A Study of Electroencephalography (EEG) and Lego Wedo 2.0 on the Attention of First Grade Special Needs Students

Fu-Yuan Chiu, National Tsing Hua University, Taiwan
Szu-Min Chiu, National Tsing Hua University, Taiwan

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Abstract
The purpose of the study was to assess the Attention of first-grade special needs students by using EEG and Lego Wedo 2.0. The research subjects are 3 special needs students of the first-grade resource class in an elementary school. There were ASD student, learning disability student, and ADHD student. The researcher used the EEG system to uniformly collect the data of Attention when these 3 students were classified LEGO Wedo 2.0. The research results are shown as the followings: 1. These 3 students classified LEGO Wedo 2.0 have Attention eSense index of 67, it is slightly higher than the normal level. According to their high score group of Attention, they have no significant difference. 2. These 3 students classified LEGO Wedo 2.0 have Mediation eSense index of 67, it is slightly higher than the normal level. According to their high score group of Mediation, ADHD student with a high level of Mediation ability accounted for up to 2 to 3 times that of students with ASD and learning disabilities. 3. Students of different obstacle types have different Flow experience (high Attention and Mediation). ASD student have most times of Flow experience during the Intervention Period, student with learning disabilities hava most times of Flow experience during the Maintenance Period, ADHD student hava most times of Flow experience during the Baseline Period.

Keywords: Electroencephalogram (EEG), Autism Spectrum Disorder (ASD), Learning Disabilities, Attention Deficit Hyperactivity Disorder (ADHD)

Introduction

In recent years, with the increasing maturity of human medical technology and signal analysis technology, a large amount of research has been devoted to the operation of the brain and mind, and brainwave technology has been widely used in medicine in other fields, among which, the application of electroencephalogram (EEG) is an example. If teachers can more accurately and objectively understand students' learning motivations and analyze their learning behaviors through the assistance of technology, they can timely provide teaching methods or teaching content that can promote learning efficiency, and improve students' Attention and learning effectiveness. As many as 98.61% (43,038) of students with special needs in Taiwan's primary education scene are educated in general schools. Among them, learning disabilities were the most at 38.19%, followed by intellectual disabilities at 20.19%, autism at 17.23%, and emotional behavioral disorders at the fourth. Therefore, in the classrooms of ordinary classes in primary schools, most students with physical and mental disabilities have learning difficulties, which often lead to the inability to concentrate, inability to concentrate, and low learning achievement, because the difficulties in literacy and reading ability affect the low learning motivation and lack of self-confidence ; According to the information processing model proposed by Atkinson & Shiffrin (1968), grabbing the Attention of students is the first level of all knowledge learning. Only when the Attention is focused can the follow-up information registration and coding organization and learning be carried out. Most students with special needs have poor performance in Attention, which is the key to learning effectiveness, and teachers need to understand students' learning status. In addition, the technology of EEG signal collection, measurement, and analysis has become more and more advanced. Mature. Therefore, this study also used EEG to collect the Attention and Mediation data of the three subjects with special needs when operating Wedo 2.0 Lego bricks for classified activities and further comprehensively analyzed the Flow experience with the brainwave data of students' Attention and Mediation. The results of the study are expected to serve as a reference for future curriculum design and editing teaching materials.

Exploring Attention with EEG

In 1929, the German psychiatrist Hans Berger detected the same electrical activity as animals on the human skull, which became the first published brain wave record in human history and was named electroencephalogram (EEG). Different frequencies can be divided into four categories: alpha (α), beta (β), theta (θ), and delta (δ). Different brainwave frequencies represent human beings with or without consciousness and various mental states. In recent years, many studies have found that the level of Attention is highly correlated with changes in the characteristics of brain wave patterns. Brain waves are like a trigger. The increase in brain wave data helps to maintain Attention (Asada et al, 1999). The better the Attention, the better the performance. (Good, & Brophy, 1995). Bransford (1979) mentioned that there is a very close correlation between Attention and learning effectiveness, Frederick (1977) found that high-achieving students spent 75% of the time in class focusing on learning, while low-achieving students only 51%. Attention also has a strong impact on students' learning journey, as one of the key pieces of Attention in students' poor learning outcomes is a lack of Attention. (Clark et al., 2006; Rush et al., 2010). Students with special needs, such as ASD, Learning disabilities, and ADHD, suffer from inattention due to developmental disabilities, affecting their overall learning outcomes.

NeuroSky MindWave Mobile was used for EEG in this study. In a previous study, Rebolledo-Mendez et al., (2009) found a positive correlation between Attention values measured by NeuroSky MindWave Mobile and self-reported reflective Attention. Chen & Huang's (2014) study found that NeuroSky MindWave Mobile was used to measure students' online reading Attention. Bos et al. (2019) also collected brainwave data through NeuroSky MindWave to understand the changes in students' Attention when using Augmented Reality (AR) in teaching activities. The results of the above studies show that NeuroSky MindWave Mobile is effective and reliable in identifying students' Attention in learning activities.

State of Flow

Csikszentmihalyi (1975) proposed the concept of "Flow" based on Maslow's peak experience. This refers to the "best experience" that people experience when they are in full Attention, called "Flow" or "Flow experience". Entering a state of high Attention in a relaxed and stress-free situation like this is the perfect time for learning, helping learners to enhance and maintain student motivation and improve learning outcomes (Schweinle et al., 2008; Tavares & Freire , 2016). At present, most of the studies on Flow experience have some limitations, because most of the Flow experience is to use self-report, reflection, reflection, and other feedback questionnaires to evaluate the Flow experience of the subjects after the activity. However, the Flow may appear suddenly without the subject's awareness, so such measurement may hide and limit key information in the Flow experience (Pearce et al., 2005). Wang & Hsu's (2014) brainwave experimental research data analysis results show that Flow experience is positively correlated with learners' Attention. The NeuroSky MindWave used in this study can capture up to 512 original brainwave signals per second, through further digital signal processing such as acquisition, amplification, conversion, filtering, and analysis of the original brain wave signal by Nielsen software, the alpha and beta wave can be presented through the eSenseTM algorithm to display the subject's Attention and Mediation status in numbers from 1 to 100. Therefore, in this study, a state of "Flow" was defined if the EEG showed a state of simultaneous high Attention and high Mediation.

Method

This study conducted an experiment with multiple baseline across-subjects and multiple-probe designs of a single-subject research approach. The selection part of the subjects is purposeful sampling, three special needs students in the first grade of a primary school in Taoyuan City, Taiwan, and all held a hospital-issued diagnosis certificate. The categories of disorders are ASD, Learning disabilities, and ADHD. Participating subjects wore an EEG and operated WeDo 2.0 Lego blocks at the same time. The researchers will use the brain wave system to collect the data on the Attention and meditation of the three students when they operate the WeDo 2.0 Lego bricks for the classification activities. The classification activities will be designed from easy to difficult three missions:
Mission 1: Students classify the corresponding LEGO bricks by referring to the tips of the picture cards and stickers.
Mission 2: Remove the picture card prompts, students only refer to the sticker prompts to carry out the corresponding LEGO blocks Classification.
Mission 3: Ask students to classify according to their personal reasoning ability and working memory ability.

The observation can be divided into three phases Baseline Period, Intervention Period, and Maintenance Period. In the Baseline Period of the 1st week to 3rd week, the researchers did

not intervene at all and allowed the subjects to complete missions 1 to 3 by themselves. Then, during the Intervention Period in the 4th week to 6th week, the researchers guided and accompanied the subjects to complete missions 1 to 3 during the Intervention Period. Finally, in the Maintenance Period in the 7th week to 9th week, the researchers did not intervene at all and let the subjects complete missions 1 to 3 by themselves. The time limit for each classification Mission is 10 minutes, and the correct rate of classification within the limited time is calculated.

In the follow-up, the collected data will be analyzed in the form of graphs to present the students' Attention and Meditation state when operating the WeDo 2.0 Lego blocks, supplemented by qualitative semi-structured interview records to conduct the "Flow" analysis.

Conclusion

Based on the results of this study, this study draws the following conclusions.

1. The building block classification correct rate (show in Figure 1)

Subject A's disorder category is ASD, in addition to naming each building block, and independently developed a set of classification rules. During the classification process, subject A laughed from time to time, deliberately imitated baby crying, rocked the chair to make noise, rubbed the floor with his feet to make noise, suddenly sang, yawned, scratched and other inattentive behaviors. During the Intervention Period of the researcher, the process of questioning and answering between subject A and the researcher helps to complete the behavior of thinking and its corresponding classification through verbal Mediation, thereby improving the correct rate of building blocks. The overall building block classification accuracy rate was improved by 33.93%.

Subject B's disorder category is Learning disabilities, with no obvious emotional ups and downs, a dull expression, and a slow and rigid way of grasping individual blocks with one hand and placing them one by one during the classification process. During the classification process, subject B often looked out of the window, looked at the table, looked at the floor, touched the table legs, touched the sofa chair, yawned, scratched his head, opened his mouth, closed his mouth, and played with his lips. During the Intervention Period of the researcher, subject B reduced various distracting behaviors. Through the classification suggestions provided by the researcher, subject B could have a specific target basis for classification, which improved the correct rate of building blocks. The overall building block classification accuracy rate was improved by 76.43%.

Subject C's disorder is classified as ADHD. Before the experiment starts, he often cannot restrain his urge to want to play Lego and urge to start the classification quickly. Subject C's screaming or excited behavior during the classification process showed that he was very interested in Lego bricks, During the Intervention Period of the researcher, subject C's classification suggestion for the researcher did not conform to the rules in his mind, and he just wanted to follow his own classification method, but in the end he could combine the classification rules developed by himself with the researcher's suggestions. Therefore, subject C once achieved 100% classification accuracy in the process. The overall building block classification accuracy rate was improved by 88.21%.

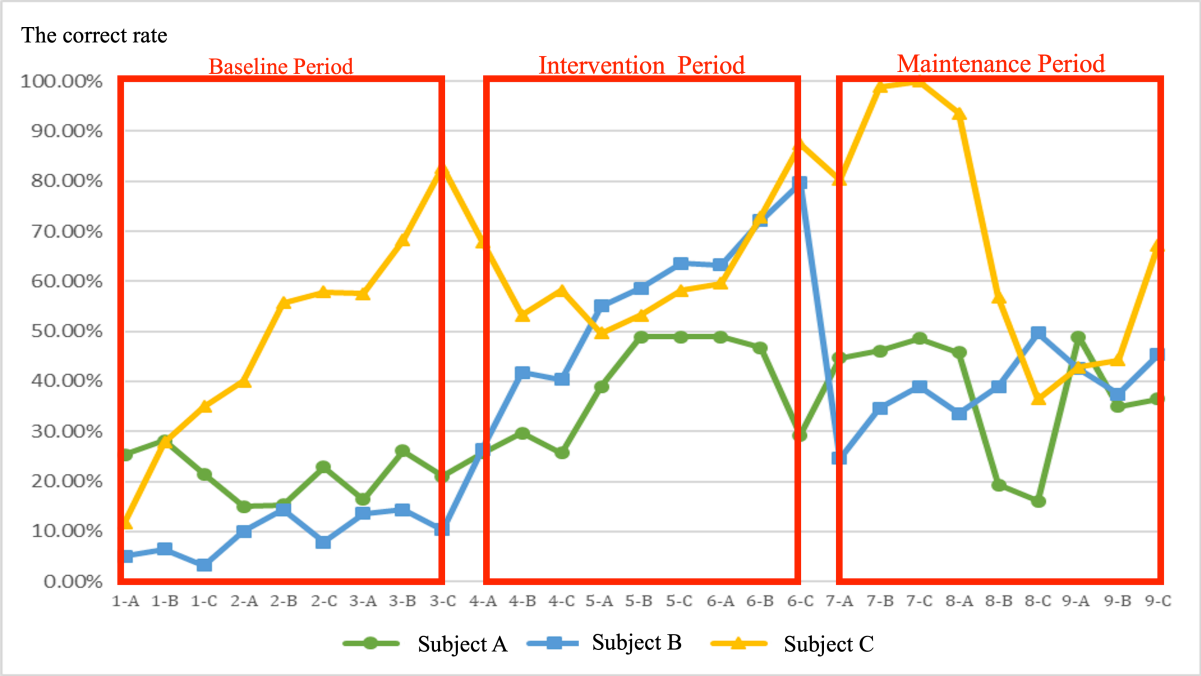

Figure 1: The building block classification correct rate

2. EEG data analysis

Since the data for Attention and Mediation are from 1 to 100, the top 30% (greater than 67) scores are used as high-performance scores in this study. And record the number of high-performance scores obtained in the Baseline Period, Intervention Period, and Maintenance Period, respectively as well as the number of times that both Attention and Mediation obtained high-performance scores at the same time, it means that the subject is both focused and relaxed. When the brain is in a state of extreme Attention, efficiency and creativity can be improved, but at the same time, the body and mind are stable and relaxed. This is the "Flow", or "Flow experience" proposed by Mihaly Csikszentmihalyi (1975). The statistical results are shown in Table 1.

Subject A's disorder category is ASD because children with ASD often have limited, fixed characteristics, and repeat strange movements or sounds, the presence of these characteristics can distract Attention and prevent them from using their self-developed classification rules. Therefore, during the Intervention Period, the researchers reminded subject A of the specific target when he was distracted, so that he could continue to maintain a clear target, and gave ambiguous feedback when the correct classification was completed. Subject A can instantly understand the correct classification of building blocks, and even though researchers intervene, he still controls his learning. Subject A perceives that the accuracy rate of his classification has improved, and he can feel the control of classification activities and exude a sense of achievement. Subject A had the most frequent Flow state during the Intervention Period and was also the best building block classification score, which can verify that the Flow state can get good learning performance.

Subject B's disability category is learning disability because children with learning disabilities have abnormalities in basic abilities such as concentration, memory, perception, movement, and reasoning. Therefore, subject B was unable to independently establish rules for building block classification during the Baseline Period. However, during the Intervention Period, with the classification recommendations of the researchers, clear and specific

guidelines were provided to help Subject B strengthen the order in memory and avoid the more difficulty to follow consecutive multiple instructions. Since Subject B has a clear goal based on the learned principles, distracted behaviors are reduced during the Maintenance Period, the movements are also smoother and more focused, the mood is more pleasant and relaxed, and finally produces the most times Flow state.

Subject C's disability category is ADHD, children with ADHD usually have obvious emotional ups and downs, dare to challenge unknown learning Missions in various fields, are full of curiosity, and are keen to explore. When subject C classified the building blocks, once the classification rules were summarized or the building blocks were classified correctly, the mood was happy, so subject C entered the Flow state most times during the Baseline Period when they were able to develop their own building block classification rules. However, during the Intervention Period, subject C hoped to follow the classification method that he had developed independently and did not want to follow the researcher's classification suggestion to affect his independent thinking, resulting in the lowest classification scores and Flow state times. Subject C's Flow rate increased slightly during the Maintenance Period, and not only reached the highest personal block correct rate, but also completed the classification of 280 blocks within the time limit, and the block correct rate reached 100%. Such a pleasant feeling continues to increase Subject C's learning motivation, making him feel satisfied and constantly want to continue to invest and continue to challenge. The researchers observed that Subject C was under the condition of Mission 3 without any cue cards and stickers. , to achieve a 100% correct rate of building blocks. Subject C showed three very focused states of action-awareness merging, Attention on the Mission, loss of self-consciousness, and even forgetting the tickling sensation of mosquito bites. Therefore, in terms of the overall number of times entering the Flow state, the overall proportion of subject C Centering the Flow experience is 2 to 3 times higher than that of subjects A and B.

Table1. The statistical results of EEG

Subject	Attention High score times	%	Mediation High score times	%	Flow state Baseline Period	Intervention Period	Maintenance Period	Total	%
A	1,763	10.56 %	2,245	13.45 %	68	94	81	243	1.46 %
B	2,013	12.09 %	3,013	18.09 %	49	56	96	201	1.21 %
C	2,441	14.66 %	3,607	21.67 %	305	130	174	609	3.66 %

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References

Asada, H., Fududa, Y., Tsunoda, S., Yamaguchi, M., & Tonoike, M. (1999). Frontal midline theta rhythms reflect alternative activation of prefrontal cortex and anterior cingulated cortex in humans. *Neuroscience Letters, 274*, 29-32.

Bos, A. S., Herpich, F., Kuhn, I., Guarese, R. L. M., Tarouco, L. M. R., Zaro, M. A., Pizzato, M., & Wives, L. (2019). Educational Technology and Its Contributions in Students' Focus and Attention Regarding Augmented Reality Environments and the Use of Sensors. *Journal of Educational Computing Research, 57(*7), 1832–1848.

Bransford, J. D. （1979）. *Human cognition: Learning, understanding, and rembering.* California: Wadsworth.

Chen, C. M., Huang, S. H. (2014). Web-based reading annotation system with an attention-based self-regulated learning mechanism for promoting reading performance. *British Journal of Educational Technology, 45*(5), 959–980.

Clark, R.C., Nguyen, F., Sweller, J., & Baddeley, M.C. (2006). Efficiency in Learning: Evidence-Based Guidelines to Manage Cognitive Load. *Perform. Improv. Q, 45*(9), 46-47

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. San Francisco: Jossey-Bass.

Good, T. L., & Brophy, J. E. (1995). *Contemporary Educational Psychology*. White Plains, NY:

Pearce, J. M., Ainley, M., Howard, S. (2005). The ebb and flow of online learning. *Computers in Human Behavior, 21(*5), 745–771.

Rebolledo-Mendez, G., Dunwell, I., Martínez-Mirón, E. A., Vargas-Cerdán, M., De Freitas, S., Liarokapis, F., & García-Gaona, A. R. (2009). Assessing neurosky's usability to detect attention levels in an assessment exercise. *Human-Computer Interaction New Trends*, 5610, 149-158.

Schweinle, A., Turner, J. C., Meyer, D. K. (2008). Understanding young adolescents' optimal experiences in academic settings. *The Journal of Experimental Education, 77*（2）, 125–146.

Tavares, D., Freire, T. (2016). Flow experience, attentional control, and emotion regulation: Contributions for a positive development in adolescents. *Psicologia, 30*(2), 77-94.

Wang, C., & Hsu, M. (2014). An exploratory study using inexpensive electroencephalography (EEG) to understand flow experience in computer-based instruction. *Information & Management, 51*（7）, 912–923.