Analysis of Electroencephalogram Data Activity During Reading Using Scanning and Survey Question Read Recite Review Techniques

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***Abstract*— Effective reading techniques are crucial for enhancing comprehension and training the brain to process information efficiently, motivating students to succeed academically. This quantitative experimental study investigates the relationship between test scores and Electroencephalogram (EEG) activity using Scanning and Survey-Question-Read-Recite-Review (SQ3R) reading techniques. Five subjects, all Electrical and Electronics Technical Education students, participated in the study. The research involved four steps, utilizing the OpenBCI EEG Headband Kit and OpenBCI GUI software for real-time data collection. Analysis revealed that three subjects showed higher effectiveness with the Scanning technique, while two favored the SQ3R technique. The findings indicate a correlation between each reading technique's evaluation scores and EEG data. This study provides insights that can help students optimize their learning strategies and reading techniques to achieve academic success.**

Keywords—reading, EEG, Scanning technique, SQ3R

I. Introduction

Reading is a complex cognitive process aimed at understanding text and fostering an interest in gaining knowledge and information [1]. The human brain processes words and analyzes various aspects of written language in the visual cortex, which is instrumental in processing and understanding reading material [2]. According to [3], reading skills are crucial for language development, and skill-based teaching at each level can help correct deficiencies in reading. Additionally, there is a significant difference between speed reading and slow reading, each requiring a deep understanding of the reading process and different strategies [4]. Everyone has a unique way of learning and faces different challenges while learning [1]. This study compares the relationship between EEG data and test scores among Electrical and Electronics Technical Education students using the Scanning Reading technique and the Survey-Question-Read-Recite-Review (SQ3R) technique.

According to [5], reading skills are typically divided into two main categories: speed reading and slow reading. Speed reading includes skimming and scanning, while slow reading encompasses techniques like KWLH (Know, Want, Learned, How) and SQ3R (Survey, Question, Read, Recite, Review). This study focuses on the Scanning and SQ3R techniques due to their complementary nature [5] (see Fig. 1 for types of reading techniques).

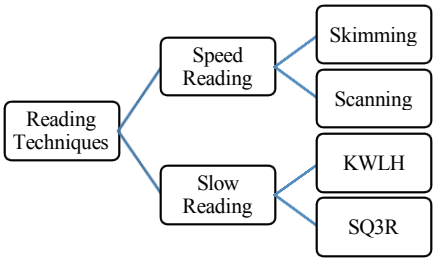

Fig. 1. Types of reading technique [5]

The least invasive method to read brain signals is using electrodes attached to the scalp, known as an electroencephalograph (EEG) [6][7]. These electrodes measure minute voltage differences between neurons, with the signal being amplified, filtered, and transferred to an external device [8].

The OpenBCI EEG Headband Kit will record real-time EEG data with the OpenBCI GUI. The headband is placed according to the international 10-20 system [9], with Fp1 and Fp2 using flat snaps and A1 and A2 for ear clips [10]. Fig. 2 shows the electrode placement for the OpenBCI, which can read thought-modulated activity from the human brain.

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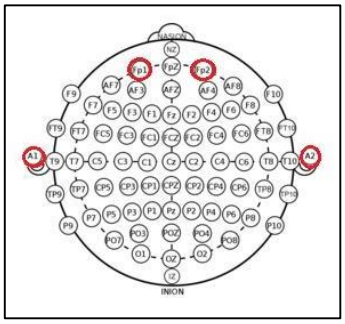


Fig. 2. Electrode placement on the scalp uses the international 10-20 system

II. METHODOLOGY

The research methodology consists of four main phases: review, testing, analysis, and evaluation. The following subsections will explain these four phases in detail.

A. Review Phase

The study objectives were analyzed in the review phase, past research was referenced, qualified subjects were selected, and study instruments were crafted. The literature review ensured a comprehensive understanding of the research context. Five subjects participated in this study, including three females (f) and two males (m), aged between 22 and 25 years. The study did not consider handedness, and all subjects provided informal written consent to participate, as detailed in Table I.

TABLE I. RESPONDENTS DETAIL

Subject	Sex	Age	Academic Qualification
1	m	22 years	Matriculation
2	m	22 years	Matriculation
3	f	25 years	Diploma Vocational
4	f	24 years	Diploma Vocational
5	f	22 years	Matriculation

Developing research instruments was crucial for collecting data that was aligned with the research goals. The reading materials were divided into three parts: introduction, description, and process, all within the same scope and level. Two different topics were developed for use during the Scanning and SQ3R reading techniques. Experts in related fields verified and evaluated the reading materials for accuracy, format, and content consistency.

Additionally, subjective comprehension questions were constructed based on Bloom's Taxonomy, covering levels C1 (remember) to C4 (analyze), which include knowledge, understanding, application, and analysis. Two sets of ten questions were developed for the two reading material topics. Relevant experts validated and reviewed these questions to ensure their appropriateness and effectiveness.

B. Testing Phase

The testing phase involved a step-by-step procedure for data collection using the OpenBCI EEG Headband Kit to ensure data accuracy. The Ganglion board supported two frontal lobe measurements for alpha and beta data, connected two ear clip electrodes to the driven ground and reference pin, and streamed the data over Bluetooth [10]. Fig. 3 illustrates the connection of the Ganglion board to the scalp, and Fig. 4 shows the actual electrode placement to the subject scalp.

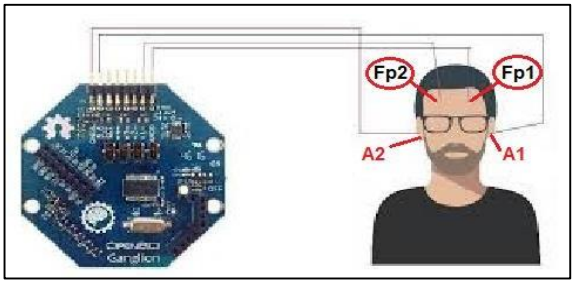


Fig. 3. Electrode placement from Ganglion board to the scalp

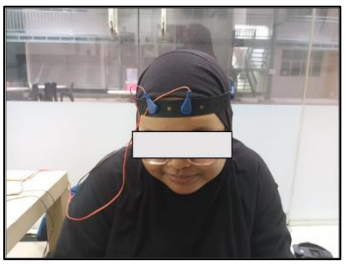


Fig. 4. Electrode placement to the subject's scalp

Each session lasted 44 minutes, as shown in Fig. 5. Initially, respondents were given three minutes to rest before starting the reading as reference data. Each respondent then engaged in the SQ3R reading technique for 10 minutes, followed by answering questions for another 10 minutes. After a three-minute rest, respondents continued with the scanning reading technique for five minutes and answered questions for an additional 10 minutes.

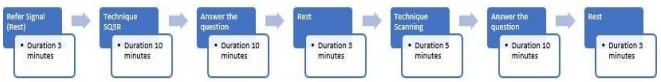


Fig. 5. Data acquisition protocol

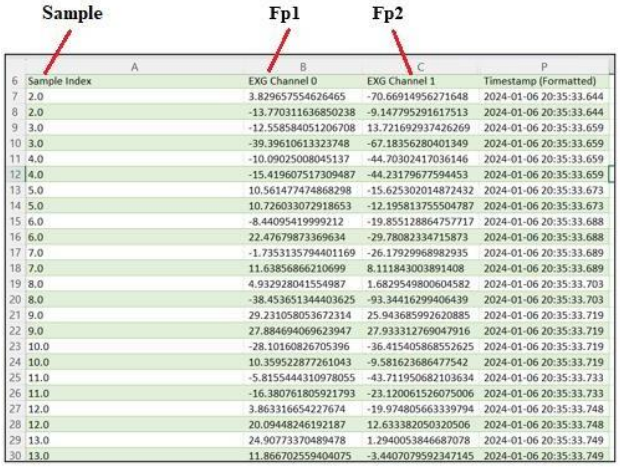
The acquired EEG signals were processed at 200 Hz, with impedance below 50 Ω. The Ganglion board featured a bandpass filter that eliminated frequencies below 0.3 Hz [10]. For optimal bioelectrical measurements, the skin-electrode contact surface impedance was kept low. By using flat snap electrodes over the frontal cortex, two channels showed lower impedance, indicated by a green light on the impedance value. If the impedance light in the GUI was red, the connection was improved by ensuring the electrodes were securely in contact with the skin.

The GUI and Ganglion system worked together to separate and categorize brain waves based on characteristics such as frequency and amplitude. Fig. 6 shows an example of the OpenBCI GUI system control panel, where the notch filter on the top right can reduce AC noise by filtering out 60 Hz noise [10].

Fig. 6. Example of OpenBCI GUI system control panel

C. Analysis Phase

The data analysis phase involved using Microsoft Excel to calculate the average Power Spectrum for each study method. After recording brainwaves via the OpenBCI GUI, the signals were saved in a text file, which was then converted to an Excel file. This conversion was crucial as it allowed the brainwave signals to be accessed and analyzed using Microsoft Excel [10]. For each sample, the minimum and maximum values for the Fp1 and Fp2 points were recorded in µVrms. The negative and positive values reflected the DC offset (~ -27.4 millivolts) on top of the microvolt variations in EEG, a significant feature of DC-coupled EEG amplifiers like the ADS1299 [12]. Fig. 7 provides an example of the file after conversion to Excel.



	A	B	C	P
6	Sample Index	EXG Channel 0	EXG Channel 1	Timestamp (Formatted)
7	2.0	3.829657554626465	-70.66914956271648	2024-01-06 20:35:33.644
8	2.0	-13.770311636850238	-9.147795291617513	2024-01-06 20:35:33.644
9	3.0	-12.558584051206708	13.721692937426269	2024-01-06 20:35:33.659
10	3.0	-39.39610613323748	-67.18356280401349	2024-01-06 20:35:33.659
11	4.0	-10.09025008045137	-44.703024170361 46	2024-01-06 20:35:33.659
12	4.0	-15.419607517309487	-44.23179677594453	2024-01-06 20:35:33.659
13	5.0	10.561477474868298	-15.625302014872432	2024-01-06 20:35:33.673
14	5.0	10.726033072918653	-12.195813755504787	2024-01-06 20:35:33.673
15	6.0	-8.44095419999212	-19.855128864757717	2024-01-06 20:35:33.688
16	6.0	22.47679873369634	-29.78082334715873	2024-01-06 20:35:33.688
17	7.0	-1.7353135794401169	-26.179299688982935	2024-01-06 20:35:33.689
18	7.0	11.638568662106 99	8.111843003891408	2024-01-06 20:35:33.689
19	8.0	4.932928041554987	1.6829549800604582	2024-01-06 20:35:33.703
20	8.0	-38.453651344403625	-93.34416299406439	2024-01-06 20:35:33.703
21	9.0	29.231058053672314	25.943685992620885	2024-01-06 20:35:33.719
22	9.0	27.884694069623947	27.933312769047916	2024-01-06 20:35:33.719
23	10.0	-28.10160826705396	-36.415405868552625	2024-01-06 20:35:33.719
24	10.0	10.359522877261043	-9.581623686477542	2024-01-06 20:35:33.719
25	11.0	-5.8155444310978055	-43.711950682103634	2024-01-06 20:35:33.733
26	11.0	-16.380761805921793	-23.120061526075006	2024-01-06 20:35:33.733
27	12.0	3.863316654227674	-19.974805663339794	2024-01-06 20:35:33.748
28	12.0	20.094482461921 87	12.633382050320506	2024-01-06 20:35:33.748
29	13.0	24.907733704894 78	1.2940053846687078	2024-01-06 20:35:33.749
30	13.0	11.866702559404075	-3.4407079592347145	2024-01-06 20:35:33.749

Fig. 7. Example file after converting to an Excel file

The following formula was used to calculate the average Power Spectrum:

$$Fpn = \frac{\max + min}{2} \quad (1)$$

* n = number of points

This formula was applied to obtain the average value for the data collected at Fp1 and Fp2. The result of adding the maximum and minimum values at each point was then divided by two to obtain the point value for each sample. This value followed the data acquisition protocol, as shown in Fig. 5, which included the reference signal (3 minutes), the SQ3R technique (10 minutes), and the Scanning technique (10 minutes).

D. Evaluation phase

The evaluation phase involves assessing brainwave responses, interpreting results, and drawing conclusions to ensure the study's objectives are systematically met. Two types of evaluations were conducted: evaluating the scores from answering the questions and evaluating the brain data obtained from the OpenBCI GUI during the reading tasks using the SQ3R and Scanning techniques.

During data collection, brainwave signals were recorded from participants as they engaged in reading tasks using both techniques. The recorded EEG data were then analyzed using Microsoft Excel to calculate the average Power Spectrum for each method. This analysis involved applying Formula 1 to the raw data to obtain the average values for the Fp1 and Fp2 points.

Finally, the analyzed data were evaluated to draw implications and formulate conclusions, ensuring they aligned with the research objectives. This meticulous approach maintained objectivity and minimized biases, thereby contributing to the validity and reliability of the study findings. The data presented in Table II, were derived using Formula 1, calculated from the raw Fp1 and Fp2 values for each technique.

TABLE II. THE MEAN VALUE FOR EACH STIMULUS

Subject	Reference		SQ3R		Scanning	
	Fp1	*Fp2*	*Fp1*	*Fp2*	*Fp1*	*Fp2*
1	-629.26	-880.35	-267.25	-1073.52	-514.77	-991.63
2	-112.35	-740.62	-112.93	-271.54	-78.42	-254.63
3	36.730	-459.66	-1358.27	-839.36	-180.67	-525.04
4	-119.65	-225.03	388.77	1124.76	-476.09	-448.36
5	20.55	6727.52	721.40	-822.89	-811.76	-823.75

III. Result

The results of this study are discussed through three subsections: reading test scores, EEG data, and the comparison between reading test scores and EEG data.

A. Reading Test Score

Constructed items were examined following a validated question scheme. Subjects answered two sets of questions to determine the most suitable reading technique. Table III illustrates the scores for both techniques. A high score indicates the subject's preference for a particular reading technique. For instance, Subject 1 scored 52% on the Scanning reading technique and 41% on the SQ3R technique, indicating a preference for Scanning. Three subjects achieved higher scores using the Scanning technique, while two obtained higher scores with the SQ3R technique.

TABLE III. READING TEST SCORES OBTAINED BY SUBJECTS FOR BOTH TECHNIQUES

Subject	SQ3R	Scanning	Conclusion
1	41	52	Scanning
2	19	25	Scanning
3	15	33	Scanning
4	64	35	SQ3R
5	53	39	SQ3R

B. EEG Data

The second result compares EEG data recorded during reading tasks using the SQ3R and Scanning techniques. Reference signals indicated the subjects' non-working state. Table 4 presents the average EEG values for each stimulus. Subject 1, Subject 4, and Subject 5 showed higher EEG values with the SQ3R technique, suggesting increased brain activity. Conversely, Subject 2 and Subject 3 exhibited higher EEG values during the Scanning technique, indicating more excellent brain activity with this method. The conclusion column in Table IV identifies the dominant technique for each respondent based on the observed EEG signals.

TABLE IV. AVERAGE VALUES FOR EACH STIMULATION

Subject	SQ3R	Scanning	Conclusion
1	-670.38	-753.20	SQ3R
2	-192.23	-166.52	Scanning
3	-1098.82	-352.86	Scanning
4	756.76	-462.23	SQ3R
5	-50.74	-817.75	SQ3R

C. Comparison of Reading Test Score and EEG Data

The third result compares the reading test scores with the average EEG data, as shown in Table V. The comparison revealed a discrepancy for Subject 1, who scored higher on the Scanning technique but showed higher EEG activity with the SQ3R technique. Subject 2 and Subject 3 demonstrated that their test scores and EEG data were more effective with the Scanning technique. In contrast, Subject 4 and Subject 5 showed higher test scores and EEG data with the SQ3R technique, indicating its greater effectiveness for them.

TABLE V. COMPARISON OF READING TEST SCORE AND EEG DATA

Subject	Technique	Score	EEG	Conclusion
1	Scanning	52	-753.20	Invalid
	SQ3R	41	-670.38	
2	Scanning	25	-166.52	Scanning
	SQ3R	19	-192.23	
3	Scanning	33	-352.86	Scanning
	SQ3R	15	-1098.82	
4	Scanning	35	-462.23	SQ3R
	SQ3R	64	756.76	
5	Scanning	39	-817.75	SQ3R
	SQ3R	53	-50.74	

CONCLUSION

The experiment demonstrates a correlation between evaluation scores and EEG data for the reading techniques studied. This research introduced hardware and software to simulate brain activity, focusing on attention and rest levels. While some inconsistencies were observed in the data, these may be attributed to participant discomfort. The findings suggest that individual brain responses can vary depending on the reading technique.

This study's findings have significant implications for educational practices. Understanding how different reading skills affect brain activity and comprehension allows educators to adjust their teaching methods to suit particular learning types. This customized strategy can improve student engagement and academic success. Furthermore, using EEG data provides a scientific foundation for assessing the efficacy of various reading tactics, which may lead to more evidence-based educational interventions.

Furthermore, this study emphasizes the significance of individual differences in cognitive processing. The diversity of brain reactions emphasizes the importance of adaptable learning systems that may meet the needs of a diverse student group. Future research could look into the long-term consequences of various reading techniques on brain activity and academic outcomes, providing more insight into how to optimize learning processes. As a result, this study gives significant insights to help students optimize their learning processes and choose appropriate reading methods to improve their academic performance.

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