Aphasia rehabilitation from a linguistic perspective and the role of tDCS

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Introduction

The effects of aphasia rehabilitation are often moderate, and there is a need to develop strategies that promote larger and generalizable gains. Semantically-based therapy produces generalization to untrained nouns (Boyle & Coelho, 1995), but this generalization is not present in semantic verb treatments (Wambaugh et al., 2014). There are, however, reports of improved production of untrained verbs during morphological treatment (Harris et al., 2012), during simultaneous semantic and phonological cueing treatments that included sentence completion with a verb (Wambaugh et al., 2002; Rose & Sussmilch, 2008) and when verb production is trained in sentence context (Links et al., 2010).
In the current study we combine linguistically motivated therapy (Thompson & Shapiro, 2005) with transcranial direct current stimulation (tDCS). tDCS increases the effect size of aphasia therapy and has resulted on a numeric (non-significant) increase in performance for untreated nouns (Baker et al., 2010). Considering that tDCS has been shown to have task dependent effects (Antal et al., 2004), it is relevant to further investigate how specific these effects are, in particular, if they are also item specific.

Methods

Participants

In this study we included three patients with aphasia, who suffer from damage to the phonological output lexicon and phonological output buffer. Mr. SP presents with an additional impairment at the semantic level. Patients LF and SP demonstrate difficulties in grammatical processing involving thematic role assignment, as well as knowledge (for SP) and realization of predicate argument structure. All patients are right handed and have a left hemisphere lesion following stroke.

Materials and procedure

Bi-cephalic tDCS was administered during the first 20 minutes of therapy using two 35cm^2 electrodes, at 1mA. Electrode placement was individually determined after inspection of each subject's MRI scan, with the anode over left and the cathode over right hemisphere areas. We used a randomized, double blind cross-over design. Each patient was treated in 2 phases (one with sham, and the other with real tDCS), each consisting of 2 weeks of daily 1-

hour sessions. The behavioral treatment included two levels of the Italian ACTION (adapted from Bastiaanse et al., 1997; see Links et al., 2010): sentence completion (in the first week of each phase) and sentence construction (in the second week of each phase). Patients were asked to produce the verb or sentence using the most frequent past, present and future forms in Italian. Structured increasing cues were provided after lexical or morphological errors.

Measures

Patients were assessed with three verb production tasks, each administered in three sessions: sentence completion with a verb in the infinitive form (henceforth, VInfinitive), or in a finite form (henceforth, VFinite) and sentence construction (henceforth, VSentence). The overall lexical accuracy across the three days of testing was used to create a treatment and a control set, balanced for 17 linguistic variables.
Changes to communication in daily living were measured using the CADL (Carlomagno et al., 2013) and mood was monitored using Beck's depression inventory (BDI, Beck, 1988). Non-word repetition from the B.A.D.A. (Miceli et al., 1994) and object naming (Laiacona et al., 1993) were used as control tasks.

Results

Baseline behavior was stable for all patients. After sham stimulation + speech and language therapy (SLT) (phase 1), Mr. GC improved for treated verbs in the following measures: VInfinitive (GC: p=0.007), VFinite (p=0.041), VSentence (p=0.015) and in 3-day accuracy (W=0, p=0.000). After tDCS + SLT (phase 2), GC improved in the same measures as after phase 1 (respectively, p=0.002; p=0.008; p=0.043; W=0, p=0.000).
After sham + SLP (phase 1) Mr. LF improved in VFinite (p=0.007), VSentence (p=0.007) and in 3-day accuracy (W=0, p=0.000). After tDCS + SLT (phase 2), he improved in the same measures (respectively, p=0.006; p=0.04; W=0, p=0.000) and additionally, in VInfinitive (p=0.009).
Mr. SP improved after tDCS + SLT (phase 1) on treated verbs, VInfinitive (p=0.004), VFinite (p=0.023), VSentence (p=0.013) and in 3-day accuracy for treated (W=0, p=0.000) and untreated verbs (W=0, p=0.047). Following sham + SLT (phase 2), improvement was restricted to 3-day accuracy (p=0.009), for treated verbs. Figure 1 illustrates the changes observed for each patient in 3-day lexical accuracy, during the two treatment phases.
Figure 1. Effects of treatment in 3-day lexical accuracy

[insert Figure 1]

The percent of change in 3-day lexical accuracy for trained items was relatively higher after tDCS than after sham (GC: sham=40% and tDCS=53%; LF: sham=35% and tDCS=48%); SP: sham=18% and tDCS=41.6%). Generalization to untreated verbs occurred only in phase 1, for the three patients, and was characterized by an increase in 3-day lexical accuracy (GC: W=0, p=0.025; LF: W=0, p=0.008; SP: W=0, p=0.047). None of the patients showed significant changes in the control measures, BDI or CADL.

Discussion and conclusion

The Italian ACTION was successfully used to improve verb and sentence production for treated and untreated items. Improvement for untreated items occurred only in the first phase, possibly indicating that the potential to improve production of untreated items may depend on separate mechanisms. Generalization may result from task practice (familiarity with a sequence of cognitive processes) and effects on trained items may results from item practice (more accessible representations of specific lexical units) (Basso et al., 2013).
All participants showed larger improvement for treated items after tDCS than after sham. This suggests that the learning mechanisms facilitated by tDCS may be particularly beneficial to trained items. Expanding our study to a larger sample will help disentangle the effects of the order of experimental conditions (sham first vs tDCS first) from the effects of stimulation types (sham + SLT vs. tDCS + SLT). This will lead to a better understanding of the mechanisms underlying aphasia recovery, as well as of the role of tDCS as an adjuvant treatment tool.

References

Antal, A., Nitsche, M. A., Kruse, W., Kincses, T. Z., Hoffmann, K. P., & Paulus, W. (2004). Direct current stimulation over V5 enhances visuomotor coordination by improving motion perception in humans. *Journal of Cognitive Neuroscience, 16(4)*, 521-527. doi: 10.1162/089892904323057263

Baker, J. M., Rorden, C., & Fridriksson, J. (2010). Using transcranial direct-current stimulation to treat stroke patients with aphasia. *Stroke; a journal of cerebral circulation*, 41(6), 1229–36. doi: 10.1161/STROKEAHA.109.576785

Basso, G., Magon, S., Reggiani, F., Capasso, R., Monittola, G., Yang, F. J., & Miceli, G. (2013). Distinguishable neurofunctional effects of task practice and item practice in picture naming: A BOLD fMRI study in healthy subjects.*Brain and language*, *126*(3), 302-313. doi: 10.1016/j.bandl.2013.07.002

Bastiaanse, R., Jonkers, R., Quak, Ch., & Varela Put, M. (1997). Werkwoordproductie op Woord -en Zinsniveau [Verb Production at the Word and Sentence Level]. Lisse: *Swets Test Publishers*. Retrieved from author

Beck, A. T., Steer, R. a., & Carbin, M. G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review*, *8*(1), 77–100. doi: 10.1016/0272-7358(88)90050-5

Boyle, M., & Coelho, C. A. (1995). Application of semantic feature analysis as a treatment for aphasic dysnomia. *American Journal of Speech Language Pathology*, *4*, 94-98. Retrieved from: http://aphasiology.pitt.edu/archive/00000227/01/25-03.pdf

Carlomagno, S., Nassimbeni, S., Zannino, G., Trifelli, E., Grattarola, C., & Razzano, C. (2013). Il Communicative Activities in Daily Life (CADL-2). Dati normativi della versione in lingua italiana. *Logopedia e communicazione,* 3(9), 285-304. Retrieved from: http://www.erickson.it/Riviste/Pagine/Scheda-Numero-Rivista.aspx?ItemId=40582

Harris, L., Olson, A., & Humphreys, G. (2012). Rehabilitation of past tense verb production and non-canonical sentence production in left inferior frontal non-fluent aphasia. *Aphasiology*, *26*(2), 143-161. doi: 10.1080/02687038.2011.624166

Laiacona, M., Barbarotto, R., Trivelli, C., & Capitani, E. (1993). Dissociazioni semantiche

intercategoriali: descrizione di una batteria standardizzata e dati normativi. Archivio di Psicologia, Neurologia e Psichiatria, 2, 209-248. Retrieved from author
Links, P, Hurkmans, J. & Bastiaanse**,** R. (2010) Training verb and sentence production in agrammatic Broca's aphasia. *Aphasiology, 24,* 1303-1325

Miceli, G., Laudanna, A., Burani, C., & Capasso, R. (1994). *Batteria per l'analisi dei deficit afasici*. Roma: CEPSAG. Retrieved from author

Rose, M., & Sussmilch, G. (2008). The effects of semantic and gesture treatments on verb retrieval and verb use in aphasia. *Aphasiology*, *22*(7-8), 691-706. doi: 10.1080/02687030701800800

Wambaugh, J. L., Mauszycki, S., & Wright, S. (2014). Semantic feature analysis: Application to confrontation naming of actions in aphasia.*Aphasiology*, *28*(1), 1-24. doi: 10.1080/02687038.2013.845739

Wambaugh, J. L., Doyle, P. J., Martinez, A. L., & Kalinyak-Fliszar, M. (2002). Effects of two lexical retrieval cueing treatments on action naming in aphasia. *Journal of Rehabilitation Research and Development*, *39*(4), 455-466. Retrieved from: http://www.rehab.research.va.gov/jour/02/39/4/pdf/wambaugh.pdf

Figure 1. Effects of treatment in 3-day lexical accuracy based on three verb production tasks