

Featured Article

# Inferior parietal transcranial direct current stimulation with training improves cognition in anomic Alzheimer's disease and frontotemporal dementia

Carlos Roncero\*, Heike Kniefel, Erik Service, Alexander Thiel, Stephan Probst, Howard Chertkow

Bloomfield Centre for Research in Aging, Lady Davis Institute of Research, Jewish General Hospital, McGill University, Montréal, Quebec, Canada

## Abstract

**Introduction:** We evaluated whether transcranial direct current stimulation (tDCS) can improve picture-naming abilities in subjects with anomic Alzheimer or frontotemporal dementias.

**Methods:** Using a double-blind crossover design, 10 participants were trained on picture naming over a series of 10 sessions with either 30 minutes of anodal (2 mA) tDCS stimulation to the left inferior parieto-temporal region (P3) or sham stimulation. We evaluated performance on a trained picture-naming list, an equivalent untrained list, and additional neuropsychological tasks.

**Results:** Participants improved significantly more receiving real stimulation rather than sham stimulation (40% vs. 19%,  $P < .01$ ), lasting at least 2 weeks after stimulation. Furthermore, these participants showed a small increase for untrained picture-naming items and digit span when they received real stimulation but a decrease when sham stimulation was received.

**Discussion:** tDCS stimulation has promise as a treatment for anomia in demented individuals and the effect can generalize to unstudied items as well as other cognitive abilities.

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**Keywords:** tDCS; Anomia; Object naming; PPA; Training

## 1. Introduction

Neurodegenerative diseases such as Alzheimer's disease (AD) and frontotemporal dementia (FTD) are accompanied by a variety of cognitive impairments involving language, executive function, and memory. Current therapies are limited in their ability to significantly improve these cognitive abilities. Transcranial direct current stimulation (tDCS) has been shown to have effects that last beyond the time of stimulation [1]. In a series of experiments in the past decade, tDCS has been shown to impact cognitive performance and emotional states [2]. tDCS has had a benefit sufficient to be used clinically in depression [3] and Parkinson's disease [4]. However, few

tDCS studies have targeted any cognitive symptoms in primary progressive aphasia (PPA) living with AD or FTD, and of the few studies done, most have examined memory improvement after a single session of tDCS stimulation without concurrent training. These initial studies were positive [5–7], but negative results have also been reported [8–11]. Crucially, these negative results have been attributed to the montage used, the participants included, or the method of evaluation, rather than representing a failure of tDCS itself. Taspinkini et al. [12] found that combining training with anodal tDCS stimulation could improve spelling scores in six PPA participants (two nonfluent, four logopenic). These results suggest that tDCS may be especially effective when combined with training, and linguistic abilities such as anomia might be amendable to improvement. For this reason, we conducted a proof-of-concept study with a mixed group of dementia

\*Corresponding author. Tel.: +1-514-999-2762.  
E-mail address: [troncero@gmail.com](mailto:troncero@gmail.com)

patients having neurodegenerative aphasia syndromes where anomia was prominent. We examined whether language training combined with anodal tDCS stimulation to the inferior parietal lobe would improve naming ability.

## 2. Method

### 2.1. Participants

Ten participants were selected for this pilot study, which was designed as a randomized cross-over of tDCS versus sham therapy. Clinically, they had evidence of dementia (AD or FTD), according to either McKhann et al. [13] criteria for AD, or the Rescovsky et al. [14] criteria for FTD. Inclusion criteria were as follows: a diagnosis of dementia (AD or FTD), scoring below a cutoff point for normal performance on the spontaneous naming task of the Cambridge Semantic Battery [15] and a demonstrated ability to do the naming task that was the focus of our investigation. For this reason, we included participants with low Montreal Cognitive Assessment (MoCA) scores and Mini-Mental State Examination (MMSE) scores if they were able to understand and cooperate for the Naming task and could make an effort to name images when prompted to do so. Some patients were taking medication (e.g., cholinesterase inhibitors), but there were no medication differences between the sham and real stimulation rounds. Finally, the study was approved by the research ethics committee of the Jewish General Hospital, Montréal, Canada. At the time of enrollment, all participants also underwent flurodeoxyglucose-positron emission topography scans to examine the level of left temporo-parietal hypometabolism—our target area of stimulation. Clinical reports from the neuroradiologist of hypometabolism in left perisylvian (temporo-parietal) regions were considered an additional inclusion criterion for the study, and the degree of hypometabolism was documented. As can be observed in Table 1, alongside demographic and diagnostic details, all

participants had mild-to-severe hypometabolism in the left perisylvian region, but variable hypometabolism on the right.

### 2.2. Experimental design

Five participants were given anodal stimulation (10 daily sessions) during the first round of testing and had 10 sessions of sham stimulation delivered at least 2 months later. For the other five participants, this order was reversed. They were first given 10 sessions of sham stimulation, with anodal stimulation administered during the second round of testing at least 2 months later. All participants and raters were blind to the stimulation condition (active vs. sham). Furthermore, regardless of condition, all participants experienced an initial ramp-up of the machine to 2 mA, which remained at 2 mA for 1 minute in the sham condition. Furthermore, a simulated ramp-up also occurred in the final 30 seconds of the sham condition. In this manner, regardless of condition, all participants felt an initial prickling sensation during the first minute which indicated that stimulation had started. In a real stimulation condition, after this initial ramp-up, participants begin to notice the sensations less as impendence becomes sufficiently low, to the extent that many participants report no longer feeling the stimulation. Thus, in a sham stimulation condition, when stimulation effectively ceases, participants in turn perceive this change as similar to the one felt in the real stimulation condition. In other words, participants have great difficulty distinguishing real and sham stimulation. Consequently, despite being informed after the experiment that some rounds had been sham, participants by and large indicated that they had considered all rounds to contain real stimulation, albeit also reporting that certain rounds were more effective than others.

### 2.3. Primary outcome measure: Spontaneous naming

Stimuli for the picture-naming task were taken from the Snodgrass and Vanderwart image set [16], with familiarity

Table 1  
Patient diagnostic and general cognition data

Patient code	Diagnosis, PPA type	Left TP	Right TP	Age	Sex (M/F)	Education (years)	MoCA	MMSE	C. naming score
BaM	FTD, nf PPA	++	+	74	M	18	3	9	59
BeJ	FTD, nf PPA	+		72	M	15	24	28	57
CaM	FTD, nf PPA	+	+	62	M	11	13	17	59
DiC	FTD, nf PPA	++	++	75	M	11	21	26	58
LaD	FTD, nf PPA	++	+	62	M	18	9	14	34
MaA	AD, nf PPA	++		63	F	18	24	27	56
McD	AD, logo PPA	++	++	69	M	11	10	17	30
OuL	AD, logo PPA	+++	++	70	M	11	6	10	30
LaA	FTD, sv PPA	++	++	56	F	18	3	8	11
TrL	FTD, sv PPA	++	++	71	F	18	22	26	9

Abbreviations: PPA, primary progressive aphasia; TP, temporo-parietal area; MoCA, Montreal Cognitive Assessment; MMSE, Mini-Mental State Examination; FTD, frontotemporal dementia; PPA subtypes: nf PPA, nonfluent PPA; logo PPA, logopenic PPA; sv PPA, semantic variant PPA; AD, Alzheimer's disease; hypometabolism levels: +, mild; ++, moderate; +++, severe, based on FDG-PET scans collected on participants at the time of study enrollment.

NOTE. C. naming is the spontaneous naming score obtained on the naming task from the Cambridge Semantic Battery (max = 64, normal elderly control mean = 62, standard deviation = 2).

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