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Something to talk about: Enhancement of linguistic cohesion through tdCS in chronic non fluent aphasia

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ABSTRACT

Several studies have shown that the modulation of cortical activity through transcranial direct current stimulation (tDCS) enhances naming performance in persons with aphasia. In this study, we investigated the potential effects of tDCS in improving spontaneous speech and the ability to use connective words to establish cohesion among adjacent utterances in a group of eight participants with chronic non fluent aphasia. They were administered five short videoclips representing everyday life contexts and two picture description tasks. Three videoclips were used to elicit spontaneous conversation during the treatment, while the remaining tasks were presented to the patients only before and after the therapy. Patients were required to talk about each videoclip, with the help of a therapist, while they were treated with tDCS (20 min, 1 mA) over the left hemisphere in three different conditions: anodic tDCS over the Broca's area, anodic tDCS over the Wernicke's area and a sham condition. Each experimental condition was performed for ten consecutive daily sessions with 14 days of intersession interval. Only after Broca's stimulation, patients showed a greater improvement in producing words that enhanced the cohesion of their speech samples (i.e., pronouns, ellipses, word repetitions, conjunctions). Beneficial effects of the stimulation were generalized also to contexts presented to the patients at the beginning and at the end of the therapy sessions. Our data further confirm the key role of the left inferior frontal gyrus in binding words into a coherent speech. We believe that positive tDCS effects may be further extended to different linguistic domains, useful to promote language recovery.

1. Introduction

Over the last few years, aphasiology has witnessed a great deal of change. Indeed, the advances in linguistic theory and the evidence coming from neuropsychology and cognitive neuroscience are dramatically boosting our knowledge about the linguistic, cognitive and neural underpinnings of the human ability to generate a discourse or take part to a conversation. As a consequence, clinicians need to devise novel ways to assess the linguistic output of their patients (Andreetta, Cantagallo, & Marini, 2012; Armstrong, 2000; Boles, 1998; Chapman & Ulatowska, 1989, 1992; Marini, Andreetta, Del Tin, & Carlomagno, 2011) and innovative rehabilitation protocols aimed at recovering not only their linguistic production but also their communicative skills (e.g. Marangolo, 2010; Marini, Caltagirone, Pasqualetti, & Carlomagno, 2007). Formerly, the research on discourse production in persons with aphasia focused on the quantity of information they could convey with their speech samples (Ulatowska, North, & Macaluso-Hayes, 1981; Ulatowska, Freedman-Stern, Doyel, Macaluso-Haynes, & North, 1983). It soon became clear, however, that, when compared to healthy speakers, non fluent aphasic individuals tend to produce fewer (and shorter) complex sentences with a general reduction of information (Ulatowska et al., 1981, 1983). But production is not only a matter of informativeness. Indeed, the production of connected discourse or a contribution to a conversation rest also on the ability to link the utterances by means of cohesive connectives. These are linguistic devices that link distinct utterances so to provide the continuity of the meanings conveyed by a discourse or conversation (Halliday & Hasan, 1976). One of the most frequently used cohesive devices is “reference”. As to this point, an important distinction has been introduced between the concepts of exophoric and endophoric reference (Halliday & Hasan, 1976). Exophoric reference consists in the ability to refer to someone or

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something (e.g., objects, ideas, persons) that is not directly detectable from the words used in the utterances (e.g., "Put it here" or "I don't believe it"). As such, exophoric reference is not a cohesive device, as it does not bind elements together into a text. Rather, its main function is to refer to a state or item that has not been introduced verbally in the preceding utterances but must be inferred by the extralinguistic context. On the contrary, endophoric reference points to concepts that have been previously mentioned in the flow of discourse. As such, this type of reference is needed to establish cohesion among the utterances that form a connected discourse. Endophoric reference can be established in different ways: through the use of lexical repetitions (e.g., "I saw a boy in the garden. The boy was climbing a tree"), anaphoras (pronouns referring to someone that has been previously mentioned, e.g., "he [the boy] was about to fall"), cataphoras (pronouns linking forward to a referent in the following utterances, e.g., "I had told him, but Marco did not listen to me"), lexical substitutions (e.g., "I was worried about the child [the boy]), ellipses (i.e., omissions as in "I ran 5 miles on the first day and 8 [miles] on the second), conjunctions (e.g., "and", "or") and words sharing some semantic relation with previously uttered lexical items (e.g., "The little man [the boy] was climbing a tree") (Halliday & Hasan, 1976). Obviously, a good communicator must be competent in both exophoric and endophoric reference. However, the latter is particularly interesting from a clinical point of view. Indeed, a verbal exchange in which the interlocutors discuss about the same topic and build on each others' contributions would be considered more cohesive than one in which each partner describes his/her physical environment with no reference to its own or the partner's prior utterances (Rochester & Martin, 1977). A number of studies have suggested that cohesive ties might be used to distinguish among different syndromes. Indeed, individuals with schizophrenia with thought disorder use ties differently than non-thought-disordered ones (Rochester & Martin, 1979). Similarly, persons with Alzheimer's disease use cohesive ties differently than healthy individuals (Ripich, Terell & Spinelli, 1983; Ripich, Vertes, Whitehouse, & Fulton, 1988). The research on cohesion in individuals with aphasia is at best scanty, controversial and limited to individuals with fluent forms of aphasia. For example, if Bloom, Borod, Santschi-Haywood, Pick and Obler (1996) reported normal cohesive levels in the language samples produced by a group of persons with fluent aphasia, in a previous study by Glosser and Deser (1990) individuals with similar deficits used often pronouns with antecedents (see also Ultaowska et al., 1981, 1983). Interestingly, they interpreted the reduced ability to provide adequate cohesive ties among utterances as a consequence of a deficit in lexical retrieval rather than a real problem in intersentential organisation (see also Bates, Hamby & Zurif, 1983). Overall, it might be hypothesized that aphasic patients engaged in conversational settings tend to use egocentric speech and do not tailor their utterances to avoid ambiguity for their addressee (Marangolo, 2010). For instance, they might opt for words with exophoric reference, such as first and second person pronouns (e.g."I have done this too") and general questions ("but what are you doing?"), which more likely refer to their own ideas or their physical environment than to topics shared with their interlocutors.

Therefore, both clinicians and researchers in the field of aphasia rehabilitation are gradually becoming aware of the need to include in their protocols also tests for the assessment of discourse level abilities such as those involved in the establishment of cohesion among adjacent utterances. This goes along with the need to provide new ways to treat also this aspect of verbal communication. Indeed, several investigators have stressed the importance of the inclusion of pragmatic treatments in severe chronic aphasic patients to elicit verbal communication (Basso, 2010; Lai, 1993; Marangolo, 2010; Marini & Carlomagno, 2004; Wilkinson & Wielaert, 2012). For example, the Conversational Therapy approach prompts a natural conversation between the therapist and the aphasic patient, a condition of communicative exchange, in which both speakers participate using their available communicative resources (Basso, 2010; Grice, 1975; Marangolo, 2010). However, to date, no studies have explicitly investigated if a pragmatic treatment of this kind might enhance the patient's ability to use cohesive devices.

Parallel to this growing interest in the way spontaneous language is processed in daily communicative interactions, in more recent years, the development of new technologies has provided both professional therapists and educators with innovative instruments. In the field of aphasia, a small but growing body of evidence has already shown that noninvasive brain stimulation, such as transcranial magnetic stimulation (TMS) or transcranial direct current stimulation (tDCS), coupled with language training can exert beneficial effects in the treatment of naming deficits (Naeser et al., 2005; Baker, Rorden, & Fridriksson, 2010; Fiori et al., 2011, Fridriksson, Richardson, Baker, & Rorden, 2011; Marangolo et al., 2013). In the context of language processing, recent investigations have suggested a potential role of the left inferior frontal gyrus and of the adjacent cortex in the selection and unification of operations by which individual pieces of lexical information are bound together into a meaningful discourse (Hagoort, 2005; Marini & Urgesi, 2012). Therefore, we might assume that coupling a pragmatic treatment with repeated stimulation over the left frontal gyrus may exert a positive influence also in the recovery of cohesive units.

This study was designed to investigate whether cohesion analysis can be used to evaluate changes in the language of eight individuals with chronic nonfluent aphasia after an intensive rehabilitation treatment based on a Conversational Therapy approach. Namely, the research addressed two major issues: 1. assess the efficacy of an intensive pragmatic treatment in enhancing discourse cohesion; 2. investigate whether the combined use of tDCS applied over the left inferior frontal gyrus (i.e., Broca's area) and the language treatment would enhance the recovery of linguistic cohesive connectives in a group of persons with chronic non fluent aphasia.

2. Materials and methods

2.1. Participants

2.1.1. Control group

Twenty healthy individuals (10 males and 10 females) matched for age (40 to 75 years) and education level (13 to 17 years) with the participants with aphasia were enrolled in the experiment. They were all native Italian speakers with no history of neurological or psychiatric illness.

2.1.2. Aphasic group

Eight participants (5 males and 3 females) who had suffered a single left hemisphere stroke were included in the study. Inclusion criteria for the study were native Italian proficiency, pre-morbid right handedness, a single left hemispheric stroke at least 6 months prior to the investigation, and no acute or chronic neurological symptoms requiring medication. The data analyzed in the current study were collected in accordance with the Helsinky Declaration and the Institutional Review Board of the IRCCS Fondazione Santa Lucia, Rome, Italy. Prior to participation, all patients signed informed consent forms.

2.2. Neuropsychological assessment

Their linguistic skills were assessed using standardized language tests (the Battery for the analysis of aphasic disorders, BADA test (Miceli, Laudanna, Burani, & Capasso, 1994) and the Token test (De Renzi & Vignolo, 1962). They were also administered a Neuropsychological Battery (Orsini et al., 1987; Zimmermann & Fimm, 1994), which excluded the presence of attention and memory deficits that might have confounded the data (see Table 1).