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Molecular & Cellular Biomechanics 2024, 21(4), 651.
https://doi.org/10.62617/mcb651

Article

Analysis of cellular and molecular biomechanical correlates in emotional response monitoring via biosensors and their impact on teaching strategy modification in Japanese language instruction

Yongping Chen

International Education College, Kaifeng University, Kaifeng 475004, China; chenyongping2059@126.com

CITATION

Chen Y. Analysis of cellular and molecular biomechanical correlates in emotional response monitoring via biosensors and their impact on teaching strategy modification in Japanese language instruction. Molecular & Cellular Biomechanics. 2024; 21(4): 651. https://doi.org/10.62617/mcb651

ARTICLE INFO

Received: 28 October2024
Accepted: 21 November2024
Available online: 17 December 2024

Abstract: Emotion states have a significant impact on language acquisition and learning outcomes. In Japanese language teaching, traditional strategies often overlook students' emotional responses, which can lead to stress and disengagement, affecting performance. To address this, the study focuses on incorporating bio-sensor-based emotional reaction monitoring. At the cellular and molecular biomechanical level, emotions can trigger a cascade of physiological changes. For example, stress can activate the hypothalamic-pituitary-adrenal (HPA) axis, leading to the release of stress hormones like cortisol. These hormonal changes can affect neurotransmitter systems and cellular signaling pathways in the brain, influencing cognitive functions related to language learning. During Japanese language sessions, teachers' emotional states are recorded using surveys and EEG monitoring. The EEG signals can provide insights into the neural activity and related cellular and molecular events. Participants are divided into experimental and control groups. In the experimental group, teaching strategies are adjusted based on emotional monitoring data. The Extreme Gradient Boosting (XGBoost) model classifier is used for EEG signal feature selection to create a stress level identification model. This model can help in understanding the cellular and molecular correlates of stress during teaching. Statistical analysis evaluates the relationship between EEG features and stress levels, as well as the effectiveness of adjusted teaching strategies. Tailored teaching strategies based on these insights can enhance teacher resilience and improve the classroom environment. By considering the cellular and molecular biomechanical aspects of emotions, the study aims to improve teacher well-being and student learning experiences, leading to more effective Japanese language instruction.

Keywords: emotional; Japanese teaching strategy; biosensors; Extreme Gradient Boosting (XGBoost); cellular and molecular biomechanical

1. Introduction

Japanese is a significant and dominant language in the world. There are more than 128 million native speakers of the language, ranking it as the tenth most spoken language in the world. Traditional grammar-focused methods for teaching Japanese have given way to more modern tactics that place importance on the educational framework and communicative capacity. Technology and multimedia combination encourage interactive learning, making the knowledge more attractive. The growth is to develop pupils' understanding and respect of the language and culture [1]. Emotional engagement is vital for improving student learning and academic success. Emotional involvement, which can be defined as the degree of both positive and negative responses to classmates, teachers, and the classroom, is a major factor in students' feelings of connection and belonging to their school. Its influence on

overall student participation and involvement in extracurricular, social, and academic activities highlights the significance of emotional engagement [2]. Since students' emotions affect their attention and perception of the material, it is critical to monitor their emotional reactions in the classroom. Conventional techniques like scales and observation are arbitrary and imprecise. Intelligent feature analysis has recently been made possible by improvements; however, training can limit these. The integration of brain investigations, particularly through Electroencephalography (EEG) data, presents a talented avenue for more accurate emotional evaluation and improved instructional methods [3]. **Figure 1** demonstrates the monitoring of emotional response.

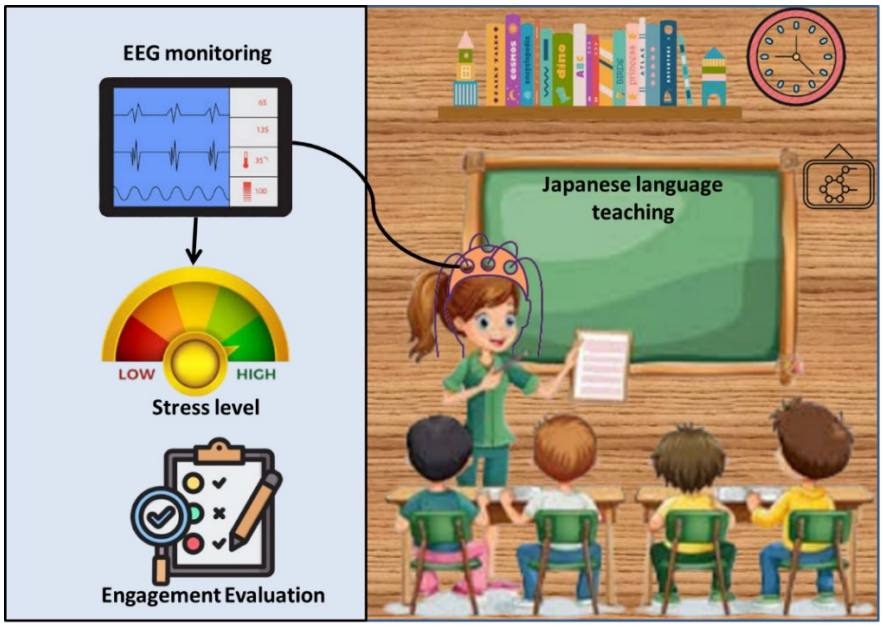


Figure 1. Emotional response monitoring.

Biosensors significantly improve learning outcomes by continuously observing student physical and emotional states. The teacher can adjust their approaches to express modified instruction, support mental health, and enhance language acquisition generally by providing data on stress levels and engagement for more effective and supportive learning environments [4]. Teachers can regulate their teaching tactics to the emotional states of their students by combining biosensors to monitor emotional reactions during Japanese language training. Teachers can adjust their tactics due to real-time data, creating a constructive learning environment. Teachers can enhance their lesson plans and enlarge student motivation, engagement, and overall language attainment grades by spotting trends in emotional responses [5]. Monitoring emotional responses is vital in education because it offers information on the health and interests of students. The technique in Japanese language instruction enables teachers to change their methods according to the emotional setting of their students, creating a promotion atmosphere. Adapting teaching methods suitably increases rendezvous, lowers anxiety, and encourages proficient learning, which finally improves understanding and memory of the subject material [6]. Participant's inconsistency in affecting responses, technological trouble with sensor accuracy,

problems interpreting data, reliance on knowledge quite than human interface, privacy concerns, limited background considerate, and a promising short-term focus on emotional states rather than long-term development are several of the drawbacks of using biosensors for teaching Japanese language monitoring and system change [7]. The integration of biosensors in tracking emotional responses has emerged as a transformative tool in Japanese language guidance, allowing data-driven modifications to coaching strategies. Biosensors, consisting of wearable devices measuring coronary heart rate variability (HRV), galvanic skin response (GSR), and facial expression evaluation through superior cameras, offer actual-time insights into college students' emotional states during lessons [8]. By detecting stress, engagement, or frustration, those technology permit educators to become aware of moments whilst learner's struggle. This enables adaptive interventions, together with enhancing lesson pacing, incorporating interactive activities, or supplying instantaneous comments to enhance comprehension and retention. Such application of biosensor technology not only personalized learning however also foster a supportive environment, in the ultimately improving language acquisition effects [9]. The study's objective is to investigate how biosensor-based emotional reaction monitoring could be incorporated into Japanese language learning. By using EEG monitoring, it aimed to determine whether tailored teaching modifications based on real-time emotional data can raise student performance and engagement, improving language instructions and overall learning outcomes.

Contribution of the research

The research highlights the critical function of emotional states in language acquisition, revealing how they influence student engagement and learning outcomes in Japanese language classrooms. The key contribution of the study is given below:

- The study explores the innovative integration of biosensor technology, specifically EEG monitoring to capture and analyze emotional states, paving the way for personalized learning experiences.
- By dividing participants into experimental and control groups, the study provides a robust framework to assess the effectiveness of teaching strategy adjustments based on real-time emotional feedback.
- The statistical analysis of EEG features against stress levels evaluates the effectiveness of the tailored strategies, contributing valuable insights into teacher resilience.
- The study outcomes promise to improve both teacher welfare and student learning experiments, eventually leading to more efficient language instruction and a more supportive classroom environment.

The research significantly contributes to the perception of how emotional states impact language achievement by integrating biosensor technology to monitor emotional responses in Japanese language teaching.

The remaining of the study separated into sections. Section 2 presents the related article. Section 3 provides the proposed methodology. Section 4 demonstrates the results. Section 5 provides the discussion of this study and Section 6 summarizes the conclusion.

2. Related work

This section provides a summary of the research focused on emotional responses in language acquisition and the influence of teaching methodologies on student engagement and learning outcomes.

The use of the Managing Your Emotions for Language Learning (MYE) tool to teach students about their emotions was investigated in research [10]. By investigating both teachers' and learners' perspectives, it identified diverse emotion-regulation strategies and their efficiency. Results showed a context-dependent catalog of strategies perceived as effectual by both teachers and learners.

The impact of instructors' emotional authenticity on students' emotions, such as happiness, anger, and anxiety, was examined in research [11]. All three perceived teacher emotions are associated with students' emotions in the classroom, according to the outcome of two tentative investigations that used trait-level evaluations and experience sampling techniques.

To assess how school principals' leadership style and emotional intelligence (EI) affected teachers' efforts to improve their teaching methods was investigated in research [12]. Using structural equation modeling (SEM), it examined the correlations between the instructional strategy scale, the principal teaching management rating scale, and Wong's EI scale, combining 534 simple educators from 54 Chinese schools and verifying their important contributions.

A theoretical framework for the sustainable integration of Social and Emotional Learning (SEL) into standard-focused education was presented in investigation [13]. It was created within the knowledge to be initiative and included formative assessment techniques and SEL standards into a united instructional approach, emphasizing the assessment of social skills and personal improvement in addition to knowledge.

By conceptualizing instructor emotions using appraisal theory, research [14] provided an approach for the relationship between teacher emotion and student results. Three psychological mechanisms were identified: recursive influences from student outcomes, mediated effects through teaching actions, and direct transfer of emotions. Both the associations between negative emotions and undesired results as well as those between positive emotions and favorable outcomes were evaluated by empirical study.

The collaborative online learning practices of Chinese students studying English as a foreign language (EFL), which were connected to emotion control and enjoyment was examined in research [15]. To examine the evolution of enjoyment in both individuals and groups using an idiodynamic approach. It also recorded interviews and videos to get insight into the mechanisms behind emotion regulation (ER). The results emphasized how enjoyment during group activities was dynamic.

The impact of teacher burnout on 174 Chinese language teachers' ER and confidence as educators was examined in investigation [16]. It was discovered through the use of SEM that emotion management contributed 11.2% of the variance in burnout, while self-esteem among educators accounted for 20%. A stronger predictor that showed its importance for EFL education initiatives was self-efficacy.

After analyzing the emotional labor strategies of 594 Chinese EFL instructors, research [17] discovered that they favored genuine emotion display above fake emotion. Socio-biographical characteristics had little bearing on the two techniques, according to the results, which indicated a moderately unfavorable association between them. Surface behavior was predicted by sociability, but naturally felt emotions were significantly influenced by emotionality and attitudes toward pupils.

The relationship between learner autonomy, academic motivation, second language (L2) learning experience, and academic emotion regulation among Iranian EFL students was investigated in research [18]. Significant correlations were found when data from 398 participants was analyzed using approved instruments. To emphasize the value of Intelligent Computer-Assisted Language Learning (ICALL) in L2 instruction and the beneficial effects of academic mindfulness.

The relationship between the resilience, well-being, and enjoyment of foreign languages teaching education (FLTE) of 174 Italian FL teachers was assessed in investigation [19]. With a 12.4% variance explanation, resilience was the best predictor of FLTE, followed by well-being (3.9%). The results emphasized how crucial resilient and contented instructors were to support student development and generate a positive learning surrounding in the classroom.

The factors affecting teachers' psychological health and well-being in an EFL context were examined in research [20]. Both teacher emotion control and self-efficacy were important predictors of well-being, with self-efficacy having a greater influence, according to SEM analysis of data from 276 Iranian teachers. For EFL teachers, these findings have significant ramifications.

Using data from surveys, interviews, and reflections, research [21] investigated the relationship between instructors' and students' feelings and their developing specialized identities. Numerous emotions were produced by course-related circumstances, and these emotions both influenced and were influenced by the growth of a specialized individual, according to both quantitative and qualitative evaluations. Insights from the study can help basic teacher education programs go better.

The lack of theoretical frameworks connecting linguistic emotion and positive psychology (PP) in second language acquisition (SLA) was investigated in research [22]. It presented the history of PP, examined its SLA research, and suggested a novel second language emotions and positive psychology (L2EPP) model that combined L2 emotions with PP pillars. The importance of the model for L2 research and pedagogy was emphasized.

Classmoto, an online tool that provides teachers with latest information on student engagement, was developed and tested in research [23]. Analysis of 124 students' involvement levels over 15 weeks showed that they thought it was helpful. The study addressed the limits of the program and made recommendations for future advancements in classroom engagement assessment.

Anxiety, boredom, and enjoyment were assessed in relation to students' performance and involvement in EFL classes was presented in research [24]. Both engagement and proficiency were most strongly predicted by enjoyment, according to statistical analyses that showed significant inter-correlations. The path analysis highlighted the significance of promoting enjoyment in EFL learning by

demonstrating clear connections between enjoyment and proficiency as well as between enjoyment and engagement.

The relationship between psychological well-being (PWB) and emotion management and work engagement in 108 English language teachers from Britain and 255 from Iran was investigated in research [25]. Measurement invariance across the two groups was demonstrated using multi-group SEM, indicating that the constructs for work engagement, PWB, and emotion control had the same theoretical framework.

The connections between immunity, ER, and reflective thinking (RT) in Iranian EFL instructors was examined in research [26]. Path analysis of a sample of 384 teachers showed a substantial correlation between RT and immunity and ER. Furthermore, a substantial relationship between ER and immunity was discovered, confirming the interdependence of these factors.

The Korean as foreign language (KFL) teachers of the local students handled their emotional experiences by utilizing their feeling of authority and nativeness was assessed in research [27]. Teachers developed a new identity as friends instead of authoritarian figures by adjusting to local conventions, which improved classroom interactions and promoted good emotional outcomes like confidence and pride.

The use of learning evaluations in the psychomotor domain for online Japanese education at Sekolah Menengah Atas Negeri (SMAN)10 Malang was presented in investigation [28]. The research employed a descriptive qualitative methodology and showed a variety of assessment options, including project assessments and online practice, have successfully handled psychomotor assessment issues during the COVID-19 emergency.

A/B testing and mental models to enhance user practice was presented in research [29]. Twenty top-grade students' performances are compared, and utility is evaluated using efficiency and satisfaction. The findings showed that hedonic behaviors are greatly enhanced by an m-learning method that uses relaxed mental models, providing a more usual and attractive learning environment.

3. Methodology

This study gathers 126 participants through EEG recordings and surveys during Japanese language classes. Participants are selected using various selection criteria. Participants are divided into experimental and control groups and EEG features are selectedusing XGBoost. The study utilized various statistical analyses to evaluate the relationship between EEG features and emotional response.

3.1. Data collection

This study gathers data from EEG recordings and survey responses from 126 participants during Japanese language classes. EEG data are recorded constantly at a sampling rate of 256 Hz for 60 min, capturing emotional states like engagement and stress. Additionally, self-reported questionnaires assessed emotional responses before and after the intervention. Observational data on classroom dynamics complemented the quantitative trials, offering an inclusive outlook of the emotional and educational influence of the targeted teaching strategies.

3.2. Process of data collection

The player choice procedure for this study involved recruiting 126 individuals enrolled in Japanese language training, with cautious consideration of numerous demographic and revel in-primarily based standards. Participants were divided into two companies: an experimental group (n = 67) and a manipulate group (n = 59). Selection criteria blanketed gender, age, language proficiency, and teaching experience. Gender distribution included 35 men and 32 women in the experimental institution, and 28 males and 31 females in the control group. Age was categorized into four tiers: 25–35, 36–45, 46–55, and 56 and above, ensuring various illustration. Experience in teaching Japanese ranged from 1–5 years to over 15 years. Participants' language proficiency become assessed as beginner, intermediate, or advanced, and educational background was also noted (undergraduate, postgraduate, or doctorate). EEG recordings were taken during class sessions, and participants additionally finished surveys to provide additional context for emotional responses. XGBoost was used to select applicable EEG capabilities for analysis.

3.3. Selection criteria

This study concentrates on individuals with unreliable ability levels in Japanese, ensuring a varied demonstration of emotional responses during language instruction. The selection criteria are dividing into two categories: inclusion criteria and exclusion criteria.

3.4. Inclusion criteria

It refers to the specific characteristics that participants must possess to be eligible for a study, ensuring that the sample is appropriate for the research objective. The inclusion criteria are mentioned below:

- Participants must be available to attend all scheduled classes and data collection sessions to ensure consistent monitoring and evaluation.
- Individuals must offer knowledgeable approval to contribute to the study, acknowledging their perception of the principle and measures involved, as well as their right to withdraw at any time.
- Participants should not have any known neurological illness or disorders that could alter their emotional reactions or EEG readings for data consistency.
- Participants must sense at ease using biosensors and EEG monitoring utensils in class to decrease any probable distractions during data collection.

Exclusion criteria

It is an exact environment that prohibits participants from being included in a study, ensuring that the sample is homogenous and the outcomes are valid. The exclusion criteria are given below:

- Participants with previous proper teaching in the Japanese language for more than six months are excluded.
- Participants currently taking medications affecting cognitive function are excluded.

- Participants who had prior knowledge of biosensors or related technologies are excluded to minimize bias.
- Individuals with previous broad knowledge in learning Japanese or other similar languages are excluded.

3.5. Data grouping

The study data is divides into two groups to assess the capability of tailored teaching strategy based on emotional monitoring.

3.5.1. Group A

The experimental group comprised 67 individuals who capable for targeted teaching approach adjustments based on concurrent emotional monitoring through EEG data. This group received tailored instructional methods customized to their emotional states, allowing educators to respond dynamically to students' engagement levels and stress responses. The aim is to generate a supportive learning situation that enhances student engagement and optimizes learning outcomes in Japanese language acquisition by integrating emotional feedback into the teaching process. The adjustments included modifying lesson pacing, introducing stress-relief techniques, and adapting satisfied relief methods to improve support with the emotional stress-relief techniques and attractive content delivery methods to better align with the emotional requests of students. This approach sought to improve not only the students' emotional well-being but also their overall performance in the language class.

3.5.2. Group B

The control group comprised 59 participants who followed the standard teaching methods without any modifications based on emotional feedback. This group followed standard teaching methods, the conventional approach to language learning, which did not account for their emotional states or provide any personalized interventions.

This section ensured a clear comparison of the influence of emotional response monitoring on engagement and learning outcomes in Japanese language instruction.

3.6. variables

The consequence of the variables in this study lies in their consistent influence on the educational procedure, mainly in the framework of Japanese language instruction. The variables are given below:

- **Stress level:** This quantifies the quantity of stress experienced by individuals, usually deliberate utilizing physiological indicators or physical evaluation. It drastically affects both teaching performance and student engagement, influencing learning outcomes in educational settings.
- **Engagement:** This measures the stage of engagement of students during the learning practice, on a scale from 0–100. A higher score mentions a superior level of association and attention in the session. It can lead to better learning outcomes. Engagement is critical for efficient language attainment, as it directly correlates with inspiration and participation.

- **Teaching performance:** It assesses the efficiency of teaching methods on a scale from 0 to 10. The higher scores reproduce superior teaching performance. This metric can comprise aspects such as clarity of instruction, flexibility to student desires, and the capacity to promote a positive learning situation. Teaching performance is necessary for facilitating student engagement and learning, particularly in language education.

These variables collectively help to understand the interactions between teacher stress, student engagement, and the overall effectiveness of teaching strategies in language acquisition.

3.7. Feature selection

The gathered EEG data features are selected using Extreme Gradient Boosting (XGBoost) for better analysis. Machine learning uses the XGBoost, an extremely scalable continuous tree-boosting technique, for both regression and classification problems. An ensemble approach of classification and regression trees (CARTs) using a collection of $L_j E|j \in 1 \ldots . L$ nodes is the first step. For all tree L^{th}, the sum of prediction scores at a leaf node e_l is used to compute the last forecast output of class label $\hat{x}_j$(Equation (1)).

$$x_j = \varphi(y_j) = \sum_{L-1}^{L} e_l(y_j), \qquad e_l \in E \tag{1}$$

where E stands for the set containing all L scores for all CARTs, and y_j is the guidance set. As indicated by Equation (2), a regularization phase is then used to enhance the outcomes.

$$\mathcal{L}(\varphi) = \sum_{j} \ell(x_j + \hat{x}_j) + \sum_{L} \Omega(e_l) \tag{2}$$

where $\mathcal{L}(\varphi)$ represents the total loss function, $\sum j$ is a summation of all over instances, $\sum L$ is the summation of all tress, Ω represents the regularization component, and ℓ represents the distinct loss function, it is mentioned by calculating the fault variance between the target class labels (x_j) and the forecast class labels $\hat{x}_j$ toavoid over-fitting problems, the second section applies penalization Ω to the model complexity. Equation (3) computes the value for the penalty Ω.

$$\Omega(e) = \gamma S + \frac{1}{2}\lambda \sum_{i-1}^{S} u_i^2 \tag{3}$$

where u_i^2 is the weight value, Ω is the degree of regularization controlled by the customizable parameters γ and λ. The tree's leaves are represented by S, and the weight values for each leaf are stored in γ.

Gradient Boosting is then used in conjunction with the loss function to solve the classification issue efficiently, and it is further extended by a second Taylor expansion. At step $\mathcal{L}^{(s)}$, a simpler aim is to be obtained by removing the constant term, as determined by Equation (4).

$$\mathcal{L}^{(s)} = \sum_{j=1}^{m}\left[h_j e_s(y_j) + \frac{1}{2} g_j e_s^2(y_j)\right] + \Omega(e_s)$$

$$= \left[h_j e_s(y_j) + \frac{1}{2} g_j e_s^2(y_j)\right] + \gamma S + \frac{1}{2}\lambda \sum\nolimits_{i-1}^{S} u_i^2 \tag{4}$$

$$= \sum_{i=1}^{S}\left[\left(\sum_{j\in I_i} h_j\right) u_i + \frac{1}{2}\left(\sum_{j\in I_i} g_j + \lambda\right) u_i^2\right] + \gamma S$$

where e_s^2 represents the predicted value, $Ij = \{i|(xi) = j\}$ indicates the instance of leaves s, and Equations (5) and (6) define the equation for the loss function's first $h_j$and second g_i order gradient statistics.

$$h_j = \frac{\partial \ell(x_j^{(s-1)}, x_j}{\partial x_j^{(s-1)}} \tag{5}$$

$$g_i = \frac{\partial^2 \ell(x_j^{(s-1)}, x_j}{\partial (x_j^{(s-1)})^2} \tag{6}$$

Equation (7) can therefore be used to get the ideal weight u_i^* of leaf j, ∂^2 represents the derivative of the loss function concerning the predicted output from the previous iteration.

$$u_i^* = \frac{\sum_J \in J_i h_j}{\sum_J \in J_i g_j + \lambda} \tag{7}$$

Equation (8), for a specific tree structure $r(y_j)$, can be used to create a system to be utilized as an index to quantify the superiority of a tree arrangement.

$$\mathcal{L}^{(s)}(r) = -\frac{1}{2}\sum\nolimits_{i=1} T \frac{\left(\sum_j \in J_i h_j\right)^2}{\sum_j \in J_i g_j + \lambda} + \gamma S \tag{8}$$

Equation (9) calculates the loss function after splitting and is typically used for assessing the divide nodes by applying scoring in the case collection of left J_K and right J_Q nodes after the division is completed.

$$\mathcal{L}_{split} = \frac{1}{2}\left[\frac{\left(\sum_j \in J_K h_j\right)^2}{\sum_j \in J_K g_j + \lambda} + \frac{\left(\sum_j \in J_Q h_j\right)^2}{\sum_j \in J_Q g_j + \lambda} + \frac{\left(\sum_j \in J_i h_j\right)^2}{\sum_j \in J_i g_j + \lambda}\right] - \gamma \tag{9}$$

$\mathcal{L}_{split}$ represents the loss function achieved after splitting a decision node in the context of the XGBoost algorithm. Since XGBoost effectively handles complex, high-dimensional EEG data, its use for feature selection in this work is noteworthy. Real-time emotion detection precision is improved by XGBoost architecture, which increases the accuracy of identifying important EEG signals associated with emotional stress. By avoiding overfitting, its regularization features make sure that the chosen features actually aid in differentiating stress levels. This improves learning outcomes by resulting in more informed teaching practices.

3.8. Statistical analysis

The study employs various statistical analyses using SPSS to evaluate the impact of emotional response monitoring on teachers' stress levels through a series of rigorous tests like descriptive statistics, paired *t*-test, correlation analysis, and Wilcoxon signed-rank test. **Descriptive statistics** is utilized to summarize key features, providing an overview of the sample help to establish a foundational understanding of the data. A **paired *t*-test** is utilized to evaluate stress levels in pre and post-intervention. It is particularly useful in this study since it accounts for the fact that the same participants are measured twice, allowing for the evaluation of the effectiveness of emotional response monitoring in reducing stress. **Correlation analysis** is employed to identify relationships between EEG features and stress levels, helping to identify whether specific emotional responses captured through EEG correlated with variations in teachers' stress levels. By determining these correlations, the study can highlight which EEG features are most indicative of stress. The **Wilcoxon Signed Rank** is utilized to evaluate feature distribution. It compares the differences between pre and post-intervention measures, making it suitable for evaluating ordinal data or non-normally distributed interval data.

These analyses of the study aim to offer a comprehensive understanding of how emotional response monitoring affects teachers' stress, revealing both the effectiveness of the intervention and the specific emotional indicators that correlate with stress levels.

4. Result

The study aims to ascertain whether using biosensors to track emotional responses improves the results of teaching Japanese. Participants are categorized using demographic analysis, performance, and emotional responses are described using descriptive statistics, pre- and post-intervention outcomes are compared utilizing paired *t*-tests, relationships between stress and engagement are examined using correlation analysis, and the overall effectiveness of the intervention is evaluated using Wilcoxon signed-rank tests.

4.1. Demographic analysis

It is a statistical attribute of participants, including factors like age, gender, education level, and experience. These characteristics are critical for understanding the context of a study, as they can influence behaviors, attitudes, and outcomes among participants. **Table 1** demonstrates the demographic features of individuals.

The demographic table provides a thorough summary of each participant and highlights important traits pertinent to the study on emotional reaction monitoring in Japanese language instruction. The 126 participants are divided into two groups, Group A (n = 67) and Group B (n = 59). The age series mainly lies between 36 and 45 years, suggesting that the study is valid to middle-aged individuals, and the gender distribution is generally balanced, with slightly more males in Group A. The study is made stronger by the variety of instructors' experience levels, which indicate a range from inexperienced to seasoned educators. Participants had intermediate language skills, and a sizable percentage had postgraduate degrees,

indicating that the sample was well-educated. The broad demographic profile strengthens the study's legitimacy and applicability by ensuring a thorough grasp of how emotional reactions can affect learning results across various student and teacher subgroups.

Table 1. Demographic features of individuals.

Categories		**Number of individuals (*n*= 126)**	
		Experimental (*n*= 67)	**Control (*n*= 59)**
Gender	Male	35	28
	Female	32	31
Age	25–35	17	15
	36–45	26	21
	46–55	14	17
	56 and above	10	6
Experience	1–5 years	12	20
	6–10 years	19	9
	10–15 years	15	16
	Above 15 years	21	14
Language proficiency	Beginner	22	19
	Intermediate	29	27
	Advanced	16	13
Educational background	Undergraduate	23	21
	Postgraduate	31	26
	Doctorate	13	12

4.2. Descriptive statistics

To summarize and arrange data and provide insights using important metrics like mean, median, and standard deviation, descriptive statistics are essential. Descriptive statistics evaluate two student groups' emotional reactions, stress levels, engagement, and instructional effectiveness during Japanese language training. **Table 2** demonstrates the descriptive statistical analysis. **Figure 2** shows the result of Descriptive statistics.

Group A showed a mean Heart Rate Variability (HRV) of 55.2 ms and a reduced mean stress level of 40.1, indicating better emotional regulation, after receiving targeted changes based on emotional monitoring. Group B, which used conventional teaching techniques, had a higher mean stress level of 47.8 and a mean HRV of 48.9 ms. Group A's engagement levels are much higher than Group B's, with an average of 82.5 on a 0–100 scale. In addition, Group B's teaching performance received a mean rating of 7.5 on a 0–10 scale, whereas Group A's received an average rating of 8.2. The favorable effects of emotional monitoring on student engagement and instructional efficacy are highlighted in the table, providing insightful information for improving language education.

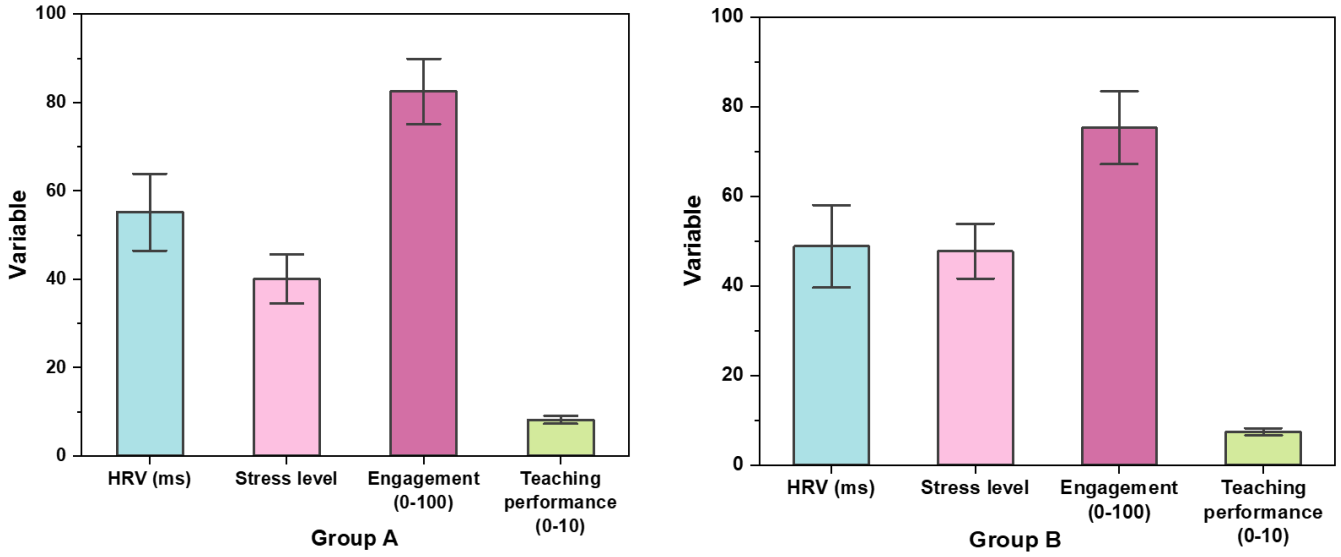


Figure 2. Result of descriptive analysis.

Table 2. Descriptive analysis.

Group	Variable	Min	Max	Mean	Median	S.D
Group A	HRV (ms)	42.0	70.0	55.2	54.0	8.7
	Stress level	30.0	52.0	40.1	40.0	5.6
	Engagement (0–100)	68.0	90.0	82.5	83.0	7.4
	Teaching performance (0–10)	6.5	9.5	8.2	8.3	0.9
Group B	HRV (ms)	35.0	63.0	48.9	49.5	9.2
	Stress level	37.0	55.0	47.8	47.5	6.1
	Engagement (0–100)	60.0	85.0	75.4	76.0	8.2
	Teaching performance (0–10)	5.9	8.8	7.5	7.6	0.8

4.3. Paired *t*-test analysis

It is employed to compare two related groups' means and find any notable discrepancies between them. An emotional reaction monitoring intervention's impact on Japanese language teachers' stress levels, engagement, and teaching performance is assessed in the study using the paired *t*-test. **Table 3** demonstrates the evaluation of emotional reactions.

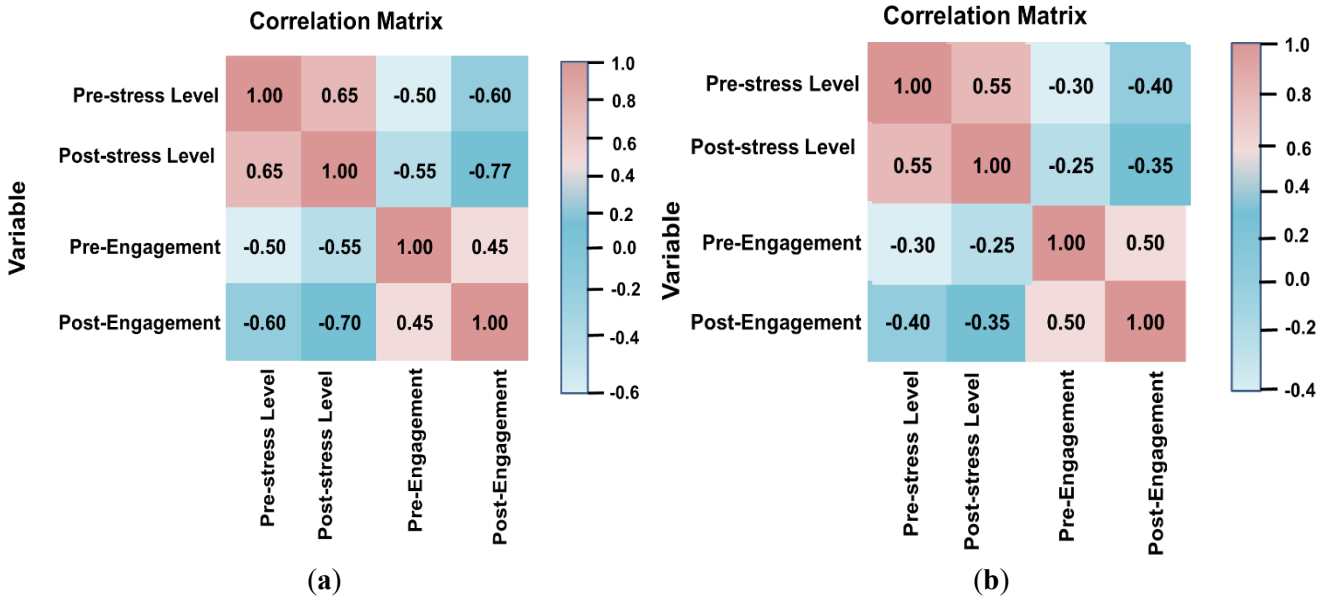
Results for Group A showed significant improvements in teaching performance (1.1, 0.002, 0.81), increased engagement (12.2, 0.004, 0.65), and stress levels (−5.2, 0.001, 0.72). With no discernible changes in engagement or teaching performance and a marginally significant decrease in stress levels (−2.8, 0.046, 0.45), Group B demonstrated less significant changes. Highlights the beneficial effects of the targeted interventions based on emotional monitoring in improving learning outcomes in a high-stress educational setting.

Table 3. Evaluation of emotional reaction.

Group	Variable	Mean		Mean difference	Standard deviation	*t*-value	*p*-value	Cohen's *d*
		Pre	Post					
Group A	Stress level	45.3	40.1	−5.2	3.2	−4.29	0.001	0.72
	Engagement (0–100)	70.3	82.5	12.2	4.5	3.45	0.004	0.65
	Teaching performance (0–10)	7.1	8.2	1.1	0.8	3.91	0.002	0.81
Group B	Stress level	47.8	45.0	−2.8	2.5	−2.11	0.046	0.45
	Engagement (0–100)	70.3	82.5	12.2	4.5	3.45	0.004	0.65
	Teaching performance (0–10)	7.5	7.8	0.3	0.5	1.48	0.157	0.34

4.4. Correlation analysis

A statistical measure that varies from −1 to +1 evaluates the direction and potency of the connection between two variables. The study examines the relationship between stress levels and engagement metrics before and following the implementation of an emotional reaction monitoring intervention in Japanese language training using correlation. **Figure 3** shows the correlation between the variables in post and pre-intervention of (a) Group A and (b) Group B.



(**a**) (**b**)

Figure 3. Correlation analysis of (**a**) Group A and (**b**) Group B.

The intervention group's pre- and post-stress levels exhibited a moderately positive correlation (0.65), suggesting that stress persisted after the intervention, while post-stress and post-engagement levels showed a strong negative correlation (−0.70), indicating that higher stress is associated with lower engagement. There was a moderately positive correlation (0.55) between pre- and post-stress levels and greater negative correlations for engagement measures in the control group. In

contrast to conventional teaching techniques, results highlight the important connections between stress and engagement, suggesting that the intervention can successfully lower stress and raise engagement.

4.5. Wilcoxon signed-rank test

When comparing two linked samples, the non-parametric arithmetic test determines whether the population means rankings of the samples differ. By evaluating the pre- and post-intervention scores of two groups, Group A used customized teaching strategies and Group B used standard procedures as the control group. The research assessed the influence of an emotional response monitoring intervention on learning outcomes in Japanese language classes. **Figure 4** and **Table 4** analyze the pre and post-intervention scores.

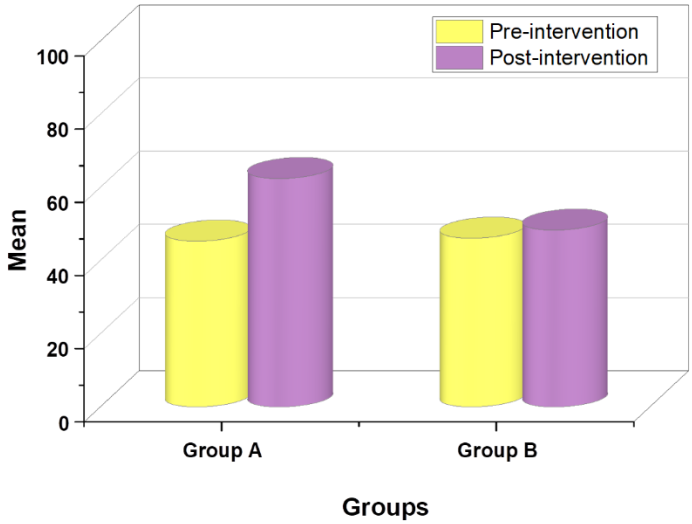


Figure 4. Comparison of pre and post-intervention.

Table 4. Before and after intervention.

Group	Mean		Wilcoxon *W*	*Z*-score	*p*-value	Size (*r*)	Interference
	Pre-intervention	Post-intervention					
Group A	45.3(5.2)	62.4(4.7)	120	−4.67	0.0001	0.76	Significant improvement
Group B	46.1(5.0)	48.3(4.9)	75	−1.99	0.046	0.31	Marginal improvement

With a mean and SD score of 45.3 (5.2) before and 62.4 (4.7) after the intervention, Group A showed a statistically significant improvement, according to the findings. A large effect size (r = 0.76) indicates a Wilcoxon W of 120, a p-value of 0.0001, and a Z-value of −4.67. Group B had a marginally significant improvement (effect size r = 0.31), with a Wilcoxon W of 75, ap-value of 0.046, and a Z-value of -1.99. Their pre-intervention mean is 46.1 (5.0), and their post-intervention mean is 48.3 (SD = 4.9). These results collectively imply that the intervention improved learning outcomes considerably, especially for Group A, but Group B shows marginal improvement.

5. Discussion

To evaluate the effects of an emotional reaction monitoring intervention on Japanese language training, 126 participants were split into experimental (n = 67) and control (n = 59) groups. Results were evaluated using a variety of analytical techniques. The demographic analysis showed that the study applied to seasoned teachers since the participants were well-educated, mostly between the ages of 36 and 45. Descriptive statistics revealed that Group A (experimental group) had a mean HRV of 55.2 ms and a pressure level of 40.1, even as Group B (manage organization) had a slightly lower HRV (48.9 ms) and a higher-stress level (47.8). These differences set the degree for evaluating the effectiveness of the intervention. Group A, which had access to emotional tracking through biosensors, confirmed vast upgrades throughout numerous metrics. Specifically, teaching performance (p = 0.002), engagement (p = 0.004), and stress levels (p = 0.001) all exhibited significant positive changes, demonstrating the efficacy of the intervention in reducing stress and improving engagement. This is in evaluation of Group B, which showed marginal enhancements in these areas. Further analysis in Group A revealed a strong negative correlation (−0.70) among post-stress and post-engagement levels, suggesting a significant relationship where reduced stress becomes related to accelerated engagement. This underscores the significance of managing emotional responses to enhance the studying experience. Additionally, the Wilcoxon signed-rank test highlighted a marked improvement in Group A (mean pre = 45.3) compared to Group B (mean pre = 46.1), further indicating the effectiveness of the emotional monitoring method. The combined results of these studies highlight how well emotional monitoring strategies can improve student engagement and instructional efficacy in a high-stress learning environment. Overall, the findings from this analysis emphasize how emotional reaction monitoring can play a pivotal position in improving student engagement and learning effectiveness, especially in excessive-stress academic environments like language education. The intervention's success in Group A supports the potential of the use of biosensors for real-time adjustments, fostering a more enticing and effective learning atmosphere.

6. Conclusion

Particularly in language education, the incorporation of emotional reaction monitoring into instructional practices is essential for improving learning outcomes and student engagement since it enables teachers to establish a more encouraging learning environment. The research aimed to examine the efficacy of utilizing biosensors to monitor emotional responses in Japanese language training and determine whether student experiences and results can be enhanced by making focused modifications to teaching methods in response to emotional feedback. The experimental group received customized treatments, and exhibited notable changes in teaching performance, engagement, and emotional regulation, according to the findings, whereas the control group only showed slight improvements. However, the research had some limitations, like its small sample size (mostly middle-aged participants) and its reliance on self-reported emotional markers, which may have restricted generalisability. To improve teaching strategies and the well-being of

students, future studies should look into the long-term effects of emotional monitoring in various educational environments, investigate real-time feedback systems, and assess the influence on subjects other than language instruction.

Funding: The research is supported by: A Study and Practice on the Construction of Teachers' Moral and Ethical Standards in Higher Vocational Colleges under the Background of Practicing Educators' Spirit (2024 Annual Teaching Reform Research and Practice Project of Higher Education in Henan Province, Project No. 2024SJGLX0868).

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

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