

# The Relationship between Reading Fluency Improvement and Brainwaves in Children with Autism Spectrum Disorders

Noor Syuhada Abdul Hakim & Nurul Hanim Nasaruddin  
Faculty of Cognitive Science and Human Development, University Malaysia Sarawak  
(UNIMAS)

Corresponding Author Email: syuhada565656@gmail.com

To Link this Article: <http://dx.doi.org/10.6007/IJARPED/v13-i1/20990>

DOI:10.6007/IJARPED/v13-i1/20990

**Published Online:** 13 March 2024

## Abstract

The purpose of this study is to determine the relationship between reading fluency improvement and brainwaves in children with Autism Spectrum Disorders when using yellow overlay. The sample in this study consisted of sixteen ASD children aged between nine and eleven years from Sarawak, Malaysia. A correlational research design was used in this study. Results from the Pearson correlation test found a strong positive relationship between reading fluency improvement and beta brainwaves ( $r = 0.707$ ,  $p < 0.05$ ) at the frontal lobe using a yellow overlay. In addition, the temporal lobe results for reading fluency improvement and beta brainwaves ( $r = 0.560$ ,  $p < 0.05$ ) showed a moderate positive relationship while using a yellow overlay. However, the correlation results for alpha brainwaves at the frontal and temporal lobes were not significant because  $p = 0.320$  and  $p = 0.601$ , respectively. In conclusion, this study proved that yellow overlay has a positive significant relationship between reading fluency improvement and beta brainwaves at the frontal and temporal lobes.

**Keywords:** Autism Spectrum Disorders, Brainwaves, Reading Fluency, Yellow Overlay.

## Introduction

Reading is a medium to obtain information and ideas from something that has been written (Pradani, 2021). The reading process includes personal connections between texts, knowledge, and our life experiences (Altman, 2003; Merrifield, 2011). Reading fluency plays a vital role during the reading process. Individuals who are fluent in reading have good skills to read any written material in a better way (Miranda and Reflinda, 2022). Solari et al (2017) found that reading fluency can be considered one of the specific predictors for interventions in reading comprehension among children with higher-functioning autism (HFASD). Typically, people diagnosed with ASD experience many difficulties related to reading, including reading fluency, because of their concentration problems, literal thinking, and inability to understand their reading content. As a result, they cannot perform well in their academics and jobs (Merrifield, 2011; Yaneva et al., 2016).

Brainwaves can be defined as a pattern of electrical activity generated in the brain. It is related to human emotions, behaviour, and thought. The dominant brainwaves that exist at a certain time will determine the level of an individual's condition. In general, there are five categories of brainwaves known as delta, theta, alpha, beta, and gamma (Hima et al., 2020; Nordin and Alias, 2022). Fauzan and Amran (2015) found that ASD subjects have beta wave deficiency in most areas of their brain. Therefore, they suffer from brain injury, learning difficulties, and concentration problems (Zukiwski, 2021). Fannin (2015) stated that individuals with a higher beta brainwave range have higher intellectual power. They can concentrate and focus more when completing tasks, especially when reading, critical thinking, writing, and solving math are involved (Das, 2017; Farnsworth, 2019).

Many previous studies have found that colour overlay can increase reading ability in individuals with ASD (Ludlow et al., 2008, 2012; Omar and Bidin, 2015). A study conducted by Hakim and Nasaruddin (2022) identified that yellow overlay can increase concentration in children with ASD while reading. Fauzan and Yang (2018) found that ASD students showed the highest mean after using yellow overlay compared to blue and white overlays during the reading session. Most studies only examined the benefits of colour overlay on reading achievements (Fauzan and Yang, 2018). Up to now, there are no previous studies in Malaysia that have investigated the relationship between reading fluency improvement and brainwaves in ASD children by using yellow overlay. Hence, this study set out to determine the relationship between these two variables among ASD subjects with the use of a yellow overlay.

### **Methodology**

This study used a correlation design to determine the relationship between reading fluency improvement and brainwaves reading with the use of a yellow overlay during the reading tasks. The sample for this study was taken using purposive sampling. Sixteen children diagnosed with ASD and able to read from Kuching, Sarawak, Malaysia, were recruited for this study.

Before the data was collected, the researcher explained the purpose of this study to the subject's parents. There are no anticipated risks when using the electroencephalography (EEG) machine; all subjects are volunteers. The data for reading fluency improvement and brainwaves reading were collected before and after using yellow overlay during the reading tasks. An EEG machine known as the Mitsar-EEG-201 amplifier was used to record the brainwaves reading. The data were collected from 19 electrodes (Frontal = Fz, Fp1, Fp2, F3, F4, F7 and F8; Parietal = Cz, C3, C4, P3 and P4; Temporal = T3, T4, T5 and T6; Occipital = O1 and O2). The WinEEG software was used to generate and calculate the raw data that had been collected from the subjects. Next, the artifacts from the raw data were removed using Independent Component Analysis (ICA). The subjects' reading fluency scores were also taken simultaneously with the quantitative EEG recordings. Data collection took approximately 45 minutes to complete for each subject.

All the data were analysed using the Pearson Correlation Coefficient test. This test was chosen because it complies with several assumptions, such as scores for the dependent and independent variables being collected from the same subjects and the results of the Shapiro-Wilk test being normally distributed. Similarly, the study done by Choong et al. (2021) also

used the Pearson Correlation test to determine the relationship between qEEG analysis from various emotions in twelve normal respondents. Before the Pearson Correlation Coefficient test was carried out, the normality test was conducted to ensure whether the collected data was linear and normal or not. In this study, the sample was less than one hundred, so the Shapiro-Wilk test was used (Coakes, 2012).

## Results And Discussion

### A. Relationship Between Reading Fluency Improvement and Alpha Brainwaves at The Frontal and Temporal Lobes

Figure and Table 1 present the results of the relationship between reading fluency improvement and alpha brainwaves at the frontal and temporal lobes when using yellow overlay. The result from the correlation test of reading fluency improvement and alpha brainwaves at the frontal lobe is 0.266, with a significance value of 0.320. It means there was a weak positive linear relationship between reading fluency improvement and alpha brainwaves at the frontal and temporal lobes after using yellow overlay during reading. Meanwhile, results at the temporal lobe showed a very weak positive linear relationship ( $r = 0.141$ ,  $p = 0.601$ ). Both results were not significant because  $p > 0.05$ .

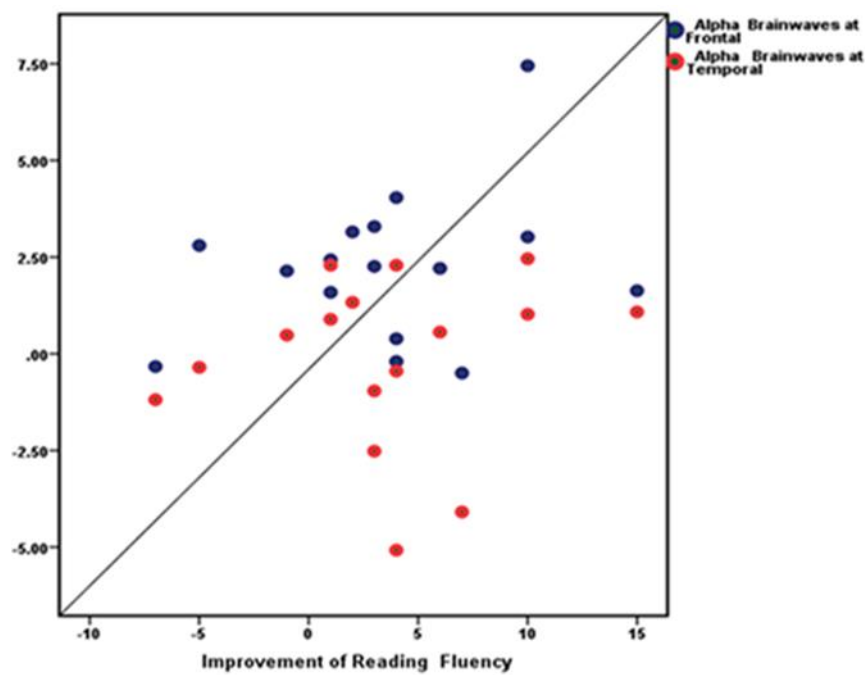


FIGURE 1: Scatter Plot of Reading Fluency Improvement and Alpha Brainwaves at The Frontal and Temporal Lobes

TABLE 1

*Results from a Pearson Correlation Test between Alpha Brainwaves at The Frontal and Temporal Lobes and Reading Fluency Improvement*

		Improvement in Reading Fluency	Alpha Brainwaves at The Frontal Lobe	Alpha Brainwaves at The Temporal Lobe
Improvement in Reading Fluency	Pearson Correlation	1	<b>0.266</b>	<b>0.141</b>
	Sig. (2-tailed)		<b>0.320</b>	<b>0.601</b>
	N	16	16	16
Alpha Brainwaves at The Frontal Lobe	Pearson Correlation	<b>0.266</b>	1	0.542
	Sig. (2-tailed)	<b>0.320</b>		0.030
	N	16	16	16
Alpha Brainwaves at The Temporal Lobe	Pearson Correlation	<b>0.141</b>	0.542	1
	Sig. (2-tailed)	<b>0.601</b>	0.030	
	N	16	16	16

### ***B. Relationship Between Reading Fluency Improvement and Beta Brainwaves at The Frontal and Temporal Lobes***

Figure and Table 2 display the results of the relationship between reading fluency improvement and beta brainwaves at the frontal and temporal lobes with the use of yellow overlay during the reading tasks. The Pearson Correlation test results found that there was a high positive linear relationship between reading fluency improvement and beta brainwaves at the frontal lobe when using yellow overlay ( $r = 0.707$ ,  $p < 0.05$ ). However, at the temporal lobe, the correlation result was 0.560 with a significance value of  $p < 0.05$ , which indicates a moderate positive linear relationship. Overall, these results proved that the reading fluency improvement and beta brainwaves at the frontal lobe have a strong positive linear relationship compared to beta brainwaves at the temporal lobe with the use of yellow overlay. The results for p-value showed a significant positive correlation for both results at  $p < 0.05$ .

These findings align with previous studies, which found that yellow overlay gives an advantage in reading performance among ASD people who suffer from concentration problems (Fauzan and Yang, 2018; Hakim and Nasaruddin, 2022). Yellow colour is also known as a warmer colour, so in theory, this colour can make people more active, quick to react, and in a positive state. As a result, this colour can attract and encourage them to focus when reading (Ayash et al., 2016; Piera, 2019).

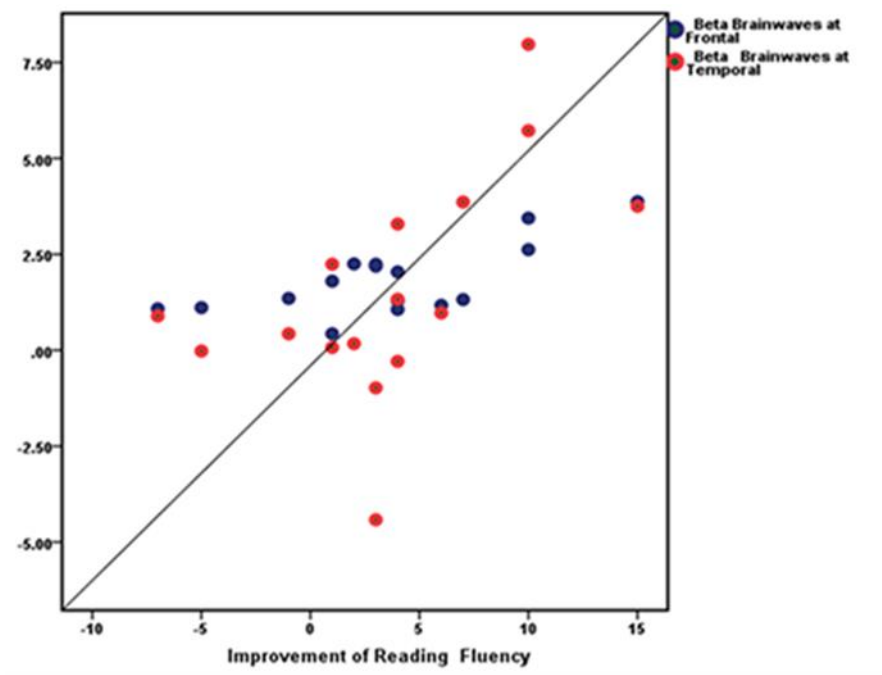


FIGURE 2: Scatter Plot of Reading Fluency Improvement and Beta Brainwaves at The Frontal and Temporal Lobes

TABLE 2

Results from a Pearson Correlation Test between Beta Brainwaves at The Frontal and Temporal Lobes and Reading Fluency Improvement

		Improvement in Reading Fluency	Beta Brainwaves at The Frontal Lobe	Beta Brainwaves at The Temporal Lobe
<b>Improvement in Reading Fluency</b>	Pearson Correlation	1	<b>0.707</b>	<b>0.560</b>
	Sig. (2-tailed)		<b>0.002</b>	<b>0.024</b>
	N	16	16	16
<b>Beta Brainwaves at The Frontal Lobe</b>	Pearson Correlation	<b>0.707</b>	1	0.403
	Sig. (2-tailed)	<b>0.002</b>		0.121
	N	16	16	16
<b>Beta Brainwaves at The Temporal Lobe</b>	Pearson Correlation	<b>0.560</b>	0.403	1
	Sig. (2-tailed)	<b>0.024</b>	0.121	
	N	16	16	16

**Conclusion**

Overall, finding from this study found that there was a high positive linear relationship between reading fluency improvement and beta brainwaves at the frontal lobe when using

yellow overlay. In other words, this study indicates that the greater reading fluency improvement, the higher beta activity at the frontal lobe, and it leads to increased concentration among subjects after using yellow overlay during the reading tasks. Findings from this study can provide evidence and additional information for therapists or practitioners about brainwaves analysis of ASD children when reading using yellow overlay. The results of brainwaves analysis can be used to select the appropriate protocol to enhance the reading ability of ASD children by using Neurofeedback Training (NFT).

### Acknowledgment

The authors wish to offer special thanks to all ASD subjects and their parents for their contribution during the data collection.

### References

- Al-Ayash, A., Kane, R. T., Smith, D., & Green-Armytage, P. (2015). The Influence of Color on Student Emotion, Heart Rate, and Performance in Learning Environments. [https://www.researchgate.net/publication/340739120\\_The\\_Influence\\_of\\_Color\\_on\\_Student\\_Emotion\\_Heart\\_Rate\\_and\\_Performance\\_in\\_Learning\\_Environments](https://www.researchgate.net/publication/340739120_The_Influence_of_Color_on_Student_Emotion_Heart_Rate_and_Performance_in_Learning_Environments).
- Altman, J. B. (2003). Irlen Syndrome and the reading process. Theses Digitization Project. 2169. <https://scholarworks.lib.csusb.edu/cgi/viewcontent.cgi?article=3170&context=etd-project>.
- Choong, W. Y., Khairunizam, W., Mustafa, W. A., Murugappan, M., Hamid, A., Bong, S. Z., Yuvaraj, R., Omar, M. I., Junoh, A. K., Ali, H., Razlan, Z. M., & Shahrman, A. B. (2021). Correlation Analysis of Emotional EEG In Alpha, Beta and Gamma Frequency Bands. *Journal of Physics: Conference Series*, 1997, 1-8. <https://iopscience.iop.org/article/10.1088/1742-6596/1997/1/012029/pdf>.
- Coakes, S. J. (2011). *SPSS Version 20 for Windows: Analysis without Anguish*. Milton, Qld.: John Wiley & Sons.
- Das, T. (2017). Consciousness as a Function of Brain Waves and Physical Constant Conscire. *NeuroQuantology*, 15(3), 1-6.
- Fannin, J. L. (2015). Understanding Your Brainwaves. [https://www.quantumuplift.com/wp-content/uploads/2019/07/understanding-brainwaves\\_white\\_paper.pdf](https://www.quantumuplift.com/wp-content/uploads/2019/07/understanding-brainwaves_white_paper.pdf).
- Farnsworth, B. (2019). EEG (Electroencephalography): The Complete Pocket Guide. <https://imotions.com/blog/learning/best-practice/eeg/>.
- Fauzan, N., & Amran, N. H. (2015). Brain Waves and Connectivity of Autism Spectrum Disorders. *Procedia - Social and Behavioral Science*, 171, 882 – 890. [https://www.researchgate.net/publication/275531489\\_Brain\\_Waves\\_and\\_Connectivity\\_of\\_Autism\\_Spectrum\\_Disorders](https://www.researchgate.net/publication/275531489_Brain_Waves_and_Connectivity_of_Autism_Spectrum_Disorders).
- Fauzan, N., & Yang, J. (2018). The Effect of Blue and Yellow Colour Overlay on Reading among Autism Spectrum Disorders (ASD). *Jour of Adv Research in Dynamical & Control Systems*, 10 (6), 315-319.
- Hakim, N. S. A., & Nasaruddin, N. H. (2022). A QEEG Study on the Usage of Yellow Overlays for Reading among Autism Spectrum Disorder Children with Irlen Syndrome Symptoms. *International Journal of Academic Research in Progressive Education and Development*, 11(2), 802 – 811.
- Hima, C. S., Asheeta, A., Chithra, C. N., Sandhya, M. J. N., & Fathima, B. U. (2020). A Review on Brainwave Therapy', *World Journal of Pharmaceutical Sciences*, 8(11), 59–66.

- Ludlow, A. K., Taylor-Whiffen, E., & Wilkins, A. J. (2012). Coloured Filters Enhance the Visual Perception of Social Cues in Children with Autism Spectrum Disorders. *ISRN Neurology*, 1-6.
- Ludlow, A.K., Wilkins, A.J., & Heaton, P. (2008). Colored overlays enhance visual perceptual performance in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 2(3), 498-515.
- Merrifield, C. (2011). *Enhancing Reading Comprehension for Students with Autism*. Education Masters. Paper 13.  
[https://fisherpub.sjf.edu/cgi/viewcontent.cgi?article=1012&context=education\\_ETD\\_masters](https://fisherpub.sjf.edu/cgi/viewcontent.cgi?article=1012&context=education_ETD_masters).
- Miranda, M., & Reflinda. (2022). A Correlation Between Oral Reading Fluency and Reading Comprehension at Tenth Grade Students MAS TI Canduang. *PESHUM : Jurnal Pendidikan, Sosial Dan Humaniora*, 1(6), 606–611.
- Nordin, N. F., & Alias, N. (2022). The Classification of Human Emotions Based on The Electroencephalogram (EEG) of Brain Waves. *Proc. Sci. Math.*, 9, 286-297.
- Omar, S., & Bidin, A. (2015). The Impact of Multimedia Graphic and Text with Autistic Learners in Reading. *Universal Journal of Educational Research*, 3(12), 989-996.
- Piera, G. (2019). The Effect of Page Color on Reading Speed and Comprehension.  
[https://www.academia.edu/44892751/The\\_Effect\\_of\\_Page\\_Color\\_on\\_Reading\\_Speed\\_and\\_Comprehension](https://www.academia.edu/44892751/The_Effect_of_Page_Color_on_Reading_Speed_and_Comprehension).
- Pradani, A. N. (2021). The Importance of Reading to Expand Knowledge.  
[https://www.researchgate.net/profile/Anindhita-Pradani/publication/352020734\\_THE\\_IMPORTANCE\\_OF\\_READING\\_TO\\_EXPAND\\_KNOWLEDGE/links/60b6102ba6fdcc476bdb30e8/THE-IMPORTANCE-OF-READING-TO-EXPAND-KNOWLEDGE.pdf](https://www.researchgate.net/profile/Anindhita-Pradani/publication/352020734_THE_IMPORTANCE_OF_READING_TO_EXPAND_KNOWLEDGE/links/60b6102ba6fdcc476bdb30e8/THE-IMPORTANCE-OF-READING-TO-EXPAND-KNOWLEDGE.pdf).
- Solari, E. J., Grimm, R., McIntyre, N. S., Swain-Lerro, L., Zajic, M., & Mundy, P. C. (2017). The relation between text reading fluency and reading comprehension for students with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 41–42, 8–19.
- Yaneva, V., Evans, R., & Temnikova, I. (2016). Predicting Reading Difficulty for Readers with Autism Spectrum Disorder.  
[https://www.researchgate.net/publication/303518649\\_Predicting\\_Reading\\_Difficulty\\_for\\_Readers\\_with\\_Autism\\_Spectrum\\_Disorder](https://www.researchgate.net/publication/303518649_Predicting_Reading_Difficulty_for_Readers_with_Autism_Spectrum_Disorder).
- Zukiwski, K. (2021). Quantitative EEG Brainmapping.  
<http://www.drzukiwski.com/brainmapping/>.