

# Exploring children's preferences and perceptions of picture book illustrations using wearable EEG headsets

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**ABSTRACT:** This study utilises picture books of different artistic styles, emotional themes, colours and design elements to explore the emotional state and expression of emotions of children. A questionnaire surveying the illustration preferences of 69 elementary school children was conducted, after which a picture book was created based on the survey results. After the book was completed, a wearable EEG instrument was used to detect brain wave changes in the school children reading the picture books to analyse the degree of attention and meditation. The research aims to analyse the children's preferences from the information obtained for the purpose of creating a series of positive picture images to assist children in achieving self-cognition and developing an accurate and positive mind-set to process emotional issues.

## INTRODUCTION

Emotional intelligence is of crucial importance to the holistic development in children. Children must learn to accept and recognise their own emotions while growing up, and they need to develop a method of communicating those emotions in a healthy manner to develop sociality, a positive mind-set, and the ability to share with others. Furthermore, the effective processing and adjusting of personal emotions facilitates empathy and understanding of others, which provides individuals with the ability to resolve conflicts and self-affirm [1].

A large number of picture books have been used in teaching over the years, not only for preschool and elementary school children, but also for older children and even, at times, for college students. As picture books feature a wealth of pictures and cover a wide variety of topics, children are able to explore the world with their senses through the listening, seeing and feeling experiences provided by picture books. Denham et al indicated that, in the past, a number of studies have explored how emotional picture books can guide emotional learning in children and described the important role teachers play in children's emotional learning [2]. Therefore, it is important to discuss how to construct picture book teaching tools designed to cultivate the emotional processing and expression abilities of children.

In this study, brain wave changes of participants exposed to stimulation by picture books are examined. The picture book preferences of children were explored by using a wearable electroencephalogram (EEG) headset, and it was possible to determine whether or not picture books are able to improve attention and relaxation in learners to improve the applicability of picture book teaching tools for emotional counselling.

On the basis of the aforementioned research objectives, this study presents discussion about emotionally themed picture books and child preferences toward images, colours and themes. This study, then, analysed the effects of these factors on child learning and emotions and created a physical picture book.

## LITERATURE REVIEW

With the development of optical theory, researchers have found that colour not only evokes different visual reactions, it is also an important element in any form of design; in addition to disseminating information, colour influences human visual and psychological perceptions. Colour incites the strongest reactions in a visual form, as it is the element of sensory stimulation that possesses the richest expression; it can directly and immediately affect the emotions [3], with different effects dependent on the degree of visual sensitivity toward colour [4].

In research related to colour, Lin and Chuang indicate that in terms of colour preferences, women have a greater preference for lighter tones compared with their male counterparts. Furthermore, women also exhibited greater

sensitivity to colour than men [5]. Hospitals and clinics often use different colour and furniture combinations to achieve an emotionally calming effect for patients [6].

Numerous scholars have developed theories of brain science and have used a variety of studies to illustrate the importance and relevance of brain science. Brain waves are the result of the generation of electric currents produced by communications in the brain between neurons; the process of recording this electrical activity is called electroencephalography (EEG). Hans Berger classified normal brain waves into four categories based on their respective frequencies:  $\alpha$  waves,  $\beta$  waves,  $\theta$  waves, and  $\delta$  waves [7].

The frequency of brain waves is calculated according to the number of cycles and oscillations produced each second; the more oscillations there are each second, the higher the brain wave frequency is. When an individual is awake,  $\alpha$  waves (alpha waves), which are small in magnitude and rapid, are characteristic;  $\beta$  waves (beta waves) are typically produced when concentrating and during intense mental activity, they are the type of brain wave oscillation with the highest frequency;  $\theta$  waves (theta waves) are generated when individuals enter a shallow sleep state, and are of low frequency;  $\delta$  waves (delta waves) are produced when individuals enter a deep sleep state, and are large magnitude low frequency waves; and  $\gamma$  waves (gamma waves) are generated when in a heightened awareness or in an alert state of consciousness.

The majority of researchers studying brain waves analyse them based on the aforementioned description. Currently, EEG can be used to detect emotions and calculate emotional features; the majority of studies use event-related potential as a method in experimental design to detect changes in emotions [8]. Event-related potential can be used to observe brain wave signal responses through visual and audio stimuli that cause emotional responses; thereby, assisting researchers in understanding subject emotional states [9]. Discernible emotional responses require the collection of brain wave signals over a long period of time for analysis and identification [10].

Conventional EEG equipment is bulky and difficult to transport. Because of technological advancements, current EEG instruments present a comparatively lower cost burden compared to conventional methods and this increased equipment flexibility has allowed researchers to apply EEG broadly to a range of different fields. For instance, in medicine, Ramirez et al used a wearable EEG instrument to explore changes in EEG data caused by music and adjusted the volume and tempo of music to suit the participants to improve depression symptoms in middle-aged individuals [11].

Other applications include the use of EEG and eye tracking instruments for studying user preferences and consumer decision-making processes [12]. Chen et al pointed out an attention aware system that can be used to provide timely alert and collected student EEG signals to assist on-line instructors to understand the degree of student attention in an e-learning environment [13].

The present study recorded the EEG data of children, while reading a picture book that was specifically created based on the children's preferences for the purpose of understanding the physiological states of attention and relaxation.

## RESEARCH METHOD

This study was divided into two stages: the first stage utilised a questionnaire to survey picture book reading habits of children and their emotional associations related to artistic style and colour. The results of the questionnaire were, then, used as an indicator for image preferences of children for determining imagery and colour use when creating a picture book. The second stage utilised an EEG instrument to examine the physiological states of attention and relaxation when the children read the designed picture book.

The research procedure involved the surveying of a total 69 children aged 9-12 (34 boys and 35 girls) in the first stage. To understand the subjective preferences of children towards colours in picture books for use as a reference in creating emotional picture books, this study conducted a colour association survey. The questionnaire items were open-ended to allow children to answer topics related to the emotions associated with each colour. The emotions associated with the content of each topic were categorised into happy, angry and sad emotions. Lastly, the story topics that children expressed interest in were addressed (including education, puzzle, culture, mythology, martial arts, suspense, science fiction, humour, history and horror). Then, the questionnaire results were analysed, with the preferences of the children used in the establishment and implementation of the picture book framework.

In the second stage of the brain wave experiment, a wearable EEG instrument (NeuroSky Mindwave) was used for the primary function of measuring attention and relaxation. The EEG instrument measured the prefrontal cortex FP1 and FP2 electrode positions and the power of five frequencies ( $\delta$ ,  $\theta$ ,  $\alpha$ ,  $\beta$  and  $\gamma$ ), and is a type of non-invasive instrument. After excluding participants exhibiting unstable EEG signals with the wearable instrument, the final participants consisted of 13 boys and 10 girls for a total of 23 individuals.

This study recorded the experiment over its entire duration and monitored the signal of the EEG instrument until the participants completed reading the picture book. Of the vast amount of brain wave data collected, average attention and relaxation were the crucial data points that this study sought to focus on; the data collection method used in examining

the degree of attention and relaxation was drawn from the eSense proprietary algorithm developed by NeuroSky using quantified parameters.

The Mindwave system used specific values between 0 and 100 to represent the degree of subject attention. Values of 40-60 indicated a normal level, values of 60-80 indicated a slightly higher than normal level and values of 80-100 were significantly higher than normal level or indicating a state of extreme attention. These values represented different degrees of nervousness, frustration and uneasiness, and were used to conduct differential analysis on the emotional responses of children toward picture books as a reference for related future projects.

## RESEARCH RESULTS

This study surveyed a total of 69 children during the questionnaire stage. The content of the questionnaire included demographic information, artistic style preferences for picture books and colour associations. The survey on their preferences for picture book drawing method indicated that children indicated a greater preference for hand-painted books (72.5%), with girls having a greater preference than boys. The preference survey for picture books' artistic styles was analysed with a frequency distribution analysis.

The results indicated that, on average, each participant showed a higher preference for six styles. The styles, in order of preference, are as follows: elegant (84.3%), science fictional (82.4%), cute (78.4%), realistic (68.6%), thrilling (66.7%), and complicated (58.8%). Of all the 10 styles, the abstract (31.4%) style was selected least often. This study, then, further conducted a cross-analysis to examine whether boys and girls exhibited different preferences for picture styles.

The results indicated that girls exhibited the greatest degree of preference for the elegant style (25 participants), followed by the cute, realistic, simple and science fictional styles. Boys indicated the greatest degree of preference for the science fictional style (26 participants), followed by the thrilling, elegant, realistic and cute styles. The abstract style was generally disliked by both boys and girls, as shown in Table 1.

Table 1: Preference survey results for artistic styles in picture books.

		Style									
		Realism	Abstract	Cute	Simple	Complicated	Vintage	Elegant	Figured	Science fiction	Thrilling
Gender	Girl	19	7	24	16	15	12	25	13	16	11
	Boy	16	9	16	9	15	13	18	15	26	23
Total		35	16	40	25	30	25	43	28	42	34

a. Dichotomy group tabulated at value 1.

In terms of image rendering tools and medium use as presentation methods in the picture books, the use of coloured pencils (52.17%) was the most preferred by both boys and girls, followed by water colours (26.08%) and other types (14.49%). According to the preference survey, preferences for picture book story content is as follows, with humorous picture books being the most popular (95.9%), followed by those with science fiction (89.8%), puzzle (85.7%), and horror (75.5%) content, whereas mythology was the least liked (38.8%).

This study, then, further conducted a cross-analysis to examine whether boys and girls exhibited different preferences for story content. The results indicated that girls exhibited the greatest degree of preference for humour (24 participants), followed by science fiction (20 participants), puzzle (19 participants), suspense (17 participants) and horror (16 participants) stories. Boys indicated the greatest degree of preference for martial arts stories (25 participants), followed by science fiction (24 participants), puzzle (23 participants), humour (23 participants), and horror (21 participants), as shown in Table 2.

Table 2: Preference survey results for the story content in picture books.

		Story content									
		Education	Puzzle	Culture	Myth	Martial	Suspense	Science fiction	Humour	History	Horror
Gender	Girl	10	19	13	9	8	17	20	24	10	16
	Boy	11	23	15	10	25	16	24	23	18	21
Total		21	42	28	19	33	33	44	47	28	37

a. Dichotomy group tabulated at value 1.

To understand the preferences of children for the use of various colours in picture books, this study conducted a colour association questionnaire survey with open-ended questions. The survey results indicate the subjective views of children regarding various colours in picture book teaching materials. Happy is most represented by blue (36.23%) and yellow (21.73%), the colour for anger is red (68.11%), and the colour for sadness is grey (55.07%). Because hand-drawn strokes and coloured pencils were found to be liked by most children, the book created during the course of this study

employed these stylistic elements. It also adopted an elegant style as the creative direction, and the story content framework was based on humour, both most preferred among the children.

Colouring was selected with the colour associations as a reference. After completing the picture book creation steps, this study conducted a brain wave experiment to examine the degree of physiological attention and relaxation in children during the process of reading the book using a single-sample *t*-test. These results demonstrate that children reading the emotional picture book created using the results of the described preference survey exhibited brain wave physiological states with an average degree of attention of  $M = 58.74$  and relaxation of  $M = 54.09$ .

According to the eSense proprietary algorithm of the NeuroSky system, wave values between 40-60 are normal, indicating that the recorded average attention and relaxation values showed that the children's physiological states were consistent with the normal baseline. Therefore, the reading and understanding of children regarding the content of the emotional picture book were further examined. The statistical results of brain wave changes representing attention and relaxation when reading and understanding the picture book are shown in Table 3.

Table 3: The statistical results of brain wave changes representing attention and relaxation.

	Test value = 50			
	T	df	<i>p</i> -value	Average deviation
Attention	3.807	23	0.001*	8.74292
Medication	1.651	23	0.112	4.09000

Note: \* $p < 0.05$

The results indicate that attention exhibited  $p = 0.001$  and, therefore, reached the level of significance. This was likely the result of the book being novel to the children, it was the first time they were exposed to it, as well as the use of preferred colours and stylistic elements in creating the picture book materials, which increased the interest and attention of the children.

The degree of relaxation exhibited  $p = 0.112$ ; not reaching the level of significance. This result was likely caused by the story content of the book, which attempted to teach children how to recognise negative emotions and how those emotions could be appropriately expressed. As the story development provided children with the opportunity to understand emotions and accept, recognise, convey and face their own emotions through healthy approaches, the teaching content provided a discussion of negative emotions, which may have affected the degree of relaxation of the children reading the book.

## CONCLUSIONS

Potential differences caused by cognitive and emotional brain activity can be used as a physiological measurement tool for determining mental processes. Thus, this study used a wearable EEG instrument as a measurement tool to examine the brain wave states of participants reading picture books to understand preferences of children for picture book styles and story content, as well as brain wave changes produced during the reading process.

This study surveyed a total of 69 participants during the questionnaire stage (35 girls, 34 boys). After excluding participants exhibiting unstable EEG signals during the experimental stage, this study successfully completed the experiment for 23 participants in examining their picture book style preferences and perceptions. Five conclusions were obtained from the results of this study concerning picture books, and are as follows:

1. Presentation method: the overall preference was for the use of coloured pencils (52.17%) and hand-drawing (72.5%).
2. Style: the greatest overall preference was for the elegant style (84.3%) and the least preferred was the abstract style (31.4%). In terms of preference differences between boys and girls, girls indicated the greatest degree of preference for the elegant style (25 participants), while boys indicated the greatest degree of preference for the science fictional style (26 participants).
3. Story content: the greatest overall preference was for humour (95.9%) and the least preferred was the mythology (38.8%). In terms of preference differences between boys and girls, girls indicated the greatest degree of preference for humour (24 participants), while boys indicated the greatest degree of preference for martial arts stories (25 participants).
4. Colour association: the overall subjective view was that blue (36.23%) and yellow (21.73%) represented happiness, red represented anger (68.11%), and grey represented sadness (55.07%).
5. Brain wave analysis: participants reading the completed picture book exhibited attention significantly higher than the baseline.

With the assistance of an EEG research instrument, this study was able to improve the understanding of changes in the degree of attention and relaxation in children; thus, further contributing to studies related to creating emotional picture books. Because the amount and type of data that can be collected through the use of EEG is enormous, many other

dimensions of this topic can be explored, including colour, composition and form. It is suggested that subsequent studies not only examine attention and relaxation, but also the emotions of subtle facial expressions.

This study utilised an experimental question-bank system to guide children in reading picture books and recorded their responses using EEG to examine brain waves representing attention and relaxation. It is hoped that the analysis results of this study can be used as a reference for subsequent picture book creation to further understand the perception and feelings of children toward pictures, providing assistance to educators for instruction and to researchers for future educational research.

## REFERENCES

1. Zhou, Q., Eisenberg, N., Wang, Y. and Reiser, M., Chinese children's effortful control and dispositional anger/frustration: relations to parenting styles and children's social functioning. *Developmental Psychology*, 40, 3, 352-366 (2004).
2. Denham, S.A., Bassett, H.H. and Zinsser, K., Early childhood teachers as socializers of young children's emotional competence. *Early Childhood Educ. J.*, 40, 3, 137-143 (2012).
3. Hubel, V. and Lussow, D., *Focus on Designing*. Taiwan TW: Liuho Publication (1994).
4. Buechner, V.L., Maier M.A., Lichtenfeld S. and Schwarz S., Red-take a closer look. *Plos One*, 9, 9, e108111 10.1371/journal.pone.0108111 (2014).
5. Lin, C.Y. and Chuang, M.C., A study on the relationship between colour preference and personal traits of college students in Taiwan. *Taiwanese Art*, 51, 34-43 (2003).
6. Kuo, J-I. and Ke, M-J., The research of visual sensation and emotional feeling for different combinations of colours tone on the wall and furniture-dental clinic waiting space as an example. *J. of Design Environ.*, 15, 53-69 (2014).
7. Haas, L.F., Hans Berger (1873-1941), Richard Caton (1842-1926), and electroencephalography. *J. of Neurology, Neurosurgery & Psychiatry*, 74, 1, 9 (2003).
8. Chen, A., Xu, P., Wang, Q., Luo, Y., Yuan, J. J, Yao D. and Li, H., The timing of cognitive control in partially incongruent categorization. *Human Brain Mapping*, 29, 9, 1028-1039 (2008).
9. Wong, T.K.W., Fung, P.C.W., McAloan, G.M. and Chua, S., Spatiotemporal dipole source localization of face processing. ERPs in adolescents: a preliminary study. *Behavioral and Brain Functions*, 5, 16 (2009).
10. Murugappan, M., Ramachandran, N. and Sazali, Y., Classification of human emotion from EEG using discrete wavelet transform. *J. of Biomedical Science and Engng.*, 3, 390-396 (2010).
11. Ramirez, R., Palencia-Lefler, M., Giraldo, S. and Vamvakousis, Z., Musical neurofeedback for treating depression in elderly people. *Frontiers in Neuroscience*, (2015), 20 July 2017, <http://journal.frontiersin.org/article/10.3389/fnins.2015.00354/full>
12. Khushaba, R.N., Wise, C., Kodagoda, S., Louviere, J., Kahn, B.E. and Townsend, C., Consumer neuroscience: assessing the brain response to marketing stimuli using electroencephalogram (EEG) and eye tracking. *Expert Systems with Applications*, 40, 9, 3803-3812 (2013).
13. Chen, C.M., Wang, J.Y. and Yu, C.M., Assessing the attention levels of students by using a novel attention aware system based on brainwave signals. *British J. of Educational Technol.*, 48, 2, 348-369 (2016).