Transcranial direct current stimulation modifies automatic and controlled verbal fluency

GORDON B, VANNORSDALL TD, LEDOUX K, PICKETT EJ, ANDREJČUK M, SUNG K, SCHRETLEN, DJ

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Background and Objective: Overt human behaviors are generally acknowledged to be the result of a variable admixture of automatic and controlled mental processes. Clustering on verbal fluency tasks (the generation of contiguous words, within semantic or phonemic subcategories) seems to originate from automatic processes. Switching from one subcategory to another seems to reflect elements of cognitive control, such as self-monitoring and self-cuing. Convergent evidence from behavioral, imaging, and lesion studies suggests that, in individuals left-hemisphere dominant for speech, automatic functions in this task rely upon left posterior temporal-parietal regions; the controlled functions, upon left prefrontal regions. Transcranial direct current stimulation (tDCS), which involves passing a weak, direct electrical current through the cortex, may enhance or inhibit the functions of underlying cerebral tissues, depending upon the polarity of the applied current. Here, we present preliminary data showing that tDCS may modify automatic and controlled aspects of word retrieval in healthy adults.

Methods: In this single-blind experiment, 57 healthy right-handed adults (ages 18-70 years [mean 34.4 years], education 12-20 years [mean 17.8 years]) were randomly assigned to receive 1 mA of active (either anodal [excitatory] or cathodal [inhibitory]) stimulation, plus sham stimulation, in counterbalanced order. Stimulation was delivered for 30 minutes via a constant current stimulator through 7.6x7.6-cm sponge electrodes. The “active” electrode was placed over the left prefrontal region (F3), the “indifferent” electrode over the vertex or right supraorbital region. At the end of each period of stimulation, subjects completed 60-second trials of two different verbal fluency tasks (letter [S or P] and category [animals or supermarket items]). Productions were scored as to the number of words generated, switches, number of clusters, and percent words in clusters.

Results: Between-groups analyses revealed that, compared to cathodal stimulation, anodal stimulation was associated with the production of more clusters and a greater percentage of words within clusters on letter-cued fluency tasks (ps = 0.02 and 0.04, respectively). For the category-cued fluency tasks, on within-group analyses, anodal stimulation showed a trend towards the generation of more clusters (p = 0.06) and a greater percentage of words within clusters (p = 0.03) compared to sham stimulation. The opposite pattern was found for cathodal stimulation –
participants produced fewer clusters and a smaller percentage of words in clusters compared to the sham condition. Males and older adults tended to show larger tDCS-related alterations in productivity.

Conclusions and Significance: To our knowledge, this is the first demonstration that tDCS can selectively alter a component process of lexical retrieval. Specifically, left frontal anodal stimulation facilitated and cathodal stimulation impeded the production of clustered word retrieval on both letter- and category-cued verbal fluency tasks in healthy adults. Subgroups that might be expected to show less-efficient verbal productivity, namely males and older adults, were most responsive to the tDCS intervention. These preliminary findings provide an empirical foundation for future studies on the investigational and therapeutic uses of tDCS in disorders of language production.