Hope vs. Hype

Closed Loop Technology Will Provide More Meaningful Improvement vs. Directional Leads in Deep Brain Stimulation

DISAGREE

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Why I disagree?

- DBS programming requires a level of anatomical detail that is best provided only by small directional electrodes

- The ability of sensing technologies in identifying sub-regions of interest within the target is limited

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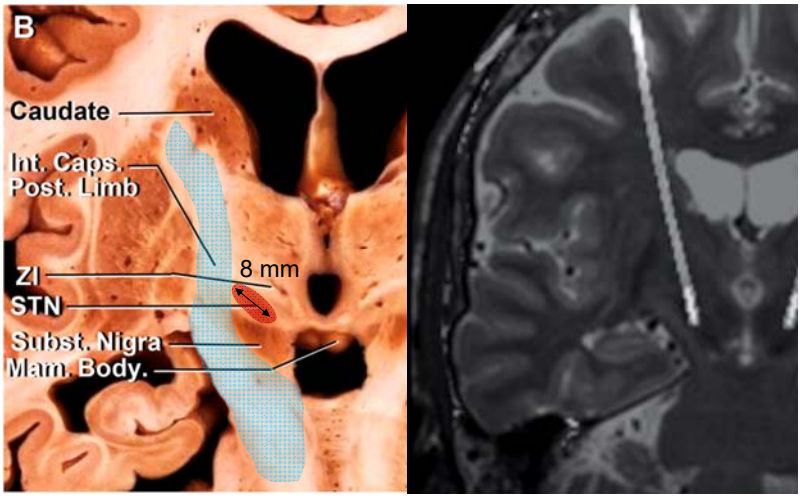
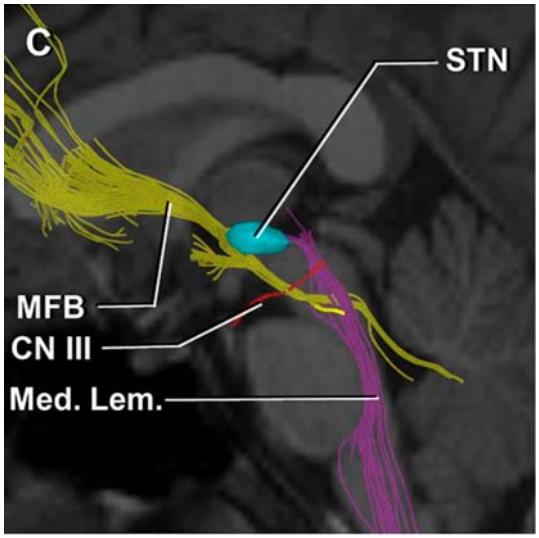
DBS Targets: Macroscopic Anatomy



Güngör et al., 2018 https://doi.org/10.3171/2017.10.JNS171513

DBS Targets: Macroscopic Anatomy



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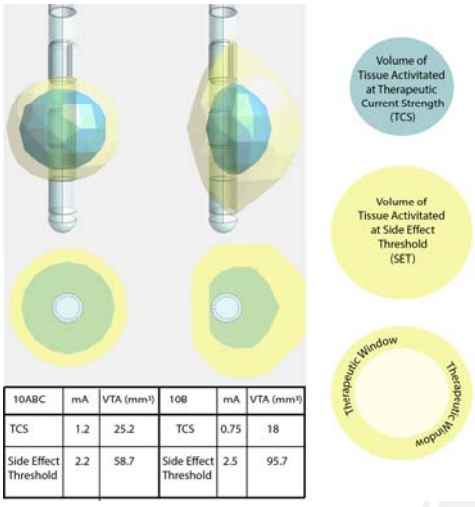
DBS Targets: Macroscopic Anatomy

	Direction of current spread	Structures involved	Side effect(s)
STN	Lateral or Antero-lateral	Internal Capsule	Controlateral muscle contractions Facial or tongue pulling Dysarthria Contralateral gaze deviation
	Antero-medial	Lateral Hypothalamic Area	Autonomic changes/vegetative side effects (nausea, heat sensation, sweating)
	Medio-ventral	Oculomotor Nerve	Disconjugate gaze Diplopia
	Posterior	Medial Lemniscus	Paresthesia Ataxia Slurred Speech

Merola et al., 2020 DOI: 10.1007/s40120-020-00181-9

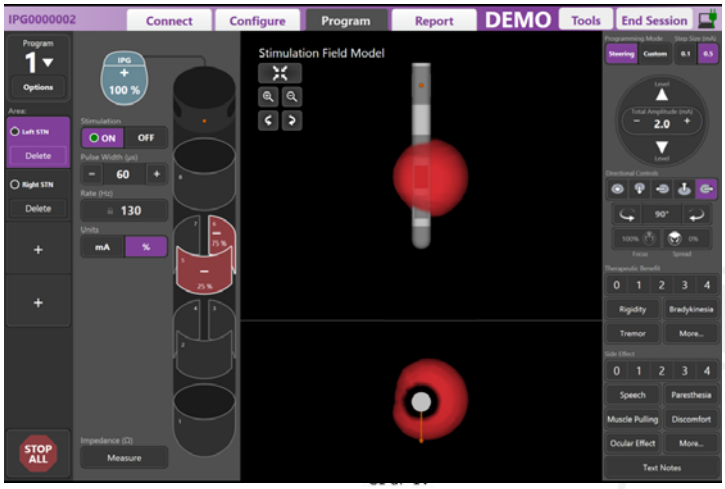
Directionality Improves Accuracy



10ABC	mA	VTA (mm³)	10B	mA	VTA (mm³)
TCS	1.2	25.2	TCS	0.75	18
Side Effect Threshold	2.2	58.7	Side Effect Threshold	2.5	95.7

Rebelo et al., 2018 DOI: 10.1016/j.brs.2017.12.015

How Directionality will change the approach to DBS?



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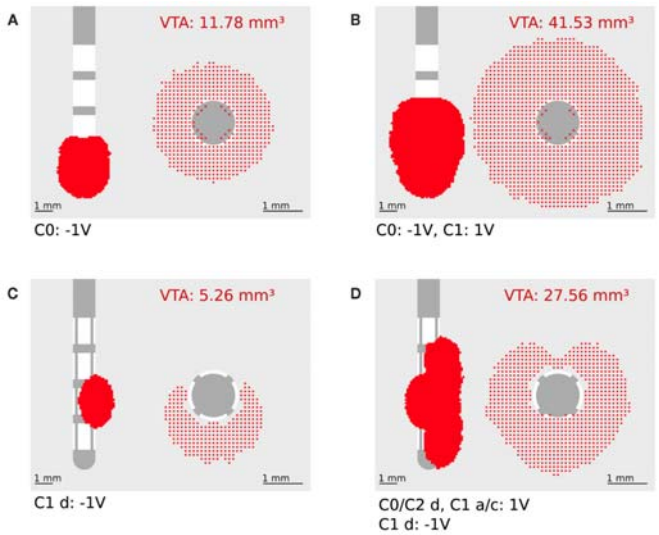
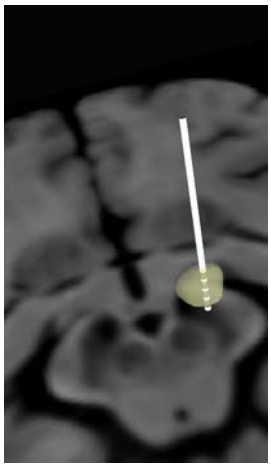


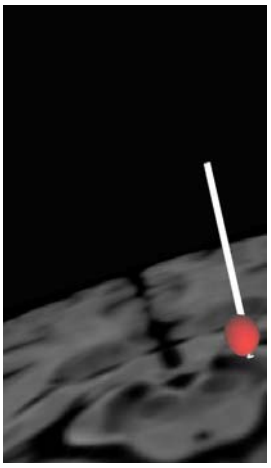
Courtesy of Surgical Information Science (SIS)

How Directionality will change the approach to DBS?

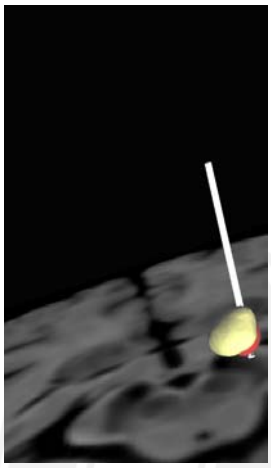
Step 1. Identify the lead location within the Target



Step 2. Estimate the Volume of Tissue Activated (VTA)



Step 3. Estimate the Overlap VTA - Target



Merola et al., In preparation

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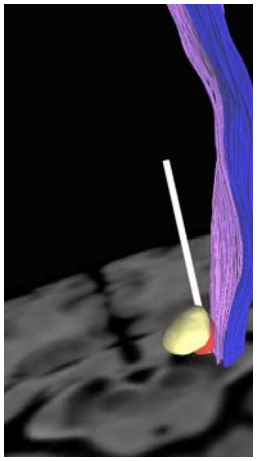
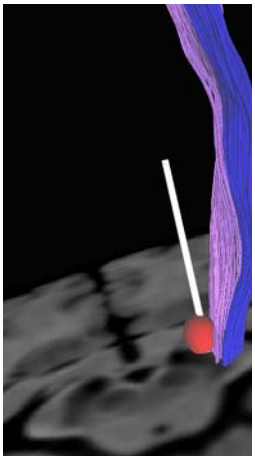
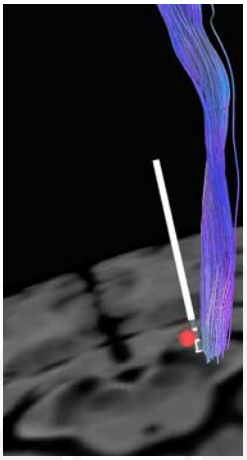
Step 4. Estimate the VTA spread into other structures



Step 5. With Conventional Programming



Step 6. With Directional Programming



Merola et al., In preparation

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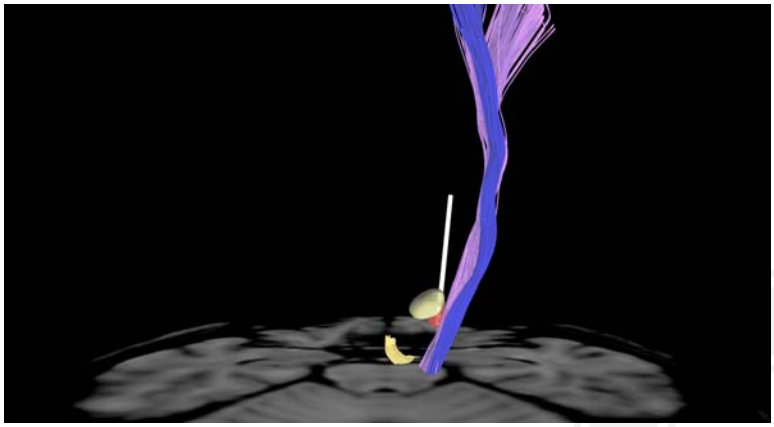

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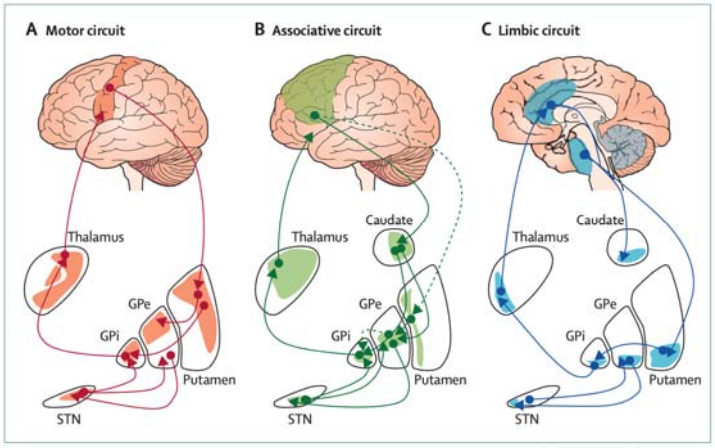
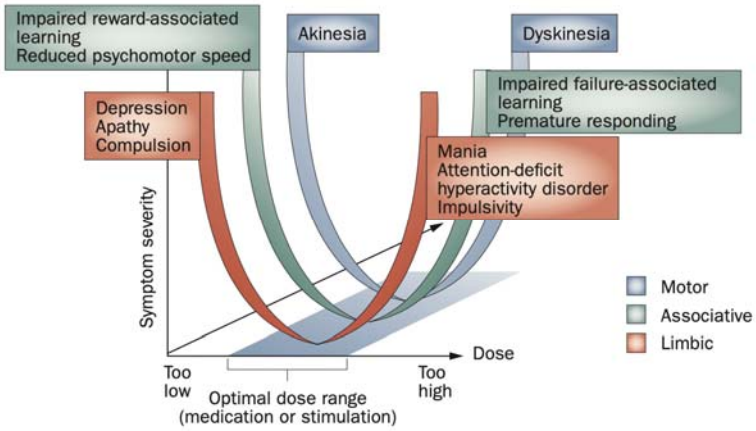
Different subregions, different networks



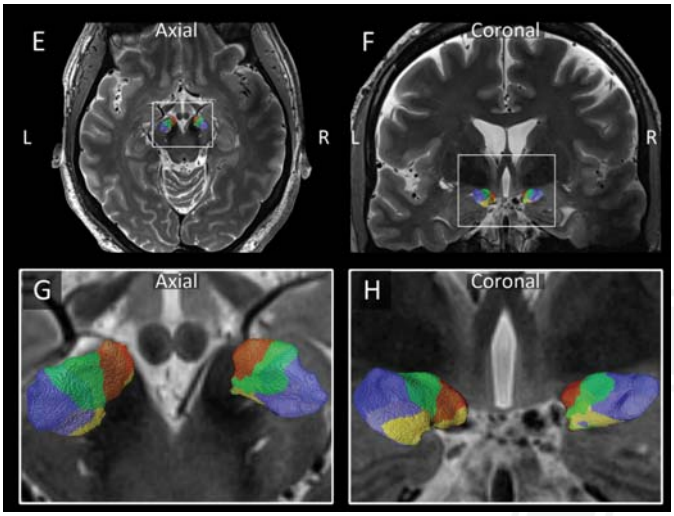
Rodriguez-Oroz et al., 2009
DOI:https://doi.org/10.1016/S1474-4422(09)70293-5

Balancing the different networks



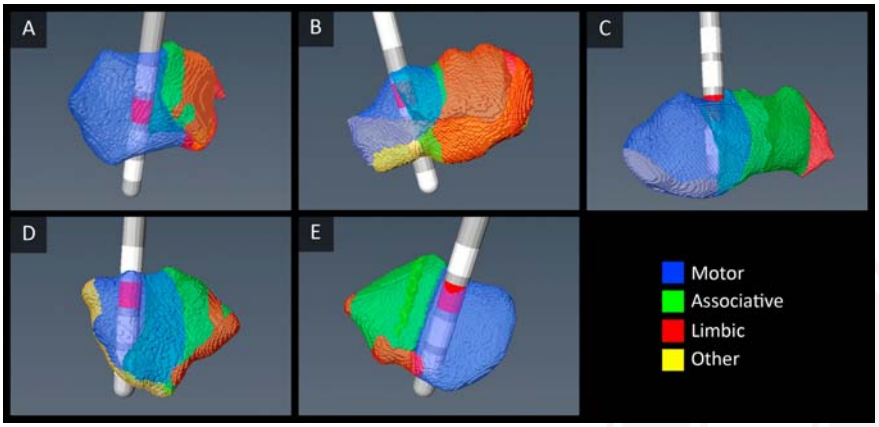
Volkmann et et., 2010 https://doi.org/10.1038/nrneurol.2010.111

Sub-regions of Interest within the STN



Platinga et al., 2016 https://doi.org/10.1016/j.neuroimage.2016.09.023

How Directionality can help stimulating selected sub-regions of the STN?



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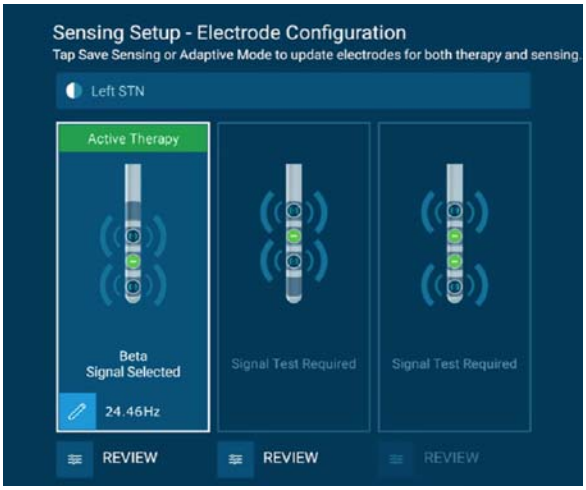
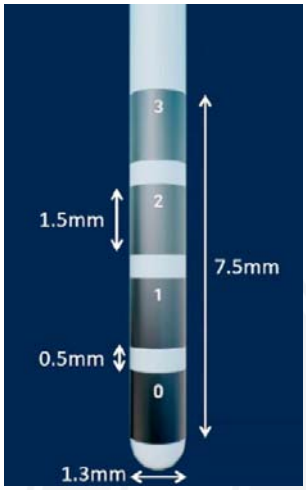
Selective Stimulation of STN subregions
Brain Sensing





Goyal et al., 2021 https://doi.org/10.1016/j.bios.2020.112888

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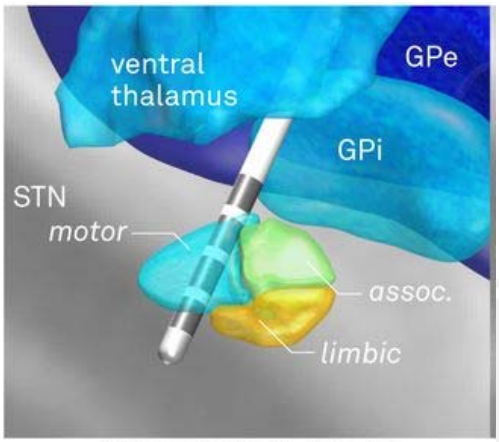
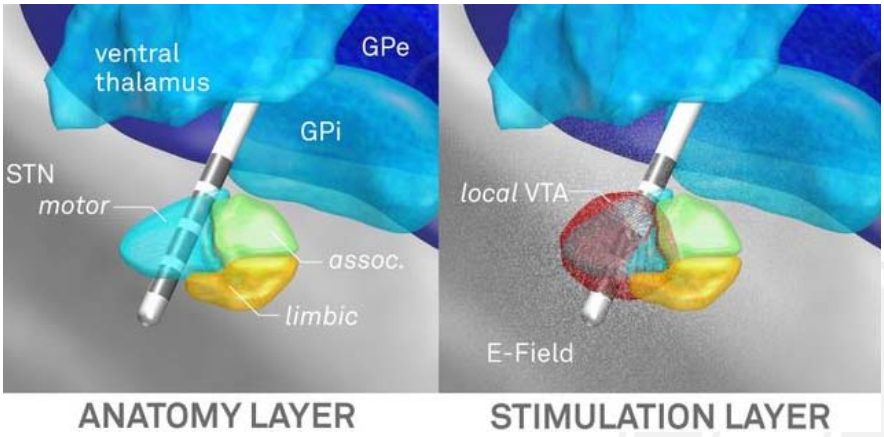


ANATOMY LAYER

Horn et al., 2019 doi: 10.1016/j.neuroimage.2018.08.068

Selective Stimulation of STN subregions Brain Sensing



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Clinical studies of Directional DBS

Study	Sample Size	Main Results
Pollo et al., 2014	11 PD (STN) 2 ET (Vim)	o TW 41.3% wider and TCS 43% lower with directional vs. omnidirectional stimulation
Contarino et al., 2014	8 PD (STN)	o TW wider with directional vs. omnidirectional stimulation
Steigerwald et al., 2016	7 PD (STN)	o TW variations from -100% to +440% with directional vs. omnidirectional stimulation o Best TW improvement with the best directional contact at the less effective level
Dembek et al., 2017	10 PD (STN)	o TW wider with directional vs. omnidirectional stimulation o SET higher with directional vs. omnidirectional stimulation
Rebelo et al., 2018	3 PD (Vim) 3 DT (Vim) 2 ET (Vim)	o TW wider and TCS lower with directional vs. omnidirectional stimulation o TEED 6-18% lower with directional vs. omnidirectional stimulation

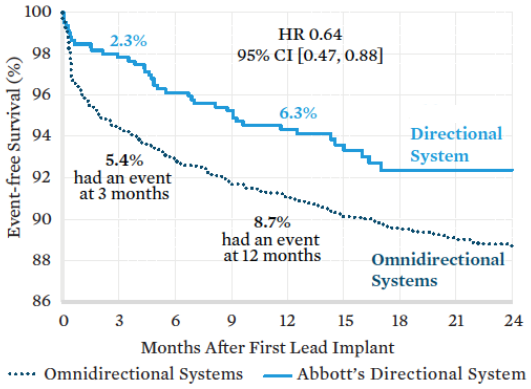
Merola et al., 2020 DOI: 10.1007/s40120-020-00181-9

Data from the PROGRESS Study

Enrollment	**234 PD patients (157 males; 77 females)**
Demographics	Age: 61.7 ±8.4 years; PD duration since onset: 11.7 ±7.6 years;
Number of centers	**37 centers, from 7 countries**
Lead Configuration	2 central segmented contacts (3 segments each), 1 proximal and 1 distal ring contacts; 1-3-3-1
Clinical Setting	Prospective, blinded subject, blinded observer, crossover study of directional versus non-directional stimulation
Study Endpoints and Results	• **Superiority benchmark**: In 90.6% of patients, TW was wider with directional stimulation as compared to non-directional stimulation ($p < 0.001$) • **Clinicians' and Patients' preference:** 58.5% of clinicians and 52.8% of patients preferred directionality 20.2% of clinicians and 21.8% of patients expressed no preference 21.2% of clinicians and 25.9% of patients preferred non-directionality

DBS revisions (Medicare data October 2016 - December 2018)

N= 3,800 patients
N= 283 hospitals
Follow-up= 2 years



Directional DBS systems had a 36% reduced risk of any surgical revision/removal of leads or IPG compared to omnidirectional systems

Abbott. Study Report. Document Number: CL1012080.

Why I think that Directionality is the most exciting innovation in DBS

1. Integration into imaging-based programming platforms

2. Stimulation of sub-regions of interest (networks) within the target

3. Strong evidence of clinical meaningfulness

4. Lower rate of surgical revisions

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