Neuromodulation of attention in reading

The Effect of Transcranial Alternating Current Stimulation in alpha range on Reading Comprehension Accuracy Moderated by Vividness of Visual Imagery

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Abstract

On a day to day basis, individuals routinely engage in numerous tasks that are carried out with minimal conscious effort. One such activity is reading: the gaze moves and the mind encodes at a very fast pace. The complexity of this seemingly effortless skill can be better understood through eye-tracking and brain stimulation experiments. In this work, the effect of transcranial alternating current stimulation (tACS) on comprehension accuracy is studied, while moderating for vividness of visual imagery. Participants were asked to read 180 sentences, with comprehension questions about the content presented intermittently throughout the reading. During this task, they received tACS on the left or right hemisphere or no brain stimulation at all. Additionally, a few questionnaires had to be completed (e.g. vividness of visual imagery, mind-wandering). Although the statistical results were non-significant, the numerical findings suggested that there might be a small increase in comprehension accuracy while receiving left-hemisphere stimulation. Moreover, there was no detected effect of vividness of visual imagery as a moderator. The lack of significant results might be partly explained by the small sample size available (N=18). Further research on this area is needed to gain a deeper understanding of the ways transcranial alternating current stimulation influences attention in reading. Future work could consider controlling for potential influencing factors such as awareness of stimulation, which could alter the results.

Introduction

Reading is a skill that involves a variety of processes, from fine eye-movements to text comprehension. The eyes move from word to word, sometimes skipping one, sometimes going back to check what was already read. Meanwhile, the brain processes and adapts to incoming information, extracting meaning and creating a narrative accompanied by mental images. The goal of the present work is to understand how brain stimulation influences the reading process, while focusing on the role of the reader's visual imagery.

1. Theoretical Background on reading

1.1 Eye-movements

Visual processing is a crucial element in reading and thus it has been investigated thoroughly in reading research. One method through which this process can be understood in more depth is by implementing a moving window paradigm. This entails having a sentence where "X"s replace letters from an upcoming and/or previous word. This window moves along the sentence with the reader's fixations, helping researchers understand the necessary conditions for efficient reading. Reducing the window size was shown to increase fixation durations, thus having the same effect on the total reading time (McConkie & Rayner, 1975).

Fixation durations as well as forward and regressive saccades are some specific eye-movements that caught researchers' attention. These eye movements can be influenced by cognitive and perceptual processes involved in reading (Özkan et al., 2020). These processes are different from person to person, varying especially between healthy individuals and those who suffer from learning disorders. For example, dyslexic participants from a Greek reading study showed more and longer fixations compared to non-dyslexic participants (Hatzidaki et al., 2010). This also translates into reading comprehension difficulties as a secondary consequence of dyslexia

(Martins & Cárnio, 2020). To exclude these differences and difficulties in reading, only healthy individuals participated in the present study.

1.2 Brain activity and stimulation

The brain plays a central role in the reading process, emitting specific brainwave frequencies during this activity. Neural oscillations of about 10 Hz are categorized as alpha waves. This type of brainwave activity in the posterior brain regions has been typically linked with a state of relaxation and rest, while being awake (Cantero, 2002). Additionally, recent studies have revealed the importance of this frequency in visual processing and in higher-level cognitive tasks such as language processing in reading (Pan et al., 2023). Electroencephalogram (EEG) recordings discussed in a paper from 2021 show alpha activity with a lower amplitude on the right hemisphere when the attended stimuli is on the left visual field, accompanied by an increase in amplitude in the left hemisphere (Peylo et al., 2021). This relates to the lateralization of posterior alpha brainwaves that revealed a sustained rightward bias of attention during saccadic reading (Kornrumpf et al., 2017). Enhancing alpha activity in one hemisphere biases visual perception towards more efficient information processing in the ipsilateral visual field. Moreover, similar effects have been detected during visuospatial attention tasks (Kasten et al., 2020).

Nevertheless, it is not clear yet whether the changes detected in alpha wave amplitude have a causal role in visuospatial attention shifts. A method of testing this is by inducing brainwave activity at a specific frequency and examining the effects. This can be achieved with non-invasive brain stimulation techniques. Transcranial Alternating Current Stimulation is one such method, being used to manipulate neural rhythmicity and amplitude (Wischnewski, 2022). Participants from a brain stimulation study received tACS over the left parieto-occipital cortex at individual alpha frequency and it was demonstrated that task performance in a spatial cueing paradigm was altered (Peylo et al., 2021). Additionally, stimulation with a slightly different method, transcranial direct current stimulation (tDCS), over the left temporal-parietal areas seems to enhance comprehension accuracy of sentences (Kim et al., 2021). Right-hemisphere stimulation seems to enhance the rightward attentional bias, while left-hemisphere stimulation could have an effect on language processing. Further research is needed to understand the lateralization of alpha activity and its effects. This could pave the way for development of more precise therapeutic techniques that would create conditions with no barriers for everyone.

1.3 Vividness of Visual Imagery

There are a lot of subtle aspects of reading. While processing a text, the mind might visualize its content. The level of vividness of this imagery can give readers different experiences. Visual mental imagery is the ability to utilize visual representations without external visual stimuli. This experience can also be interpreted as “seeing with the mind's eye” (Ganis, G., Schendan, H.E., 2010). Although this is part of most people’s daily life, for others this experience is unknown. This condition is referred to as aphantasia (Keogh, R., Pearson, J. , 2018). However, this is just the lower extreme of a spectrum that can be assessed with the Vividness of Visual Imagery Questionnaire (VVIQ). The scores range from 16 to 80, where a score of 16 could indicate aphantasia (Marks, 1973). It has been confirmed that aphantasics have more difficulties in explicitly creating mental images of common actions, while highly visual individuals show a greater utilization of imagery in everyday life. This finding also translates into the level of automatic imagery during reading (Dupont, 2024). However, some important moderating factors are the difficulty and length of the text. Complicated narratives and linguistic structures impede the production of visualizations (Brosch, 2018). To understand more about this process, it is important to identify the ways it interacts with text comprehension. In a study from 2020 conducted by Devi et al., it was demonstrated that there was a significant change in reading comprehension due to mental imagery. Even more fascinating is that vividness of mental imagery was a significant predictor for students' reading comprehension competencies

(Kocaarslan, 2016). Not only this, but visual mental imagery explained the most variance of reading comprehension, although auditory, olfactory and emotional mental patterns also significantly predict reading comprehension (Atoum & Reziq, 2018). Thus, a more conscious use of mental imagery can also be used as a strategy tool that may remediate comprehension for students who fail to engage with the content while reading (Kelly, 2006). This could be further implemented in treatments for people who struggle with disabilities.

2. The present study

In this study it is investigated whether tACS in the alpha range neuromodulates attention during reading. Some of the measures used are reading speed, text comprehension, along with eye-movements such as saccadic rhythmicity or number of regressions. Additionally, a moving window paradigm will be used as a validity check, expecting total reading time to be reduced during this condition, regardless of the stimulation condition.

Vividness of visual imagery seems to have an influence over reading comprehension, especially when the sentences are not very complex (Brosch, 2018). Since this study is using simple sentences, vividness will not be hindered. Thus, the present work aims to investigate the effect of tACS in alpha range on text comprehension accuracy, while moderating for vividness in visual imagery.

My main hypothesis states that alpha-tACS on the left hemisphere will increase comprehension accuracy when compared to right-side stimulation and sham. Additionally, the second hypothesis states that this effect would be moderated by the level of vividness of mental imagery. More specifically, as individuals score higher in vividness of visual imagery, they will also have a higher increase in comprehension accuracy when receiving transcranial alternating current stimulation in range alpha.

Methods

1. Participants

The data collection procedure lasted from 22nd of April until 9th of May 2025. The sampling technique used in the present study is a convenience sampling method. Firstly, each member of the thesis project team recruited participants between the ages of 19 and 29. Besides the recruited participants (N = 12), there were also first-year psychology students of the Rijksuniversiteit Groningen who participated in the study through the SONA platform (N = 8), receiving 2.5 SONA credits. Thus, there were 20 participants, out of which only the data of 18 was used after preprocessing.

The exclusion criteria for this experiment were: neurological or psychiatric conditions (including ADHD), diagnosis of dyselxia, memory-related disorders, skin conditions, history of epileptic episodes, tattoos or piercings on the scalp, metallic implants. Additionally, people with difficulties in the reading area were excluded, whether they had issues reading the text on the screen or were wearing glasses that made the eye-tracking data noisy.

2. Procedure

The experimental procedure of the PSY-2425-S-0301 study was approved by the Ethical Committee of the Faculty of Behavioral and Social Sciences of Rijksuniversiteit Groningen.

2.1 Experimental Process

The experiment was conducted in person at one of the laboratories of Heymans building. Before beginning the experiment, the participant had to be tested for being trackable on the eye-tracking machine. If everything was in order, the participant received an information sheet about the experiment and could ask questions at any point. Additionally, the participant had to sign an informed consent form and complete a demographic questionnaire which is explained in more details in section 3.3.

Before starting the experiment, there was a test run for the brain stimulation technique in which one of the hemispheres was stimulated at 750 mA for 60 to 90 seconds. If the participant did not mention discomfort, the experiment would continue.

The individual would then be invited to sit at a table, having the electrodes placed on the scalp and the chin positioned in the eye-tracking equipment. First, a practice round took place, in which the participant had to read a few sentences on a screen, from time to time responding to questions about the content. After the participant accommodated to the procedure, the data collection followed. The reading task lasted for about 30 minutes. After the experimental stage was finalized, the participant had to complete three post-session questionnaires that are mentioned in more detail in section 3.3 as well. At the end of the task, the electrodes were removed and the participant was informed about the possibility of washing their hair and taking the information sheet at home. Additionally, there was no deception involved except for hiding the order of the conditions. Therefore, there was no formal debriefing session. However, participants were free to ask for information about the experiment or the order of the conditions they experienced.

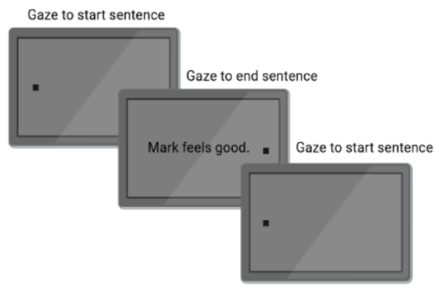
One experimental session lasted for 90 to 120 minutes, depending on the speed at which the participant responded to the questionnaires and on the time spent preparing the person for brain stimulation.

2.2 Task

There were 180 sentences that the participant had to read throughout all conditions. The participant had to fixate on a tiny black dot positioned on the far-left of the screen for the sentences to appear. At the end of the sentence there was another dot that, once looked at, would trigger the end of the sentence and the loop will continue. This is represented in Figure 1.

Figure 1

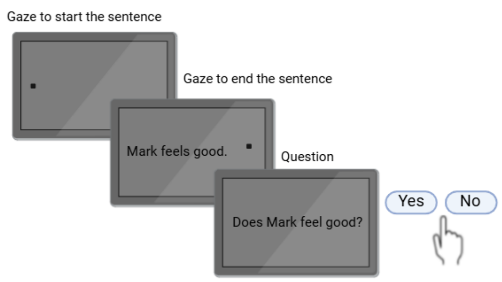
Schematics of reading task



Out of all sentences, 33% were followed by a comprehension question instead of a new sentence. The participant would respond to these questions by clicking left on the mouse for “yes” and press right for “no”. . If the participant responded correctly, the black dot would appear at the far-left of the screen to continue the cycle. If the answer was wrong, there was an announcement “Incorrect answer” written in red in the middle of the screen, followed by the dot. This was implemented to keep the participants aware of their progress. This is represented in Figure 2.

Figure 2

Schematics of reading task with comprehension question



2.3 Conditions

The present study adopted a within participants design, having each participant complete trails within all 6 conditions portrayed in Table 1. Regarding the brain stimulation, there were three conditions: stimulation on the left hemisphere, stimulation on the right hemisphere and sham/placebo. The conditions were counterbalanced with a Latin square. Regarding the reading task, there were two conditions: natural reading and moving window paradigm, which was set at four letters to the right of the fixation. The details about the brain stimulation parameters can be found in section 3.2.

Table 1

Experimental conditions: 3 x 2 design

	Moving window paradigm	
Brain Stimulation Condition	Left & moving window	Left & natural reading
	Right & moving window	Right & natural reading
	Sham & moving window	Sham & natural reading

During each stimulation condition, both reading conditions were presented, thus having 3 experimental rounds. Each round consisted of 60 statements, lasting about 10 minutes. Throughout the experiment, the sentences were randomly assigned to one of the reading condition, half of the sentences being presented with the moving window paradigm and the other half being under natural reading. After each round, the experimenter changed the settings according to the condition that followed: either changing the cables / the hemisphere stimulated, or changing the cycle settings.

3. Materials

During the experiment, the participant is set at a table, being 735 mm away from the screen. The monitor had a refresh rate of 120 Hz and the resolution of the screen was full HD (1920 x 1080 pixels). One character was 13 pixels wide, which can be translated to a width of 0.32° degrees of visual angle per character.

The 180 sentences were selected from Frank et al corpus (Frank et al., 2013). An example of a sentence used in the experiment is “This man’s hair is black”, along with its corresponding comprehension question “Is the man blond?”.

3.1 Apparatus

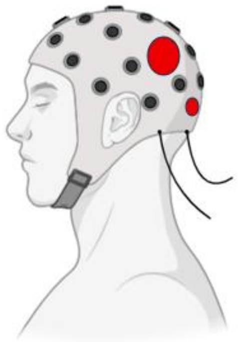
The experiment was conducted using two major pieces of equipment. The eye-tracking system used was Eyelink 1000 Plus (SR Research), recording activity from the right eye. Fixation detection was based on Eyelink online detection algorithm, with the threshlod for saccade velocity set at 30° per second and for saccade acceleration, at 8000° per second. The other aparatus was Eldith DC-Stimulator (Plus, NeuroCare), a transcranial alternating current stimulation device used for alpha waves (10 Hz). The details regarding the settings of this apparatus are in section 3.2. The experiment was coded in MATLAB.

3.2 Brain Stimulation

The participant had his/her scalp cleaned with Nuprep gel and then with a wet towel. This was done to have a better conduction of the electrical stimuli. The electrodes were placed on the locations O1, O2, CP3 and CP4, according to the International 10-10 system for EEG electrode placement (Nuwer, 2018). All electrodes were placed at the beginning of the experiment and stayed on the head until the end, being stabilized with an EEG mask over them. Figure 3 showcases the placement of the electrodes as well as the EEG cap.

Figure 3

Electrode placement view from the side



Our team chose this method so the participant is unaware of which cables are connected to the tACS machine, thus being unbiased regarding the hemisphere stimulated. However, some participants have physical sensations from the stimulation, such as slight itching or warmth sensation, understanding which condition they are in.

Regarding the brain stimulation parameters, during the left / right hemisphere brain stimulation 1500 mA were used for the whole duration of that condition with the intensity gradually increasing over the first 30 seconds. During the sham condition, the same intensity (1500 mA) was used, but the cycle was only of 300 seconds. Thus, the stimulation would gradually increase for 30 seconds, staying constant for 30 seconds and then gradually decrease for 30 seconds. This was done so that the participants could feel the physical sensations of the stimulation, without any cognitive effects. Additionally, if impedance was higher than 20 Ω, the device would stop automatically and the electrodes would have to be checked until impedance is lower than 20 Ω.

3.3 Questionnaires

In the pre-session questionnaire some demographic information about the participant was asked, including the name, age and gender. Additionally, there were questions regarding the level of proficiency in English. This would help understand more about how the process was affected by the level of proficiency. Some examples are: “Is English your native language?” and “For how long have you been actively using English?”. Moreover, there was a handedness questionnaire that included questions regarding the usage of a predominant hand in general, as well as in some specific scenarios such as using scissors.

After the reading task was over, the participant had to complete three more questionnaires. One of them was a post-session questionnaire consisting of questions about the physical effects of the brain stimulation technique such as possible light flickering. Along this, the participant was asked to identify the order of the conditions. This would give more details about the validity of the sham condition, as well as helping taking into account the possible effects awareness of condition could have. The other two questionnaires were the APA mind wandering questionnaire and the APA vividness of visual imagery questionnaire. The first one included statements such as “I have difficulty maintaining focus on simple or repetitive tasks” that were rated by the participant on a 6-point Frequency Likert scale (Mrazek et al., 2013). The vividness of visual imagery questionnaire had 4 scenarios such as “Think of some relative or friend whom you frequently see (but who is not with you at present) and consider carefully the picture that comes before your mind’s eye.”. Under each scenario there were 4 statements focusing on details of the scenario such as “The exact contours of face, head, shoulders and body.”. These were rated on a 5-point Quality Likert scale, were one is “No image at all, you only “know” that you are thinking of the object” and five is “Perfectly clear and lively as real seeing” (Marks, 1973).

4. Data Preprocessing

Before the daa analysis, some participants had to be removed. For one participant, slight noise in the eye-tracking data reduced the effectiveness of the fixation detection algorithm, thus making the data not reliable. Due to counterbalancing the stimulation condition, the last participant had to be removed as well. After these operations the sample size was 18. Additionally, trials and specific data from the eye-tracking system were also preprocessed. Trials that had more than 2 blink events were removed, as they could cause noise and invalid data. Moreover, it was decided that saccades and fixations were removed if they were closer than 50 ms to any blink samples. Fixations shorter than 80 ms or longer than 1000 ms were excluded from the analysis as well.

Results

1. Hypothesis 1

In this paper, the main hypothesis states that left-hemisphere tACS in alpha range could improve comprehension accuracy. Throughout this section some descriptive statistics are presented, followed by the statistical analysis. Table 3 captures the means of comprehension accuracy, expressed in terms of percentage of correctly answered questions, for each stimulation condition. As shown in Table 3, the means support the hypothesis, as the left condition had higher scores on comprehension accuracy than the right side stimulation. Compared to sham, an improvement could still be noticeable, although the difference between conditions is smaller. Thus, the numerical difference indicates that tACS on the left hemisphere might improve comprehension accuracy.

Table 3

Descriptive Statistics: Comprehension accuracy for each stimulation condition

Condition	Mean	Std. Deviation
Sham	.891	.113
Left	.928	.095
Right	.857	.157

To analyze this relationship in more depth, a Repeated Measures ANOVA was used. The assumptions were checked before using this method. Mauchly's test indicated that the assumptions of sphericity was not violated, $\chi^2(2) = .860$, $p = .30$; therefore, no correction was applied. However, both the Kolmogorov-Smirnov and the Shapiro-Wilk tests of normality showed violation of the assumptions. The significance levels for all conditions in both tests can be found in Table 4.

Table 4

Tests of Normality for each stimulation condition

	Kolmogorov-Smirnov	**Shapiro-Wilk**
	Sig.	**Sig.**
Acc_sham	< ,001	,003
Acc_left	< ,001	< ,001
Acc_right	,002	,004

Because of this result, Q-Q plots for each stimulation condition were also conducted. All the plots indicate a normal distribution of comprehension accuracy. Thus, it was decided to continue the analysis using a Repeated Measures ANOVA.

The null hypothesis cannot be rejected, $F(2, 34) = 1.631$, $p = .211$, meaning that the effect of left-hemisphere tACS on comprehension accuracy was not significant. Moreover, the partial η^2 indicates that the stimulation has a small to medium effect on comprehension accuracy. However, the observed power is quite small, indicating that the study might have not detected the true effects. These data are presented in Table 5.

Table 5

Tests of Within-Subjects Effects

		df	F	Sig.	Partial Eta Squared	Observed Power
Acc	**Sphericity Assumed**	2	1.631	.211	.088	.320

a. Computed using alpha = .05

2. Hypothesis 2

The second hypothesis was considering vividness of visual imagery as a moderator for the relationship presented above. It was hypothesized that people who score higher in vividness of visual imagery would score higher in comprehension accuracy when stimulated on the left hemisphere, compared to people with lower vividness scores.

Table 6 presents some descriptive statistics about vividness of visual imagery scores. It can be observed that the minimum score was equal to the lowest score on the Vividness of Visual Imagery questionnaire. This means that there were a few aphantasic participants. On the other side of the spectrum there were people approaching hyperphantasia, as the maximum score of this sample was only 5 points away from the maximum score of the questionnaire. The mean indicated that this sample consisted of people with moderate vividness of visual imagery, being spread across almost the whole spectrum. This wide variety in vividness is beneficial for the analysis as it makes the moderator more valid. Having individual who scored only in the lower side of the spectrum would have influenced the results, being able to conduct an analysis that would be true only for the lower extreme of vividness.

Table 6

Descriptive Statistics: Vividness of Visual Imagery

	Vividness
Min.	16
Max.	75
Mean	51,7

To understand how this factor influences the relationship between tACS and comprehension accuracy, an ANCOVA was used, having vividness of visual imagery as the covariate.

Table 7

Tests of Within-Subjects Effects: Stimulation Condition & Vividness of Visual Imagery

Source		**df**	**F**	**Sig.**
Cond	Sphericity Assumed	2	.957	.395
Cond*Vivid	Sphericity Assumed	2	.505	.609

This data suggests that the main effect remains non-significant after controlling for the covariate, meaning that the effect of stimulation does not have an effect on comprehension accuracy, even when controlling for vividness of visual imagery. This result is in accordance with prior expectations, given that the relationship was not significant to begin with. Additionally, the interaction effect is also non-significant, $F(2, 32) = 0.505$, $p = 0.609$. This means that vividness of visual imagery does not moderate the effect of brain stimulation and comprehension accuracy in any way. Further interpretation of the results and experimental procedure is discussed in the next section.

Discussion

1. Summary

The present study investigated two hypotheses. The first one focused on whether comprehension accuracy improves when the left hemisphere is stimulated with tACS in the alpha range. The statistical results indicate that there is no effect of this stimulation method when looking at the percentage of correctly answered questions about the read content. This could mean that tACS does not influence comprehension accuracy in any way.

The Kasten et al. study shows that alpha-tACS only had an effect on endogenous attention (Kasten et al., 2020). This type of attention is used also in the present work, as participants had to be focused on the reading task to be able to respond to comprehension questions. The usage of tACS in the present study is supported by a study from 2021 that showed how tACS can improve attention better than tDCS in tasks such as Stroop-color test (Kim et al., 2021). Although these findings would seem to support the present hypothesis, the details of the tasks are different, as the attention used in reading is far more complex than the one used in a Stroop-color test. Thus, although tACS can be a good method to improve attention, it might not be the best suited technique for comprehension accuracy. However, the numerical results ($M = .928$) indicate a slight improvement when stimulating the left hemisphere. This might indicate that there is a small effect that might have been hindered by the limitations of this project, presented in more detail in section 2.

The second hypothesis focused on the role of vividness of visual imagery in this relationship presented above. The results show that it does not act as a moderator in the present work. Although vividness of visual imagery was shown to improve comprehension accuracy (Kelly, 2006), it might not have an effect when used in combination with brain stimulation. In the Kelly study, vividness was used as a tool, thus indicating that there might be a certain level of consciousness about this factor to have an effect on reading.

2. Limitations

One of the limitations is the fact that this study is underpowered, as a G*Power analysis in the beginning of the project indicated that the ideal sample size would be 24 for reaching a power level of 0.8. The sample size of 18 participants allowed for the conditions to be counterbalanced perfectly, but it raises the risk for Type II error. Because of this, it might be hard to detect real effects. Additionally, participants were asked to recognize the correct order of the conditions, having a 0.3333 chance-level probability of guessing the sham condition. Half of the participants recognized the sham condition correctly in the post-session questionnaire. Even though this placebo condition should replicate to some extent the physical sensations of stimulation, for some individuals the interaction of tACS with the scalp might be more prominent. Thus, even if the participant was not actively trying to guess the condition they were in, the sensations would make it easier to recognize. This raises the question of whether the participants were changing their behavior in accordance to the condition they thought they were in. It might be that some were more focused on the task when feeling the stimulation, thinking they should perform better.

These limitations can be avoided in future research, implementing more and more precision for finding accurate results. Future research implementing these changes is discussed in the nest section.

3. Potentially improved research on this area of study

First of all, studies with a larger sample would increase robustness to violations of normality of statistical tests. This would strengthen the analysis, getting closer to a better understanding of the effects of tACS on comprehension accuracy. Secondly, brain stimulation studies could implement a screening session in which it is checked whether the individuals have strong physical sensations from tACS. These participants would be excluded, thus increasing the validity of the sham condition. Knowing that the participant is unaware of the condition they are undergoing can open doors for exploration of true potential of tACS.

Additionally, for this type of research to have more reliable therapeutic implications, more experiments on natural reading should be conducted. As the moving window paradigm slows down total reading time, it might hinder some of the effects brain stimulation has. Thus, I believe more research containing only natural reading should be implemented in both within - and between – participants studies. Within-subjects studies could allow for exploration of different types of brain stimulation, using a wider range of frequencies. This way we can understand more about how individual differences could be accounted for in techniques such as tACS and whether personal modulation of neural oscillations would be more promising. A between-participants study would be better suited for understanding whether, during a simple task, brain stimulation impacts people differently based on specific mental disorders such as ADHD or dyslexia. This type of research design could also be used to gain more knowledge in the ways conscious use of mental imagery can help comprehension. Different types of presentations of the text, such as auditory or visual, can also be inquired in the experiments.

4. Future Practical Implications

Multiple mental disorders such as dyslexia or ADHD can impede sentence understanding (Wiseheart et al., 2009; Rhonda, 2015). If tACS would be proven to be a reliable method for improving functions used in reading, therapeutic interventions could be designed. Individuals who struggle with language processing or mind-wandering could benefit from these methods of treatment and consequently have a better learning experience. For example, individuals with ADHD showed a pattern of abnormal alpha modulation in the left hemisphere, potentially being associated with attentional deficits (Guo et al., 2019). Transcranial alternating current stimulation in alpha range may help rebalance the dysregulated rhythms and thereby alleviate symptoms. This would offer an innovative method to treating mental disorders as it would be a non-pharmacological alternative with potentially fewer side effects.

I believe research in vividness of visual imagery could help understand more about the underlying processes of reading and sentence comprehension. In the book "The power of visual imagery", Karen Kelly presents how to train vividness of visual imagery by getting into more detail about the sentence read. This way, children understood more about the power of the details in the texts they read and were able to have a better comprehension of it. This way, therapeutic techniques can be implemented in individuals with normal levels of vividness who suffer from attentional disorders, using their visual imagery to improve their reading skills.

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For this paper, I acknowledge to have used the AI tool, ChatGPT, at a minimal level. No content generated by AI technologies has been presented as my own work. The main use was for checking my grammar, using prompts such as "Check the grammar of this sentence". Additionally, I have used it to slightly improve my academic writing style. When prompted with "Rephrase this in a more academic manner" the AI tool would give a revised text from which I would only pick some of the words and expressions and implement the academic tone in my own writing. Thus, when I used this tool more as an inspiration for academic phrasing.

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