Cortical Stimulation and Language Outcomes in Aphasia

Research Problem and Rationale

With the increased focus on evidenced-based outcomes in Speech-Language Pathology, a trend towards inclusion of instrumentation and technology in the treatment of aphasia has emerged. One technique at the forefront of this movement is the use of cortical stimulation as an adjunct to behavioral interventions. The purposes of this brief analysis are to review articles published over the course of six years (2006-2011) that combine stimulation with language treatment and to report trends that emerge.

Methods of Data Acquisition

The articles selected for inclusion in this review were chosen from a larger corpus of treatment studies spanning all intervention approaches, appraised by the Department of Veterans Affairs Field Advisory Council on Evidence-Based Treatment Outcomes in Aphasia Task Force. In order to be included in the Task Force review, and therefore in this evaluation, articles had to meet the following criteria: 1) must be a treatment article; 2) must describe treatment in enough detail to be at least somewhat replicable; 3) must have outcome data; 4) must address aspect(s) of speech/language and communication; and, 5) must address acquired aphasia. Potential articles were identified via a literature search using the MEDLINE, PsycINFO, Psychology & Behavioral Sciences, and PsycARTICLES databases, with the following search terms: Aphasia Therapy, Aphasia Treatment, Language Therapy, Language Treatment, Word Retrieval, Reading Therapy, Reading Treatment, Auditory Comprehension.

Applying these criteria, eight articles examining the use of cortical stimulation were identified for inclusion in this review. For each article, the following study attributes were assessed during Task Force review: Study Class (I, II, or III), as refers to the quality of evidence ratings described by the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology (1994) and the Quality Standards Subcommittee of the American Academy of Neurology (2001); Phase (I, II, III, IV, or V), as described by the National Cancer Institute (Cullen, 1986, 1988); Purpose; Design (within-subject, between-subject, or mixed); Subjects; Treatment (including length); Outcome Measures; Analysis (descriptive versus inferential); and, Conclusions.

Results and Analysis

Two distinct types of cortical stimulation are represented in the selected articles: repetitive transcranial magnetic stimulation (rTMS), and transcranial direct current stimulation (tDCS). While both interventions impact neuronal activation, they differ in the mechanism of doing so. tDCS involves application of weak electrical current such that anodal, or (A)tDCS, increases the neuronal excitability of the area being stimulated, whereas cathodal, or (C)tDCS, decreases it (Plautz et al., 2003). rTMS, by contrast, involves magnetic stimulation and modulates neuronal activity according to the frequency of stimulation such that higher frequency stimulation (high) induces increased neuronal activity whereas lower frequency stimulation (low) decreases neuronal activity (Speer et al., 2000). One suggested potential advantage of tDCS over rTMS is that it is easier to employ a no-treatment or "sham" condition (i.e., by delivering a quick pulse of current followed by no current for the remainder of the stimulation interval), which is of particular interest to research endeavors seeking to utilize a randomized/control methodology (Fusco et al., 2013). It is also proposed that tDCS is easier and less costly to administer, both in terms of equipment and provider training (Fridriksson, Richardson, Baker, & Rorden, 2011; Miniussi et al., 2008).

Table 1 provides, for each study, a brief description of subjects (number and diagnosis), a summary of the type and location of cortical stimulation applied, and the reported outcome(s) of the treatment. Type of aphasia studied ranges in severity from global to anomic and includes one individual with primary progressive aphasia. The number of subjects with aphasia studied ranges from 1 to 21. Outcomes studied include various aspects of verbal production (e.g., verb production, naming phrase length) as well as auditory comprehension.

Table 2 provides, for each study, the level of research evidence (Class and Phase) assigned by the Task Force, as well as the mechanisms of improvement proposed by the study investigators. Three studies reviewed were assigned a rating of Class III (evidence provided by expert opinion, case series, case reports, and studies with historical controls); two, Class II (evidence provided by well-designed observational studies with concurrent controls); and three, Class I (evidence provided by one or more well-designed, randomized, controlled clinical trials). Four studies reviewed were assigned a rating of Phase I (designed to develop and test hypotheses, determine safety of procedures, and detect influence of the intervention), and four were assigned a rating of Phase II (designed to develop, standardize, validate, and optimize procedures). Mechanisms proposed by study investigators for improvement in subjects' language include activation of left hemisphere cortex, as well as suppression of right hemisphere structures.

Conclusions

Based on the articles reviewed, it appears that both activation of left-hemisphere language regions and inhibition of activation of right-hemisphere homologues, in conjunction with provision of language treatment, are beneficial in promoting improved language function. In fact, a slight advantage for inhibition of the right hemisphere emerges if one considers the findings reported by You and colleagues (2011), which indicate that right-suppression was of more benefit than left-activation, and the findings reported by Naeser and colleagues (2010), which note that right-suppression was of benefit even in the face of chronic deficits. Further, the studies reviewed suggest that, while both rTMS and tDCS can be effective tools in promoting language recovery, a slight advantage for tDCS may exist due to both the greater ease of proving a "sham" tDCS condition as compared with rTMS (an important consideration if embarking on a research project with the need for a control condition) and the proposed greater ease and lower cost of utilizing tDCS.

A limitation of this review, and more generally, in attempts to conduct meta-analyses of outcome data from published studies evaluating tDCS and rTMS as adjuncts to language treatment, is the relatively small number of participants in the studies, both individually and collectively. A further challenge in conducting a conclusive analysis of the potential benefits of these interventions is the relatively weak level of evidence provided in the studies. Although three of the studies were assigned a Study Class of I (best evidence), none exceeded preliminary (Phase I and II) stages of investigation. That is, the three studies providing best evidence were randomized control trials but were the first or second study to examine the specific treatment protocol. However, even with these constraints, there appears to be a slight advantage for tDCS, with more subjects included (39 in all, as compared with 26 for rTMS) and more Class II/I ratings of evidence, as assigned by Task Force to the articles included in this review.

Clinical Implications

The combined results of the studies included in this brief review suggest that the greatest promise for cortical stimulation as an adjunct to behavioral therapy to address language function appears to come from tDCS applied in an inhibitory fashion to the right hemisphere.

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Table 1

Stimulation type, location, and outcome

Study	Stimulation	Number of Subjects	Aphasia Type(s)	Outcome(s)
Finocchiaro et al. (2006)	rTMS (high), applied to left hemisphere	1	Primary Progressive	Improvement in verb production
Kakuda et al. (2010)	rTMS(low), applied to Wernicke's area	2	Sensory dominant	Improvement in auditory comprehension
Naeser et al. (2010)	rTMS(low), applied to right hemisphere	1	Non-fluent	Improvement in phrase length and score on Boston Naming Test (BNT, Kaplan, Goodglass, & Weintraub, 2001)
Barwood et al., (2011)	rTMS(low), applied to right Broca's homologue	12	Non-fluent	Improvement in Boston Diagnostic Aphasia Examination (BDAE) Cookie Theft Picture Description (Goodglass, Kaplan, & Barresi, 2001), BNT, and picture naming
Fridriksson et al. (2011)	(A)tDCS, applied to left hemisphere	8	Fluent	Reduced reaction time on naming task
Kang et al. (2011)	(C)tDCS, applied to right Broca's homologue	10	Broca's, Global, Transcortical Motor, Anomic	Improvements in naming accuracy
Weiduschat et al. (2011)	rTMS(low), applied to right Broca's homologue	10	Not specified	Improvement in aphasia quotient on Aachen Aphasia Test (AAT, Huber, Weniger, Poeck, & Wilmes, 1980)
You et al. (2011)	tDCS, applied to right and left hemispheres	21	Global	Improvement in auditory comprehension with (C)tDCS to right hemisphere

Table 2

Study Class, Phase, and proposed mechanism of improvement

Study	Class	Phase	Proposed Mechanism of Improvement in Language
Finocchiaro et al. (2006)	III	I	**Activation** of **left** anterior midfrontal gyrus results in **improved** performance on verb tasks
Kakuda et al. (2010)	III	I	Low-frequency/inhibitory rTMS was successful and without adverse events
Naeser et al. (2010)	III	I	**Inhibition** of **right**-hemisphere structures may be **of benefit** in promoting language recovery, even in chronic aphasia
Barwood et al. (2011)	I	II	**Suppression** of **right** hemisphere Broca's homologue followed by language treatment **improves** performance on language measures
Fridriksson et al. (2011)	II	II	**Activation** of the **left** hemisphere during language treatment **reduces processing time** during picture naming
Kang et al. (2011)	I	II	**Suppression** of **right** hemisphere Broca's homologue during naming treatment **improves** naming accuracy
Weiduschat et al. (2011)	I	II	**Suppression** of **right** hemisphere Broca's homologue followed by language treatment **improves** performance on language measures
You et al. (2011)	II	I	**Suppression** of **right** hemisphere is **more effective** than activation of left hemisphere