

Relationship of Patient-Specific Models of Deep Brain Stimulation to Verbal Fluency Performance



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BACKGROUND

- Deep Brain Stimulation (DBS) surgery of the subthalamic nucleus (STN) is an effective treatment for medication-refractory Parkinson disease (PD).
- DBS is often associated with declines on verbal fluency tasks.
- Electrode placement in the dorsal lateral region of the STN has been suggested to lead to optimal motor outcome, but no studies have investigated the relationships between locus of stimulation and verbal fluency performance.

AIMS of Study

- Create patient specific-models of DBS activation to:
- Visualize the locus and volume of activated tissue
 - Investigate the relationship between modeled activation within the STN to verbal fluency performance.

METHODS

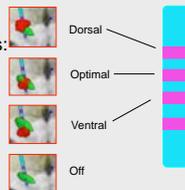
Participant	Unilateral STN DBS Patients (N=8)	Mean (SD)
Characteristics	Age	65.4 (9.8)
	Years with symptoms	12.0 (3.0)
	Education	15.0 (3.0)
	Pre-surgical UPDRS score	
	ON medication	24.0 (5.8)
	OFF medication	44.0 (13.4)
	MMSE	27.4 (2.2)
	Side of surgery	Left: N=6 Right: N=2
	Gender	Male: N=6 Female: N=2
	Post-surgical UPDRS score	
	ON medication	27.1 (10.5)
	OFF medication	34.6 (6.1)

Testing Procedure

Participants performed verbal fluency tasks under the following DBS conditions:

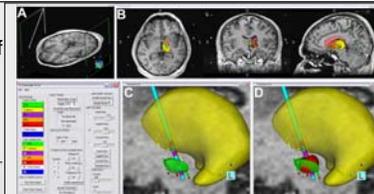
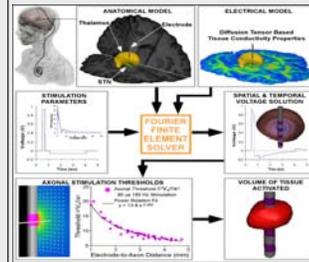
- the contact providing optimal motor benefit
- the contacts dorsal and ventral to the optimal contact
- OFF stimulation.

Testing occurred "off" dopaminergic medication.



Models of DBS activation

- Computer-generated models of activated tissue were created for each contact based upon anatomical, electrical, and neural activation information.

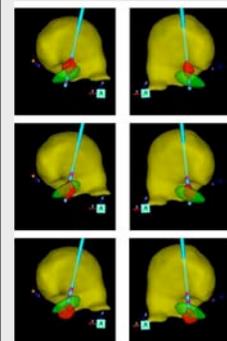


Human Cicerone software interface for model generation. A) The green localizer box is aligned to the MRI stereotactic frame fiducial markers. B) A 3D brain atlas is customized to the subject's MRI. C) Microelectrode recording data and the DBS electrode position are viewed in stereotactic space with the MRI and anatomical nuclei. D) Theoretical predictions of the volume of tissue activated by DBS (red volume) are generated.

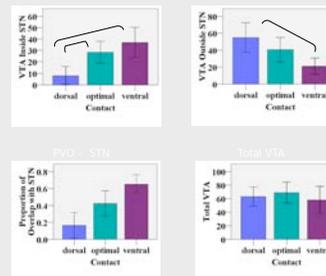
- Outcome measures included the volume of tissue activation (VTA), and the amount of VTA occurring both inside and outside of the STN.
- Spearman correlations were conducted to evaluate the relationship of these outcome variables to verbal fluency change scores with stimulation relative to OFF stimulation.

RESULTS

Two patient-specific models of activation (red volumes) at dorsal, optimal, and ventral contacts on the DBS electrode. Anatomical nuclei (yellow volume – thalamus; green volume – STN) are also depicted.



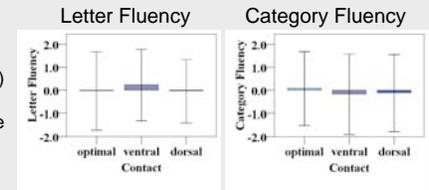
Stimulation of each of the three contacts yielded different amounts of activation overlap with the STN.



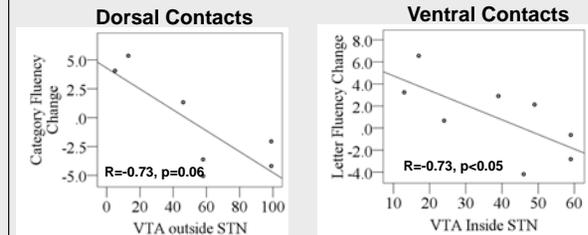
Mean volume of tissue activated (VTA) values for each of the three DBS electrode contacts. Brackets indicate significant difference between contacts ($p < 0.05$).

RESULTS cont.

Verbal fluency change scores (relative to OFF) did not differ among the three contacts.



Correlation analysis revealed that stimulation dorsal to and outside of the STN, as well as ventrally within the STN was negatively related to verbal fluency performance.



Negative fluency change values indicate lower than predicted scores obtained with stimulation relative to OFF stimulation, and positive values indicate higher than predicted scores.

CONCLUSIONS

- This study suggests that stimulation dorsal to and outside of the STN, as well as ventrally within the STN may adversely affect verbal fluency performance.
- Ventral STN stimulation may interfere with the functioning of the associative circuit, with passes through the ventral STN.
- Dorsal stimulation is thought to lead to beneficial motor outcome, and there may be a tradeoff in terms of verbal fluency performance.
- Patient specific models should be studied more to optimize motor and cognitive outcome. Larger sample sizes are needed.

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