CoDAS
ISSN 2317-1782 (Online version)

Original Article
Artigo Original

Transcranial direct current stimulation: a study on naming performance in aphasic individuals

Estimulação transcraniana por corrente contínua: estudo sobre respostas em tarefas de nomeação em afásicos

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Keywords

Electric Stimulation
Aphasia
Stroke
Language
Rehabilitation

ABSTRACT

Purpose: Compare the results in naming tasks of after-stroke aphasic individuals divided into active and placebo groups pre- and post-transcranial direct current stimulation. **Methods**: A double-blind, randomized, controlled study conducted with 14 individuals. Patients underwent five 20-min sessions with stimulation of 2mA's on consecutive days. The cathode was placed over the Broca's homologous area and the anode was placed over the supraorbital region of the left hemisphere. Boston and Snodgrass naming tasks were assessed before and after the stimulation sessions and the results were compared between the groups. **Results**: No significant results were observed for sequences 1 and 2 in the Snodgrass test. The Boston test results indicated significant difference related to mean time for correct responses with strategy. **Conclusion**: The results suggest that simultaneous transcranial direct current stimulation (anodic and cathodic) is a method that can improve the rehabilitation of patients with anomic and Broca's aphasia after stroke, and that language strategies should be considered in the analysis of naming task responses.

Descritores

Estimulação Elétrica
Afasia
Acidente Vascular Cerebral
Linguagem
Reabilitação

RESUMO

Objetivo: Comparar os resultados nas tarefas de nomeação de pacientes afásicos após AVC dos grupos ativo e controle. **Método:** Estudo duplo-cego, randomizado controlado com 14 pacientes. Os indivíduos foram submetidos a cinco sessões de 20 minutos de 2 mA em dias consecutivos. O catodo foi posicionado na área homóloga à Broca e o anodo sobre a região supraorbital do hemisfério esquerdo. Os testes de Boston e Snodgrass foram aplicados e os resultados comparados entre os grupos. **Resultados:** Não houve resultados significativos para as sequências 1 e 2 no teste do Snodgrass. No teste de Boston, os dados indicaram uma diferença significativa para o tempo médio de acertos com estratégia. **Conclusão:** Os resultados sugerem que a ETCC simultânea (anódica e catódica) é um método que pode auxiliar a reabilitação de pacientes com afasia do tipo anômica e de Broca, após AVC, e que as estratégias linguísticas deveriam ser consideradas nas análises das respostas dos testes de nomeação.

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Received: October 19, 2016

Accepted: March 24, 2018

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Financial support: nothing to declare.

Conflict of interests: nothing to declare.

INTRODUCTION

Aphasia is an acquired disorder characterized by receptive and expressive problems with oral and written language. Progress in neuroimaging techniques provides new resources for left hemisphere's functional activity analysis, contributing to further comprehension of brain lesions and their relationship to aphasia and the rehabilitation processes[1,2].

The concept that language recovery depends only on the extent and location of the dominant hemispheric lesion can no longer be considered definitive, since investigations that incorporate functional neuroimaging also show activity in the non-injured contralateral hemisphere area in language tasks[3].

Studies in communication and language associated with the initial degree of aphasia severity after a stroke suggest that some examinations of the linguistic markers, such as verbal fluency and naming, could indicate a greater or lesser risk for chronicity symptoms[4].

Transcranial direct current stimulation (tDCS) is a safe, non-invasive, neurophysiological technique that supports the alteration of neuronal membrane resting potential, which induces the level of cortical excitability and modulates the firing rate of the neurons. Its effects depend on, among other factors, the position and size of the electrodes, current intensity, duration of stimulation and total number of sessions[5]. It is likely that during rehabilitation these variables associated with tDCS significantly impact the changes in communication and language processes as well as the underlying neural processes.

Studies of tDCS effects, with or without concomitant speech therapy, can clarify neurophysiological and rehabilitation aspects in aphasia. In this sense, the authors[5-9] recommend tDCS as an adjunct to speech therapy for aphasia due to its therapeutic effects, even when low intensity current is applied, because it can be observed a transient modification in the neural network resulting in the modulation of brain activity that causes local cortical excitability and synaptic alterations[10]. Investigations also confirmed improvements in linguistic abilities associated with gestural communication[11] and vocabulary acquisition[12]. The authors described a positive evolution of the aphasic condition when the motor area of language is activated[13,14], with an improvement in verbal fluency with anodic stimulation of the lower left frontal area associated with melodic speech therapy[15], a gain in overall linguistic performance in non-fluent patients after anodic stimulation in the left inferior frontal area[16] and significant results in naming task performance after anodic and cathodic stimulation followed by speech-language therapy[17]. Regarding response time in comprehension tasks, it was confirmed there was maintenance of the improvement during three weeks after tDCS in the left posterior and right frontal cortex[8]. The diversity of the results verified in literature could be explained by methodological aspects, particularly: variables in control methods such as type of aphasia, place of stimulation, time interval from the beginning of the aphasia onset to the moment of stimulation, schooling, age and characteristics of language tests[1,5,10,14,18].

Naming is an activity that involves semantic, syntactic and phonological processing related to the visual image processing which is responsible for decoding lines, curves and points of the image, lexical and phonological access that corresponds to word meaning and the execution of an articulatory motor program. The verbal response is the product of all these neuronal tasks[19]. Several experimental studies include the naming task as part of their procedures although they do not consider it in their analysis of the linguistic strategies related to the subject's attempt to name, which is an important issue in speech-language pathology testing[8,14,18].

In this study we describe the performance of aphasic subjects in naming tasks, before and after the application of tDCS, considering the responses with linguistic strategies.

METHODS

The present is a prospective, descriptive, qualitative and quantitative, double blind, randomized and placebo-controlled study.

The subjects were recruited following an inclusion criteria: subjects with mild and mild to moderate non fluent aphasia, secondary to stroke (onset from three months to three years) and who accepted to perform a speech-language evaluation with the Montreal Toulouse Battery (Alpha version), to check the type and severity of aphasia. The exclusion criteria were: presence of disorders or illnesses such as dysarthria, speech dyspraxia, dementia, psychiatric problems, seizures, epilepsy (or taking medication for this purpose) and increased intracranial pressure. Also this criteria included: pregnancy, use of cochlear implants, use of intracardiac catheters, cardiac pacemaker, implanted metallic material, uncontrolled clinical comorbidities, alcohol dependence, chemical dependence, and language and/or communication disorders prior to stroke.

A total of 14 subjects were selected and the group was characterized as being of both genders, right-handers, aged from 18 to 80 years, with a minimum of primary education, diagnosed with anomic aphasia or Broca's aphasia and without prior speech-language therapy.

Subjects were randomly assigned into two groups: G1 - active group and G2 - placebo group. The Boston Naming Test[20](reduced version - 15 figures) and the Snodgrass and Vanderwart Test[21] were administered to all subjects during three time phases: T1 –before tDCS, T2 – after five consecutive days of tDCS and T3 – after 30 days of the last tDCS session.

For Group G1, the tDCS was transferred to saline-soaked sponge electrodes and distributed by a continuous current stimulator, model NEURODYN portable TENS, procedure approved by ANVISA. The intensity was 2mA and the stimulation time was 20 minutes. The area stimulated with the cathode was homologous to the Broca area in the right hemisphere at position F8 of the 10-20 system. The anode was positioned in the supra orbital region of the left hemisphere. The active

and the placebo group, underwent the same procedure, but for G2 the stimulator was switched on for only 20 seconds to mimic the effect of the stimulation.

The responses were recorded and the CronoFonos program[22] was used for later measurement of the response time in the acoustic analysis program Praat[23]. The CronoFonos Software presented the instruction sequences for both naming tests.

The variables studied were: 1) number of hits (NH): number of pictures named correctly in each application; 2) number of hits with strategies (NHS): number of correctly named pictures using linguistic strategies (For example, in the present study it was considered a linguistic strategy when subject named "boat" for canoe or "to comb" for comb); 3) Mean time (MT): mean latency time observed for the correct naming of the target picture; 4) Mean time of correct answers with strategies (MTS): average latency time of correct answers using linguistic strategies; 5) total time (TT): sum of the latency time of answers with correct answers and correct answers with strategy.

In this study, it was designated *seconds* as a measure of time and in the absence of answers an interval of 20 seconds was observed between the presentations of the pictures (maximum time designate for correct answer). Language strategies were considered as the set of linguistic elements that constitute language construction, phonological, lexical, semantic and pragmatically[24].

The statistical analysis was performed with the SPSS (Statistical Package for Social Sciences) program V13.0. In relation to the descriptive analysis, absolute and relative frequencies (n and %) were used for the qualitative variables and mean and standard deviation for the variables "age" and "schooling".

For hypotheses verification, the Friedman and Wilcoxon non-parametric tests were used to compare between pairs of administration moments (T1-T2, T1-T3 and T2-T3). The level of significance adopted was $p \leq 0.050$.

The study was approved by the Ethics Committee of the Irmandade da Santa Casa de São Paulo Hospital, registered under number 171.747, and all the individuals involved signed the terms of Free and Informed Consent Agreement.

RESULTS

The sample was composed of adult and elderly subjects with a mean age of 52.38 years (standard deviation of 17.26 years), 8 male subjects (57.14%) and 6 (42.85%) female subjects. As for schooling, 8 subjects (57.14%) presented primary education, 4 subjects (28.57%) secondary education and 2 subjects (14.28%) higher education. Regarding the type of aphasia, 8 subjects (≈57.14%) were diagnosed with anomic aphasia, 4 in G1 and 4 in G2, and 6 subjects (≈42.85%) with Broca's aphasia, 3 in G1 and 3 in G2.

Considering the small size of the sample, two analysis approaches were used: one with the Friedman test that compared all the times simultaneously and the values that appear are the mean times and the P-value; and the other with the Wilcoxon test, in which the analysis was carried out by pairing the three moments (T1, T2 and T3) and the P-value.

The behavior of the variables for the Snodgrass and Vanderwart Naming Test can be seen in Tables 1 and 2, as follows:

The Friedman test did not present a significant difference between the variables for both groups, although in the NHS variable a significant trend ($p = 0.058$) was observed for the placebo group.

The study results for the Boston naming test are presented in Tables 3 and 4:

The Friedman test indicated a statistically significant difference ($p=0.050$) in relation to MTS and the Wilcoxon Test showed significance ($p = 0.018$) from moment T2 to T3 for the control group. For G2, it was verified only a trend from moment T1 to T2 in the variable NH ($p = 0.059$) in Wilcoxon test.

Table 1. Subjects performance in the Snodgrass Naming Test for the Friedman test

Variable	Group	Friedman Test – Snodgrass			
		Mean time in seconds			
		T1	T2	T3	P Value
NH	G1	1.93	1.79	2.29	0.444
	G2	2.36	1.64	2.00	0.189
NHS	G1	1.93	1.86	2.29	0.646
	G2	2.29	1.50	2.00	0.058
MT	G1	2.21	2.07	2.21	0.618
	G2	2.29	1.86	2.21	0.651
MTS	G1	2.21	2.07	1.71	0.618
	G2	2.29	1.86	1.86	0.651
TT	G1	2.07	2.36	1.57	0.317
	G2	1.86	2.57	1.57	0.156

Caption: G1: active group 1; G2: placebo group 2; NH: number of hits; NHS: number of hits with strategies; MT: mean time of hits; MTS: mean time of correct answers with strategies; TT: total time; T1: before the tDCS; T2: after five consecutive days of the tDCS; T3: after 30 days of the last tDCS

Table 2. Subjects performance in the Snodgrass Naming Test for the Wilcoxon test

Wilcoxon Test - Snodgrass				
Variable	Group	p-valor		
		T1 – T2	T1 – T3	T2 – T3
NH	G1	1.000	0.197	0.197
	G2	0.109	0.713	0.273
NHS	G1	0.655	0.366	0.197
	G2	0.066	0.655	0.102
MT	G1	0.753	0.398	0.735
	G2	0.237	0.499	0.866
MTS	G1	0.753	0.499	0.735
	G2	0.237	0.612	1.000
TT	G1	0.197	0.398	0.091
	G2	0.237	0.735	0.091

Caption: G1: active group 1; G2: placebo group 2; NH: number of hits; NHS: number of hits with strategies; MT: mean time of hits; MTS: mean time of correct answers with strategies; TT: total time; T1: before the tDCS; T2: after five consecutive days of the tDCS; T3: after 30 days of the last tDCS

Table 3. Subjects performance in the Boston Naming Test for the Friedman test

Friedman Test – Boston					
Variable	Group	Mean time in seconds			
		T1	T2	T3	P Valor
NH	G1	2.29	2.14	1.57	0.326
	G2	1.43	2.43	2.14	0.074
NHS	G1	1.93	1.93	2.14	0.867
	G2	1.57	2.43	2.00	0.076
MT	G1	2.57	1.71	1.71	0.180
	G2	2.00	2.43	1.57	0.276
MTS	G1	2.14	1.29	2.57	0.050
	G2	2.00	2.57	1.43	0.102
TT	G1	1.86	1.86	2.29	0.651
	G2	2.43	2.14	1.43	0.156

Caption: G1: active group 1; G2: placebo group 2; NH: number of hits; NHS: number of hits with strategies; MT: mean time of hits; MTS: mean time of correct answers with strategies; TT: total time; T1: before the tDCS; T2: after five consecutive days of the tDCS; T3: after 30 days of the last tDCS

Table 4. Subjects performance in the Boston Naming Test for the Wilcoxon test

Wilcoxon Test – Boston				
Variable	Group	p-valor		
		T1 – T2	T1 – T3	T2 – T3
NH	G1	0.915	0.246	0.084
	G2	0.059	0.167	0.257
NHS	G1	0.892	0.713	1.000
	G2	0.066	0.197	0.180
MT	G1	0.043	0.063	1.000
	G2	0.449	0.398	0.176
MTS	G1	0.176	0.866	0.018
	G2	0.612	0.237	0.128
TT	G1	1.000	0.735	0.128
	G2	0.063	0.176	0.237

Caption: G1: active group 1; G2: placebo group 2; NH: number of hits; NHS: number of hits with strategies; MT: mean time of hits; MTS: mean time of correct answers with strategies; TT: total time; T1: before the tDCS; T2: after five consecutive days of the tDCS; T3: after 30 days of the last tDCS

DISCUSSION

This study presents a description of the performance of non-fluent aphasic subjects in naming tasks, before and after the application of CTEC, additionally considering responses with linguistic strategies.

Regarding the responses and time variables, the results indicated an improvement from moment T2 to T3 for mean time with strategies, in G1. Many studies on tDCS in aphasic subjects demonstrate MT improvement in naming tasks[6-10,25-27].

The Friedman test suggests a tendency for NHS responses in G2 in the Snodgrass and Vanderwart test. This test did not present a significant difference between the variables for G1 and G2 groups, although in the NHS variable a significant trend ($p = 0.058$) was observed in the placebo group. It should be considered that those results may be due to the placebo effect of the simulated intervention and that future investigations may or may not confirm such results, taking into account that the literature presents studies[16,25-27] which describe statistically significant results for this type of group.

For the Boston Naming test, the results indicated that there was significance only for the MTS variable in G1 and a tendency for the NH variable in G2; despite being a trend, due to the reduced number of subjects in the present study, it may suggest improvement in lexical access, which is one of the stages of the linguistic process in the naming task. Investigations on tDCS and language tasks propose improvement in naming and response latency time [6-10,16,17,20].

A pilot study[28] observed that naming performance was unsatisfactory in relation to the figures that did not correspond to the socio-cultural aspects of the target population and that this factor could affect the results in this task. Thus, this condition could be considered a reason why in the present study the Snodgrass and Vanderwart test did not show sensitivity for the performance with TDCS. For future research, it is suggested an assessment in healthy subjects, allowing the possible socio-cultural interference to be analyzed.

One of the limits of the present study was the insufficient description of neuro imaging examinations because studies of the current path produced by the stimulation, and its subsequent effects, indicate that these factors are at least in part determined by the anatomical and functional connectivity of the stimulated region[16,25,28,29].

CONCLUSION

The results suggest that simultaneous tDCS (anodic and cathodic) is a method that may improve the rehabilitation of patients with anomic and Broca's type aphasia, especially regarding response time effects, and that language strategies should be considered in the analysis of the responses of naming tests because they provide knowledge about how the subject processes a response to a naming task.

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Author contributions

FRS - conceived the main topic and the study design; data collection; analysis and interpretation of data, preparation writing of the article; APMGMK - Interpretation of data; preparation and writing of the article; JCTC - Data collection; review of the subjects' medical data; MDS - Data analysis; preparation of the article; RJG - conceived the original idea; group supervision; critical article review.