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Analysis of the role of professional vocal training in enhancing singers' artistic expressiveness

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Abstract Machine learning algorithms provide a research observation pathway for vocal technique training processes. This paper examines the impact of vocal technique training on singing ability and artistic expression, utilizing kernel ridge regression methods to study their specific enhancement relationships. Kernel methods are employed to transform relational issues into high-dimensional linear problems. Ridge regression algorithms are combined to enhance model fitting capabilities. Nonlinear regression methods (KRR) are integrated to improve regression performance in high-dimensional spaces. Research findings: The internal consistency reliability of the five influencing factors reached 0.936, with validity exceeding 0.7. The impact on singers' artistic expression exceeded 0.06. The experimental group's artistic expression was significantly superior to the control group at the 0.01 level, with average scores exceeding 90 points.

Index Terms vocal technique training, artistic expression, kernel ridge regression method, high-dimensional linear regression

I. Introduction

The Role of Professional Vocal Training in Enhancing a Singer's Artistic Expression Artistic expression in vocal performance refers to the emotions, style, and flavour that a singer conveys through their performance, based on their personal knowledge of vocal theory, vocal performance skills, and stage experience. This expression is achieved through a comprehensive analysis and understanding of the piece, and it can resonate with the audience, leaving a lasting impression. From this theory, it is clear that artistic expression in vocal performance has a decisive impact on the quality of the performance.

In contemporary vocal music education, most singers have already mastered certain vocal performance skills. Technically, singers do not face significant issues; they can both fully interpret a piece and perform vocally challenging works with high quality. However, they often struggle to leave a lasting impression on the audience [1], [2]. Singers' performances seem to be focused on completing a challenging task, turning their singing into a mere display of vocal technique. This is a direct manifestation of the lack of artistic expression. Singing that lacks artistic expression not only goes against the basic principles of vocal art development but also hinders the professional growth of singers [3]-[5].

Therefore, enhancing artistic expression must be given full attention by university teachers and made a priority in teaching, with continuous improvement in practice, in order to achieve the comprehensive development of singers in vocal music education. Ding [6] noted that good vocal art expression requires a healthy voice and emotional expression, and that emotional vocalisation can enhance the artistic expression of music. Fernandez-Fresard and Acevedo [7] developed a training tool called the 'Voice Expression Chart,' which can be used to enhance performers' vocal expressiveness. Meissner and Timmers [8] found in a study on children's musical performance that a dialogue-based teaching model centred on teacher demonstrations can help improve children's musical performance expressiveness. Wang et al. [9] found that integrating Italian Belcanto singing techniques with Chinese ethnic vocal music can enhance the vocal expressiveness of Chinese singers.

Vocal music is both a technical skill and an art form, characterised by the integration of 'technique' and 'artistry.' Technical training is undoubtedly the most fundamental and essential aspect, but teachers often overlook the importance of artistry, confining vocal performance solely to the realm of technical training. However, the true pinnacle of vocal performance lies in the expression of style and emotion [10]-[13]. In summary, the cognitive biases and shortcomings of teachers are the direct causes of the lack of artistic expression in vocal music performances by professional singers. Additionally, artistic expression in vocal music requires scientific training methods and long-term practice to achieve ideal results. However, given the current age, experience, and background of singers, achieving meaningful innovative performances or expressions without targeted training is extremely challenging [14]-[16]. More concerning is that, without proper methods as a reference, some singers, in their pursuit of novelty, often fall into misconceptions, resulting in counterproductive outcomes. Therefore, professional vocal training is urgently needed to assist singers in developing their artistic expressiveness. Chen and Tao's [17] research indicates that sustained and scientific vocal training is a crucial factor in enhancing singers" perception of roughness, control, vocal clarity, pitch accuracy, and expressiveness.

This paper analyzes the content of vocal technique training and identifies the key factors influencing the relationship between vocal technique training and the artistic expressiveness of singing. It introduces a kernel-based ridge regression method, combining kernel methods with ridge regression, to explore the linear relationship between vocal technique training and the artistic expressiveness of singers. Specifically, to address the issue of inseparability between vocal technique training data and artistic expression data, kernel methods are used to map low-dimensional data to high-dimensional data, providing a high-dimensional space for the ridge regression algorithm to operate in. By incorporating a regularization term into the ridge regression, the model's fitting accuracy is enhanced, enabling a deeper exploration of the relationship between the two variables.

II. The Impact of Vocal Technique Training Based on Nuclear Ridge Regression on Artistic Expressiveness

II. A. Exploring the Impact of Vocal Technique Training on Singers

II. A. 1) Vocal technique training to improve singing ability

In the field of vocal art, vocal technique training has long been regarded as one of the key methods for enhancing a singer's overall proficiency. Vocal technique training encompasses a wide range of content, including voice control, expanding vocal range, emotional expression control, and pitch accuracy. Systematic vocal technique training not only helps unlock a singer's innate talent and potential but also comprehensively enhances their vocal performance capabilities, thereby improving their professional and overall artistic literacy. Mastering vocal techniques to control singing voice is of great significance. Good voice control techniques can make singers' performances more stable and clear during singing.

First, through effective vocal technique training, singers can master proper breathing methods and vocal techniques, thereby avoiding issues such as voice breaks or vocal cord damage during performance, and presenting singing works with stable performance. Secondly, pitch accuracy is an important criterion for evaluating a singer's professional level. During general vocal technique training, pitch accuracy can be improved through exercises such as "listening and identifying pitch." From the audience's perspective, good pitch accuracy not only reflects a singer's professional competence but also enables listeners to more accurately understand and feel the theme and inner emotions of the song. Additionally, expanding a singer's vocal range is another important method to enhance their singing performance capabilities. Generally, singers select songs within their suitable vocal range based on factors such as their voice quality and timbre. However, with the diversification of music genres, many singers now venture beyond their comfort zones during vocal technique training to expand their vocal ranges, increase the diversity of their repertoire choices, and thereby enrich their musical expression.

As such, vocal technique training significantly influences a singer's performance capabilities. Through exercises in voice control, pitch accuracy, and vocal range expansion, vocal technique training can elevate the overall level of singing performance. Moreover, vocal technique training can expand a singer's vocal range and enhance their performance capabilities. This plays a crucial role in improving a singer's professional and comprehensive skills, meeting audience expectations for musical appreciation, and promoting the development of vocal performance arts.

II. A. 2) Vocal technique training promotes artistic expression

Vocal techniques, as tools for artistic expression, should provide strong support for artistic expression during the singing process. The application of techniques should not merely be for the purpose of showcasing the singer's vocal skills, but rather to better convey the emotions and depth of the song. During singing, techniques can add depth to the voice, but their purpose is to better present the emotional tone of the song. Every note and every lyric in a song carries specific emotions and stories, and the use of techniques should align with these emotions. This means that when employing techniques, singers should consider how to use their voices to better express the song's emotions, rather than merely pursuing vocal brilliance. Techniques should serve as a medium for conveying emotions, helping singers establish a deeper emotional connection between the song and the audience. During technical training, singers can consciously apply techniques to key sections of a song, emphasizing emotional climaxes or turning points to enhance the song's expressive power. Additionally, techniques can be used to highlight emotional keywords in the lyrics, enabling listeners to more deeply understand the emotions the song aims to convey. However, this does not mean that techniques should be overly emphasized on every note; rather, they should be used appropriately to achieve an organic integration of technique and emotion.

II. B. Vocal technique training based on kernel ridge regression methods

II. B. 1) Nuclear Methods

The data from the professional vocal technique training process is used as the independent variable data, while the data on the singer's artistic expression is used as the dependent variable data. The kernel ridge regression method is employed to analyze the relationship between the independent and dependent variables. This study aims to investigate the specific impact of vocal technique training on the singer's artistic expression.

Kernel methods are machine learning algorithms commonly used to address nonlinear problems. Data that is linearly inseparable in a lower-dimensional space may be linearly separable in a higher-dimensional space. Therefore, kernel methods transform data from a lower-dimensional space to a higher-dimensional space through feature transformation, thereby converting the nonlinear problem into a linear problem in the higher-dimensional space.

Define a nonlinear mapping Φ

$$\Phi : X \in \mathbb{R}^{m\times N} \to \Phi_X \in \mathbb{R}^{h\times N} \tag{1}$$

$$\Phi_X = \left[\phi(x_t), \phi(x_{t+1}), \ldots, \phi(x_{t+N-1})\right] \tag{2}$$

where N and m represent the number of samples and the number of variables, respectively, and h is the dimension of the projected variables. Kernel methods introduce kernel functions to replace inner product calculations in high-dimensional spaces and do not require an explicit expression of the nonlinear mapping Φ_X. Available kernel functions include linear kernels, polynomial kernels, and Gaussian kernels. The Gaussian kernel is the most commonly used kernel function due to its nonlinear mapping capabilities and good numerical stability, and is expressed as:

$$K = \Phi_X^T \Phi_X = \left\{k_{i,j}\right\} \in \mathbb{R}^{N\times N} \tag{3}$$

$$k_{i,j} = \left\langle \phi(x_i), \phi(x_j) \right\rangle = \exp\left(\frac{-\left\|x_i - x_j\right\|^2}{\sigma}\right) \tag{4}$$

Here, σ is a hyperparameter used to control the range of Euclidean distance. The following explains why the Gaussian kernel function can project variables into infinite dimensions. $k_{i,j}$ can be expressed as:

$$k_{i,j} = \exp\left(\frac{-\left\|x_i - x_j\right\|^2}{\sigma}\right) = \exp\left(\frac{-x_i^T x_i}{\sigma}\right)\exp\left(\frac{-x_j^T x_j}{\sigma}\right)\exp\left(\frac{2x_i^T x_j}{\sigma}\right)$$

$$= \exp\left(\frac{-x_i^T x_i}{\sigma}\right)\exp\left(\frac{-x_j^T x_j}{\sigma}\right)\sum_{n=0}^{\infty}\frac{\left(\frac{2}{\sigma}\sum_{k=1}^{m} x_{ik}x_{jk}\right)^n}{n!}$$

$$\left(Expand\ according\ to\ the\ Taylor\ formula : e^x = \sum_{n=0}^{\infty}\frac{x^n}{n!}\right)$$

$$= \exp\left(\frac{-x_i^T x_i}{\sigma}\right)\exp\left(\frac{-x_j^T x_j}{\sigma}\right)$$

$$\sum_{n=0}^{\infty}\left(\frac{2}{\sigma}\right)^n \sum_{l_1=1}^{L}\frac{1}{n_{l_1}!n_{l_2}!\cdots n_{l_m}!}\left(x_{i1}^{n_{l_1}} x_{i2}^{n_{l_2}} \ldots x_{im}^{n_{l_m}}\right)\left(x_{j1}^{n_{l_1}} x_{j2}^{n_{l_2}} \ldots x_{jm}^{n_{l_m}}\right)$$

$$\left(\begin{array}{l}\left(Expand\ according\ to\ the\ polynomial\ theorem: \left(\sum_{k=1}^{m} x_k\right)^n\right. \\ = \sum_{l=1}^{L_n} \frac{n!}{n_{l_1}!n_{l_2}!\cdots n_{l_m}!} x_1^{n_{l_1}} x_2^{n_{l_2}} \ldots x_m^{n_{l_m}}, Which \sum_{k=1}^{m} n_{lk} = n, L_n = \frac{(n+m-1)!}{n!(m-1)!} \\ = \sum_{n=0}^{\infty}\sum_{l=1}^{L_n} \phi_{l_n}(x_i)\phi_{l_n}(x_j) = \phi^T(x_i)\phi(x_j) \\ \left(\text{Order } \phi_{l_n}(x_i) = \sqrt{\frac{2^n}{(n_{l_1}!n_{l_2}!\cdots n_{l_m}!)\sigma^n}} \exp\left(\frac{-x_i^T x_i}{\sigma}\right)\left(x_{i1}^{n_{l_1}} x_{i2}^{n_{l_2}} \ldots x_{im}^{n_{l_m}}\right)\right. \\ \phi_{l_n}(x_j) = \sqrt{\frac{2^n}{(n_{l_1}!n_{l_2}!\cdots n_{l_m}!)\sigma^n}} \exp\left(\frac{-x_j^T x_j}{\sigma}\right)\left(x_{j1}^{n_{l_1}} x_{j2}^{n_{l_2}} \ldots x_{jm}^{n_{l_m}}\right) \end{array}\right) \tag{5}$$

Therefore, from equation (5), we can see that n is an integer without an upper bound, so $\phi(x)$ is infinite-dimensional, and $k_{i,j}$ is the inner product of an infinite-dimensional vector. Before implementing the algorithm, it is typically necessary to perform decentralization processing. The decentralized Φ_X and K are represented as

$$\overline{\Phi}_X = \Phi_X - \frac{1}{N}\Phi_X 1_N 1_N^T \tag{6}$$

$$\overline{K} = \overline{\Phi}_X^T \overline{\Phi}_X = \left(I_N - \frac{1}{N}1_N 1_N^T\right) K \left(I_N - \frac{1}{N}1_N 1_N^T\right) \tag{7}$$

Among them, $I_N \in \mathbb{R}^{N\times N}$ is the identity matrix, and $1_N \in \mathbb{R}^{N\times 1}$ is a column vector with all elements equal to 1.0.

II. B. 2) Ridge regression

Ling regression is an improved algorithm of least squares, which adds a regularization term to the least squares optimization objective to solve the multicollinearity problem in multiple regression. Ling regression is a biased regression algorithm that improves the fitting performance of ill-conditioned matrices by sacrificing regression accuracy. The optimization problem of multiple Ling regression can be described as

$$\min_W \left\|Y - W^T X\right\|_F^2 + \lambda \left\|W^T\right\|_F^2 \tag{8}$$

where the ridge parameter $\lambda > 0.0$. The optimal solution W^* is easy to obtain.

$$W^* = \left(\lambda I + XX^T\right)^{-1} XY^T \tag{9}$$

The size of the ridge parameter is set according to the actual data situation. A commonly used setting method is to control the ridge parameter to obtain a suitable value by limiting the size of the sum of squared residuals. When the ridge parameter is set to 0.0, ridge regression degenerates into ordinary least squares.

II. B. 3) Nuclear Ridge Regression

KRR is a nonlinear regression algorithm that combines kernel methods and ridge regression. It projects independent variables into high dimensions, where independent and dependent variables are more likely to exhibit linear relationships, thereby improving regression performance. The parameter estimation results based on kernel methods are as follows:

$$\hat{W} = \left(\lambda I_h + \overline{\Phi}_X \overline{\Phi}_X^T\right)^{-1} \overline{\Phi}_X Y^T \tag{10}$$

However, $\overline{\Phi}_X$ cannot be explicitly expressed, and equation (10) still needs further processing. Let $A = \lambda I_h$, $C = I_N$, $U = \overline{\Phi}_X$, $V = \overline{\Phi}_X^T$, according to the formula for the inverse of the sum of matrices (Lemma 1) and its generalized form (Lemma 2), we have

$$\begin{aligned}&\left(\lambda I_h+\overline{\Phi}_X\overline{\Phi}_X^T\right)^{-1}\overline{\Phi}_X\\&=A^{-1}U-A^{-1}UV\left(I_h+A^{-1}UV\right)^{-1}A^{-1}U\\&=U\left(\lambda^{-1}C-\lambda^{-1}CV\left(I_h+U\lambda^{-1}CV\right)^{-1}U\lambda^{-1}C\right)\\&=U\left(\lambda C+VU\right)^{-1}\end{aligned}\tag{11}$$

Therefore, $\tilde{W}$ is rewritten as

$$\tilde{W}=\overline{\Phi}_X\left(\lambda I_N+\overline{\Phi}_X^T\overline{\Phi}_X\right)^{-1}Y^T\tag{12}$$

At time t, the estimated value of the dependent variable can be expressed as:

$$\begin{aligned}\tilde{Y}(t)&=\tilde{W}^T\overline{\phi}(x_t)=Y\left(\lambda I_N+K\right)^{-1}\overline{\Phi}_X^T\overline{\phi}(x_t)\\&=Y\left(\lambda I_N+K\right)^{-1}k_{X,x_t}\end{aligned}\tag{13}$$

Among them

$$k_{X,x_t}=\left[k_{1,t},k_{2,t},\ldots,k_{N,t}\right]^T\tag{14}$$

Thus, even when the nonlinear mapping is unknown, the original data can be projected from low dimensions to high dimensions, and then the ridge regression algorithm can be performed in the high-dimensional space to effectively solve nonlinear regression tasks.

Lemma 1: Formula for the inverse of the sum of matrices: Suppose that A, C, and $A+UCV$ are nonsingular matrices satisfying

$$\left(A+UCV\right)^{-1}=A^{-1}-A^{-1}U\left(C^{-1}+VA^{-1}U\right)^{-1}VA^{-1}\tag{15}$$

Lemma 2: Generalized form of the inverse formula for the sum of matrices: Suppose that A, C, and $A+UCV$ are non-singular matrices satisfying

$$\left(A+UCV\right)^{-1}=A^{-1}-A^{-1}UCV\left(I+A^{-1}UCV\right)^{-1}A^{-1}\tag{16}$$

III. The influence of singers' artistic expression on practice based on nuclear ridge regression

III. A. Analysis of Factors Affecting Artistic Expressiveness

III. A. 1) Analysis of basic information about survey participants

The study focuses on the artistic expression and influencing factors of 250 students across four grades at the Music College of University A. To identify the influencing factors of vocal artistic expression, a survey was conducted using questionnaires. A total of 250 questionnaires were distributed, 250 were returned, and all 250 were valid, resulting in a 100% response rate. Table 1 summarizes the basic information of the 250 participants. Among them, 40% were male and 60% were female. The proportions of students across the four grades were 30%, 24.8%, 22%, and 23.2%, respectively. The largest proportion of students studied bel canto singing (48%), followed by ethnic singing and pop singing (26%). Among those studying for 1–3 years, 40% were enrolled, with the proportion decreasing as the duration of study increased.

Table 1: The basic information of 250 student participants

Project	Category Name	Percentage/% (quantity)
Gender	Male	40% (100)
	Female	60% (150)
Grade	1	30% (75)
	2	24.8% (62)
	3	22% (55)
	4	23.2% (58)
Professionalism	Opera singing style	48% (120)
	National singing style	26% (65)
	Pop singing style	26% (65)
Training duration	1-3	40% (100)
	4-5	22% (55)
	6-7	22% (55)
	8-10	16% (40)

III. A. 2) Descriptive indicators of factors influencing artistic expressiveness

Based on the results of the questionnaire survey and the opinions of vocal experts, the factors influencing the artistic expressiveness of singers were identified. Table 2 shows the specific descriptive indicators of the factors influencing the artistic expressiveness of singers. There are five major categories of influencing factors, namely breathing methods, vocal techniques, pitch accuracy, vocal range, and emotional expression techniques. Each category contains two descriptive indicators.

Table 2: Factors Affecting the Artistic Expression of Singers

Influencing factors	Serial Number	Description of Indicators	Serial Number
Breathing methods	A1	Smooth breathing	B1
		Unnoticeable breathing	B2
Voice production skills	A2	Stable voice production	B3
		No broken sounds	B4
Pitch accuracy	A3	Timbre accuracy	B5
		Pitch accuracy	B6
Range breadth	A4	Appropriate range	B7
		Diverse repertoire	B8
Emotional expression skills	A5	Various levels of emotional expression	B9
		Appropriate application of techniques	B10

III. A. 3) Reliability testing of influencing factors

The internal consistency reliability of the five influencing factors was examined. Table 3 shows the reliability results of the survey on the influencing factors of singers' artistic expressiveness. The reliability coefficients for the five influencing factors are 0.931, 0.925, 0.917, 0.946, and 0.963, respectively. The internal consistency reliability reaches 0.936, which is greater than 0.900. This indicates that the consistency reliability of the survey on the influencing factors of singers' artistic expressiveness is relatively good.

Table 3: Reliability of Factors Affecting Artistic Expressiveness

Variable	Cronbach's coefficient	Overall Cronbach coefficient
Breathing methods	0.931	0.936
Voice production skills	0.925	
Pitch accuracy	0.917	
Range breadth	0.946	
Emotional expression skills	0.963	

III. A. 4) Factor analysis structural validity statistics

Using SPSS software, factor analysis was conducted on each item, with the KMO and Bartlett's sphericity test selected. A KMO value closer to 1.0 indicates better questionnaire quality. Table 4 presents the structural validity statistics from the factor analysis. As shown in Table 4, the KMO values for all influencing factors exceed 0.7, indicating a high overall explanatory power, with each factor having only one common factor. The overall KMO value for the questionnaire is 0.912, indicating that this dimension is suitable for factor analysis. The eigenvalue is 4.729, explaining 79.231% of the variance. This suggests that the items effectively reflect the factors, and the observed variables adequately represent most of the information in the corresponding latent variables, allowing the study to proceed. The questionnaire designed in this study to investigate the factors influencing singers' artistic expressiveness through professional vocal technique training can accurately and effectively reflect the impact of various factors on singers' artistic expressiveness. Further research analysis can be conducted to identify the specific role of vocal technique training in enhancing singers' artistic expressiveness.

Table 4: Factor analysis structural validity

Influencing factors	Factor KMO value	Overall explanatory power of factors	Overall questionnaire KMO value	Questionnaire characteristic value	Overall explanatory power of the questionnaire
Breathing methods	0.793	79.302%	0.912	4.729	79.231%
Voice production skills	0.802	80.217%			
Pitch accuracy	0.814	81.425%			
Range breadth	0.767	76.710%			
Emotional expression skills	0.785	78.501%			

III. B. Analysis of the relationship between vocal technique training and artistic expressiveness

III. B. 1) Descriptive statistics of influencing factors

Using nuclear ridge regression methods, descriptive statistics and correlation analysis were conducted on the collected data related to influencing factors to identify the impact of vocal technique training on singers' artistic expressiveness. Table 5 presents the descriptive statistical results for the five influencing factors. In the descriptive statistics of the influencing factors, vocal technique had the highest average score at 0.852, with a skewness of only 0.034. The lowest average score was for breathing technique, at 0.805, with a skewness of 0.019.

Table 5: Descriptive statistics of the five influencing factors

Influencing factors	N	Mean	Std.dev.	Min	Max	Skewness
Breathing methods	250	0.805	0.732	0.000	5.000	0.019
Voice production skills	250	0.852	0.561	0.000	5.000	0.034
Pitch accuracy	250	0.824	0.609	0.000	5.000	0.057
Range breadth	250	0.810	0.745	0.000	5.000	0.062
Emotional expression skills	250	0.816	0.692	0.000	5.000	0.047

III. B. 2) Correlation analysis of influencing factors

Figure 1 shows the results of the correlation analysis between the five influencing factors. In the figure, * indicates $p < 0.05$, ** indicates $p < 0.01$, and *** indicates $p < 0.001$. Based on the correlation results of the five influencing factors, the p-values for all correlations between the factors are greater than 0.05, indicating that there is no significant correlation among them. Additionally, the influence of the five vocal technique training methods on the singer's artistic expression is greater than 0.06, indicating that all five influencing factors have a positive correlation with the singer's artistic expression.

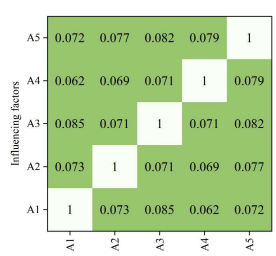

Figure 1: The correlations among the five variables

III. C. Controlled experiment on improving artistic expressiveness based on kernel ridge regression method

III. C. 1) Research subjects and research design

This section investigates the impact of different vocal technique training methods on singers' artistic expressiveness, employing a controlled experiment to assess the role of nuclear ridge regression analysis in evaluating the effectiveness of vocal technique training and making continuous adjustments. The experiment involved 120 students from the Music College of University A who were studying bel canto singing. The 120 students were evenly divided into two groups of 60 each. Prior to the experiment, there were no significant differences between the groups, and the initial artistic expressiveness levels of the singers within each group were comparable. The experimental group combined the kernel regression method to study the relationship between vocal technique training and artistic expression, and adjusted training techniques based on the regression results. The control group used traditional examination methods to study the relationship and adjusted training techniques based on examination results. The experiment lasted for one academic year, and after its conclusion, singing tests were conducted to evaluate the artistic expression of students in both groups.

III. C. 2) Testing the difference in artistic expression between the experimental group and the control group

Table 6 presents the results of the post-experiment comparison of artistic expression between the two groups of students. After a one-year controlled experiment, the average scores of the 60 students in the experimental group all exceeded 90 points, while the highest average score of the 60 students in the control group was only 81.25 points, with a difference of over 8.75 points between the two groups. Furthermore, in five influencing factors, the p-values for both the experimental and control groups were less than 0.01, indicating that the experimental group's vocal artistic expression was significantly superior to that of the control group at the 0.01 level. This suggests that using nuclear ridge regression to study the impact of vocal technique training on artistic expression, and dynamically adjusting the training process, can enhance singers' artistic expression, making vocal performances more compelling to audiences.

Table 6: Comparison of differences in artistic expression between 2 groups

Influencing factors	Group	N	M	SD	T	P
Breathing methods	Experimental group	60	90.38	0.33	15.30***	0.001
	Control group	60	80.19	0.47		
Voice production skills	Experimental group	60	91.06	0.41	12.19***	0.000
	Control group	60	79.28	0.52		
Pitch accuracy	Experimental group	60	90.92	0.37	13.48***	0.002
	Control group	60	81.25	0.76		
Range breadth	Experimental group	60	91.64	0.40	12.37***	0.000
	Control group	60	80.24	0.78		
Emotional expression skills	Experimental group	60	92.71	0.29	13.56***	0.000
	Control group	60	80.63	0.81		

IV. Conclusion

This paper employs nuclear ridge regression to analyze the linear relationship between vocal technique training and artistic expression, enabling targeted adjustments to the training process to enhance singers' artistic expression. The average score for vocal techniques was 0.852, with a minimum skewness of 0.034. The five technical factors had a positive correlation with artistic expression. In the control experiment, the average score difference in artistic expression between the experimental group and the control group exceeded 8.75 points, with $p < 0.01$. Based on the regression results, dynamically adjusting the training methods can effectively enhance singers' artistic expression.

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