Clinical Neuromodulation Technology

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Financial Conflicts of Interest
Kernel
Boston Scientific Neuromodulation
Surgical Information Sciences
Neuros Medical
Autonomic Technologies
Cardionomic
Enspire DBS
Neuromodulation Origins

Mortimer & Shealy, circa 1966
Clinical Neuromodulation

Spinal Cord Stimulation

Sacral Nerve Stimulation

Vagus Nerve Stimulation

Deep Brain Stimulation

Market Share

SCS

VNS

SNS

DBS

Market Size

~$5B/year
Clinical Deep Brain Stimulation

Parkinson’s Disease
Essential Tremor
Dystonia
Obsessive-Compulsive Disorder
Depression
Epilepsy
and more...

~150,000 DBS patients
Deep Brain Stimulation
Subthalamic Nucleus DBS

Gunalan et al., *PLoS ONE*, 2017
DBS Network Modulation

McIntyre & Hahn, Neurobiol. Dis., 2010
Intracranial Electrodes

Lempka et al., (in preparation)
Directional DBS Electrodes


Model | Span
--- | ---
BSC DB-2201 | 15.5 mm
MDT 3389 | 7.5 mm
MDT 3387 | 10.5 mm
STJ 6146-61499 | 9.0 mm
STJ 6142-6145 | 12.0 mm

Directional Current-Steering

GUIDE DBS, *Boston Scientific*
Adaptive DBS

McIntyre et al., *Brain Stimul.*, 2014
Adaptive DBS Control Systems

No DBS
beta amplitude
profile

short bursts and
long bursts

Stim

cDBS
beta amplitude
profile

Short and long bursts
suppressed in proportion

Stim

aDBS
beta amplitude
profile

Increase short bursts and
decrease long bursts

Tinkhauser et al., *Brain*, 2017
Learning the Language

de Hemptinne et al., Nat. Neurosci., 2015
Connectomic DBS Targeting

Noecker et al., *Neuromodulation*, 2017
Next Generation Hardware
Conclusions

• Intracranial stimulation/recording has wide-ranging therapeutic value and potential.
  – Today movement disorders
  – Tomorrow psychiatric disorders

• Device technology is expanding rapidly, accelerating scientific understanding of human brain circuits.
  – Learning how to communicate with the brain
  – Learning where to put the electrodes

• As we transition from devices with ~10 to ~100 electrodes, the bandwidth for bidirectional communication will dramatically increase.
  – When do we begin infringing upon autonomy?
Acknowledgements

Current Lab Members
- Ross Anderson, Ph.D.
- Sinem Balta-Beylergil, Ph.D.
- Kelsey Bower
- AmirAli Farokhniaee, Ph.D.
- Anneke Frankemolle
- Kabi Gunalan, Ph.D.
- Bryan Howell, Ph.D.
- Nick Mailing, Ph.D.
- Angela Noecker
- Sarah Ozinga, Ph.D.
- Suraj Thyagaraj, Ph.D.

Financial Support
- National Institutes of Health
  - Principal Investigator
    - R01 NS059736
    - R01 NS085188
    - R01 NS086100
    - R01 MH102238
    - R01 MH106173
  - Co-Investigator
    - P50 NS098573
    - R03 MH111320