4. Huang, X. T. (1991) Introduction to Psychology. Beijing: Peoples Education Press.
5. Li Mengyao (2021) The Importance of Meta-mood in Mental Health Education of Middle School Students, Education Research Frontier, 2021 (2).
6. Minkin, V. A. (2017) Vibraimage. St. Petersburg: Renome. https://doi.org/10.25696/ELSYS.B.EN.VI.2017
7. Minkin, V. A. (2020) Vibraimage, Cybernetics, and Emotions. St. Petersburg: Renome. https://doi.org/10.25696/ELSYS.B.EN.VCE.2020
8. Minkin, V. A., Nikolaenko, N. N. (2008) Application of Vibraimage Technology and System for Analysis of Motor Activity and Study of Functional State of the Human Body, Biomedical engineering, 2008 (4). DOI: 10.1007/s10527-008-9045-9
9. Namrata, Nirmali Puzari (2018) Academic Stress and Mental Health among Secondary School Adolescents, Psyber News, 2018 (1).
10. Sang Biao, Deng Xinmei (2015) Emotion Regulation Development of Chinese Adolescents, Psychological Development and Education, 2005 (01), pp. 37–43. DOI: 10.16187/j.cnki.issn1001-4918.2015.01.06
11. Sara L. Bryson, Caitlin M. Brady, Kristina K. Childs, Kim Gryglewicz (2020) A Longitudinal Assessment of the Relationship Between Bullying Victimization, Symptoms of Depression, Emotional Problems, and Thoughts of Self-Harm Among Middle and High School Students, International Journal of Bullying Prevention (prepublish). DOI: 10.1007/s42380-020-00073-4
12. Sung Teac Hwang, Sangin Park, Myoung Ju Won, Kwan Choi, Mincheol Whang (2014) Evaluation of Social Relationship Between Two Persons Using Micro-Movement in Vestibular System, Proceedings of the Korean Kinesiology Society Conference, 2014.
13. Wei Yuan, Li Fang Zhang, Mingchen Fu (2017) Thinking Styles and Academic Stress Coping Among Chinese Secondary School Students, Educational Psychology, 2017 (8). DOI: 10.1080/01443410.2017.1287343
14. Yeoun Kyoung Hwang, Chang Seek Lee (2018) Relationship Between Stress and Happiness in Middle School Students: Dual Mediation Effect of Growth Mindset and Self-Esteem, Medico-Legal Update, 2018 (1). DOI: 10.5958/0974-1283.2018.00053.1