Critical Review:
Does tDCS accompanied by speech-language therapy improve anomic deficits in individuals with aphasia

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Globally stroke affects 15 million people every year, of these people, 25-40% will acquire aphasia (WHO, 2002). It is well known that aphasia is often accompanied by anomia and together they have a large influence on the communication of the individuals they affect. Recently, studies have investigated the effects of transcranial direct current stimulation (tDCS) coupled with naming therapy on anomia recovery. This critical review explored the results of seven of these aforementioned studies. Overall the research indicated that tDCS, specifically anodal tDCS, paired with naming therapy is an effective treatment that can improve naming accuracy and/or speed in individuals with post-stroke anomia. While these studies are limited due to their small samples sizes, there is little to no risk of harm to patients with this procedure and, thus, it can be used to shape the future treatment of anomia.

Introduction

Aphasia is a language disorder caused by an injury to the brain and can result in difficulties with reading, writing, and the production or comprehension of speech. Difficulty retrieving words from memory, also known as anomia, is a common symptom that occurs amongst individuals with aphasia. Anomic deficits are often treated by a speech-language pathologist through naming therapy. Naming therapy facilitates improvement in word-finding abilities by having the client name pictures in a confrontation style while moving through a hierarchy of cues. Although naming therapy can be effective, the gains in word-finding capabilities may be gradual especially in the later stages of recovery (Fridriksson, Richardson, Fillmore & Cai, 2012). This is because anomia recovery is dependent on the return of blood flow and function to damaged areas of the brain as well as neuroplasticity; this is not quickly achieved with speech-language therapy alone (Sandars, Cloutman & Woollams, 2016). To enhance treatment results, the use of transcranial direct current stimulation (tDCS) has been investigated. tDCS is a non-invasive stimulation technique that involves the delivery of an electrical current to the brain through two electrodes (ALHarbi, Armijo-Olivo & Kim, 2017). The anode electrode results in increased neuronal firing of the surrounding area while the cathode electrode results in the inhibition of neuronal firing in that area (ALHarbi et al., 2017). The idea is that this change in neuronal firing can influence the function and neuroplasticity of the brain to enhance recovery. Because tDCS interacts with ongoing cortical activity, it should be combined with language therapy rather than implemented separately for best results in naming recovery (ALHarbi et al., 2017). Research has been mixed on the location of stimulation, the electrode used, the amount of stimulation current, and the overall effects of tDCS and therapy as a treatment of anomia (ALHarbi et al., 2017). Because of the impact anomia has on communication, it is important to determine if tDCS coupled with speech-language services can reduce anomic symptoms in individuals with aphasia.

Objectives

The purpose of this review is to critically evaluate the existing literature on tDCS coupled with naming therapy as a treatment for anomia.

Methods

Search Strategy

Studies were found using online databases including CINAHL and PubMed using the following search terms: [(transcranial direct brain stimulation) OR (tDCS)] AND (aphasia) AND (naming) NOT (progressive). The search was limited to studies written in English and those that included human participants.

Selection Criteria

Articles selected for this critical review had to use naming therapy with simultaneous tDCS, include adult individuals with aphasia, and assess some form of naming performance. Articles were excluded if the therapy was not specific to naming, used other brain stimulation therapies, or had participants with average naming abilities in some areas.

Data Collection

Six articles that met the selection criteria were included in this review. These articles include one randomized controlled trial, four within-subject crossovers, and one systematic review.

Results

Randomized Controlled Trials (RCTs)

Randomized controlled trials (RCTs) are experimental studies that determine the effect of a treatment on a specific population through the comparison of randomized groups where one group receives treatment and the other does not. RCTs are viewed as the most superior design that can be implemented in a research study. When executed correctly, the findings from this design are often more reliable than other designs and can be used to guide evidence-based practice (Spieth et al., 2016).

Meinzer, Darkow, Lindenberg & Floel (2016) examined the long- and short-term outcomes of naming therapy accompanied by left hemisphere anodal tDCS on naming accuracy of trained and untrained items in patients with aphasia. Twenty-six stroke patients that met a particular criteria were randomly assigned to two matched groups: anodal tDCS (n=13) and sham tDCS (n=13). Both groups participated in naming therapy sessions twice a day, four days a week for two weeks. In these sessions, the participants named images while moving through a hierarchy of fading cues. At the start of each therapy session, the participants in the anode tDCS group received 20 minutes of computer-delivered tDCS over the left hemisphere. The sham group had the electrodes placed on their head and turned on tDCS for 30 seconds for blinding purposes. Treatment performance was recorded by a blinded speech-language pathologist. Naming accuracy on trained and untrained items for both groups was assessed before treatment, immediately after treatment, and six months post-treatment.

This experiment found that both the sham and anode groups improved from baseline on naming accuracy of trained items immediately after treatment and six months later. Researchers reported that the anode group had a larger, yet statistically insignificant, immediate effect on naming accuracy than the sham group. This difference between naming accuracy in the anode and sham group was also noted at the six-month follow-up and this time the findings were significant. Both groups showed improvements in naming accuracy of untrained items immediately after training, however, these gains were significantly greater in the anode group. Furthermore, at the six-month follow-up, the anode group maintained these generalization effects while the sham group did not.

This experiment implemented appropriate and thorough statistical analysis, calculated the sample size needed to achieve a significant effect size, matched the participants in the two experimental groups, blinded the participants and clinicians, and used appropriate exclusion/inclusion criteria. Researchers also used a naming therapy method deemed effective in the literature. The previously mentioned factors are all strengths of the work by Meinzer and colleagues (2016). One weakness of the study is the uneven ratio of males to females within the sample. Overall, this study yields suggestive evidence that naming training accompanied by anodal tDCS results in improved naming abilities in patients with post-stroke anomia.

Within-Subjects Crossover

Within-subjects crossover studies investigate the effects of a treatment by using the same participants in the control and experimental group. Benefits of this study design include lessened risk of confounding variables between control and treatment groups, and decreased statistical power requirements and sample size. It is important to note that there must be a washout period between treatment and sham. This period allows the effects of treatment to dissipate before participating in the next phase of the experiment since the same participants receiving treatment are the control group as well. (Wellek & Blettner, 2012)

Fiori et al. (2011) explored the short- and long-term effects of tDCS paired with therapy on naming accuracy and reaction time in healthy individuals as well as individuals with aphasia. The focus of this review is on aphasia so results involving the healthy subjects will not be discussed. An appropriate inclusion/exclusion criteria resulted in the recruitment of three male participants with aphasia. Each of these participants underwent a period of sham tDCS and a period of anodal tDCS while naming pictures in each session. The subjects and the examiner were blind in regards to when the subjects were receiving treatment or not, and an investigator not involved in the data analysis administered the tDCS. The participants attended daily sessions for five consecutive days, succeeded by a three week follow-up period, and then a one week break before the start of the next condition. Performance on naming accuracy and speed was measured before the start of each period to ensure the washout time was sufficient to prevent carryover of treatment effects. To examine the long-term effects, the researchers followed-up with the participants at one and three weeks post-treatment in both conditions to assess naming performance.

After running the appropriate statistical analyses, researchers found that naming accuracy improved in both sham and anodal tDCS conditions. However, the anodal condition resulted in significantly greater improvements in naming accuracy and reaction time. The data from the one-week follow-up illustrated that

naming accuracy had decreased slightly from the final treatment session. However, there was no significant difference between the one-week follow-up and the three-week follow-up in the anodal condition indicating that there was no further atrophy in naming performance. Naming accuracy in the anodal tDCS condition was found to be significantly higher than in sham condition at each follow-up. Conversely, reaction time showed a reversal of effects at each follow-up. Though not significant, the reaction times in the anodal tDCS condition at both follow-up points were shorter than in the sham group.

This study used repeated baseline measurements, effective exclusion and inclusion criteria (e.g. handedness, first language, number of strokes), and blinded both clinicians and patients, all of which are strengths. The researchers also used appropriate statistical analyses, however, effect sizes were not reported. Weaknesses in this study included the small sample size, especially in the follow-ups, and using only male participants. Overall, the research by Fiori et al. (2011) provides suggestive evidence that the use of anodal tDCS with naming therapy is an effective treatment for improving naming abilities in individuals with anomia.

Floel et al. (2011) conducted a study to investigate the long- and short-term effects of anodal tDCS paired with speech-language services on naming accuracy. The sample consisted of 12 individuals with post-stroke anomia who met the specific inclusion/exclusion criteria. This study consisted of three experimental conditions: sham tDCS, right hemisphere anodal tDCS, and right hemisphere cathodal tDCS; each of the subjects participated in all three conditions. In each condition, participants attended daily therapy sessions where they named a set of 15 pictures for three consecutive days. Subjects' naming accuracy was assessed immediately after the treatment condition concluded and again two weeks later. After this three week window, the participants began the next experimental condition. During the anodal and cathodal conditions, tDCS was delivered by an individual impartial to the analysis of the experimental data. In the sham group, the participants had the electrodes placed on their head without receiving tDCS for blinding purposes.

At baseline, participants had a naming accuracy of 0% but after receiving treatment naming accuracy increased to 83%. The results showed that anodal tDCS yielded better naming ability than the sham and cathode condition. Conversely, the results discovered no difference in naming performance between cathodal tDCS and sham. Post-treatment results indicated that the effects of anodal tDCS were still present two weeks after the end of treatment, while no long-term improvements were noted in the other two conditions. Additionally, researchers found that those with poorer naming ability before completing treatment had greater improvement after receiving anodal tDCS.

Strengths of this study include the use of appropriate statistical tests and inclusion and exclusion criteria, blinding of participants, a relatively equal ratio of male and female participants, and reporting of effect size. However, the small sample size and number of stimulus items, as well as the scarce descriptions of long-term effects of each condition are limitations of the study. Overall, this study provides suggestive evidence of the beneficial naming effects anodal tDCS coupled with naming training adds to the current literature on this treatment strategy for anomia.

Fridriksson, Richardson, Baker & Rorden (2011) investigated changes in naming reaction time in response to left hemispheric tDCS with naming therapy. Inclusion requirements for this study were only specific in regards to aphasia type and location of injury. There were eight individuals with anomia that met this criterion and were included in the study. All of the subjects participated in two treatment conditions: sham tDCS and anodal tDCS. Each treatment condition involved daily sessions across five consecutive days followed by a three-week intermission before starting the next condition. In these sessions, participants received one of tDCS conditions while naming sets of pictures. tDCS was administered by a computer to ensure blinding of the examiner; participant blinding was achieved by placing the electrodes on the participants head without activating tDCS for the sham condition. Naming performance was assessed six times for each condition (at baseline, immediately post-treatment, and three weeks post-treatment).

The research found that naming reaction time lessened in both conditions across all assessment periods. However, there was a more significant reduction in naming reaction time in the anodal tDCS condition versus the sham tDCS condition at treatment completion and at the 3-week follow-up.

Strengths of this study include a strong blinding procedure for both participants and clinicians, controlling for the aphasia type and lesion location, and frequent baseline and progress measures. Conversely, this study had a small sample size, and limited descriptions of the statistical methods and patient demographics (e.g. gender, education, handedness). Overall, this experiment yields suggestive evidence that tDCS with language therapy can improve naming

abilities, specifically naming speed, in individuals with aphasia.

Wu, Wang & Yuan (2015) conducted a study that explored if left hemispheric anodal tDCS with naming therapy could improve naming accuracy in 12 individuals with aphasia who met the appropriate inclusion/exclusion criteria. Researchers also wanted to analyze the cortical effects of tDCS, however, this is not the focus of this review and, thus, will not be discussed. Participants all experienced one round of sham tDCS, one round of left hemisphere anodal tDCS, and then another round of sham tDCS. During the anodal phase of the experiment, participants received 20 minutes of tDCS, while in the sham phase the participants received 30 seconds of tDCS for blinding purposes only. Patients participated in 20 language therapy sessions for five consecutive days over four weeks for each of the three conditions. During these sessions, the participants had to name pictures from 500 stimulus items with cues as needed. Subjects' naming abilities were assessed before and after each treatment condition.

While described inadequately, the results of this experiment found that naming accuracy during the anodal tDCS phase was significantly higher than baseline and the first phase of sham. No significant changes in naming performance between the anodal tDCS phase and the final round of sham tDCS were noted, thus, indicating that naming performance remained stable after receiving anodal tDCS. There was also no difference found between the first phase of sham tDCS and baseline suggesting that therapy alone was insufficient in improving naming accuracy.

The inclusion and exclusion criteria of this study, as well as the large stimulus size, were strengths, however, there were far more limitations. These limitations included a poor description of the results and the statistical analysis of these results, inability to blind researchers due to study design, and a small sample size consisting of mainly male participants. After reviewing this article, the evidence provided in regards to the positive effects of tDCS and naming therapy on naming performance can be considered equivocal.

Systematic Studies

A systematic review is a design that summarizes the information found in a number of research articles that all investigate a similar clinical question (Uman, 2011). In a systematic review, researchers gather all of the relevant literature that applies to the desired topic, thus, limiting any selection bias (Uman, 2011). Analyzing data from multiple studies allows for the determination of the overall effectiveness of treatments and their clinical value. When the articles explored in a systematic review are RCTs, the evidenced produced is considered of high caliber.

Sandars, Cloutman & Woollams (2016) explored the current evidence for tDCS with and without language therapy as a treatment for naming deficits in individuals with anomia. Researchers had particular interest in the treatment's effectiveness, the use of anode or cathode polarization, and the location of stimulation on the brain. Three electronic databases were searched as well as the reference lists of these articles. The papers yielded from this search were only included in the review if they met the following implicitly stated inclusion criteria: the use of tDCS with or without language training, adult participants with chronic post-stroke aphasia, outcomes analyzing single verb or noun naming abilities, and English articles in peer-reviewed journals. Studies were excluded if they analyzed healthy individuals, or had participants that were in the acute or subacute stages of stroke recovery. Fourteen studies met the criteria, however, only those that implemented tDCS with naming training will be discussed in this review.

Based on the results of all of the included studies, researchers concluded that significant advances in naming accuracy and/or speed are present after receiving tDCS and naming therapy, though this varied based on electrode type and location. Many of the studies also found that the results were still significant when following up with the participants after treatment had ended.

Strengths of this study include using broad search terms to prevent selection bias when selecting articles and, though not explicitly stated, including numerous RCT trials to be analyzed. Limitations of this study include the poorly defined inclusion/exclusion criteria and the lack of statistical comparison of the studies. Overall, this study provides suggestive evidence in support of tDCS and naming therapy to treatment post-stroke anomia.

Discussion

The studies analyzed in this review were all congruous in supporting the use of tDCS with naming therapy as an effective treatment for anomic deficits in individuals with aphasia. Although several of the studies found that independent naming therapy improved the participants' naming performance, these gains were not as significant as when it was paired with tDCS. Anodal tDCS seemed to produce the greatest improvement in naming ability among patients with post-stroke anomia. Though not as effective as anodal tDCS, a number of the studies concluded that cathodal tDCS can result in greater increases in naming performance than therapy alone. Ultimately it is evident based on the research that tDCS,

whether it be anodal or cathodal, is advantageous to naming performance when paired with naming therapy. What still remains unclear is the precise location of stimulation, the current that is necessary to evoke maximal changes, the permanency of the effects, and how effects differ with varying aphasia types and severities. While there are several unknowns, tDCS is a noninvasive procedure with documented benefits and a low risk of harm to the client. Therefore, according to this risk-benefit balance, tDCS is a suitable option when treating individuals with anomia, especially in the later stages of their recovery. Future research in this area is recommended, particularly research with larger sample sizes and an experimental design that results in stronger evidence levels. Future research should also focus on:

a) Determining when in recovery process tDCS should be introduced.
b) Determining the effects of tDCS and naming therapy when controlling for the severity and type of aphasia.
c) Determining the approximate cerebral locations that should be stimulated for optimal anomic recovery.
d) Studying the permanency of these effects by monitoring clients for longer periods of time post-treatment.

Clinical Implications

The information provided by this review can provide clinicians with the confidence to use tDCS and naming therapy together without fear of negative consequences due to the noninvasive nature of tDCS. The evidence in this review also indicates that clinicians can add tDCS to naming therapy when progress is slow or non-existent in order to achieve greater improvements in naming performance. While there are still many unknowns about tDCS, clinicians can still attempt this therapy approach with individuals of varying severities and recovery times as there are only possible benefits to implementing this treatment method.

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