

Group C7.

April 12, 2024

BMEG 321 | Final Project Electroneurogram for Multiple Sclerosis Diagnosis

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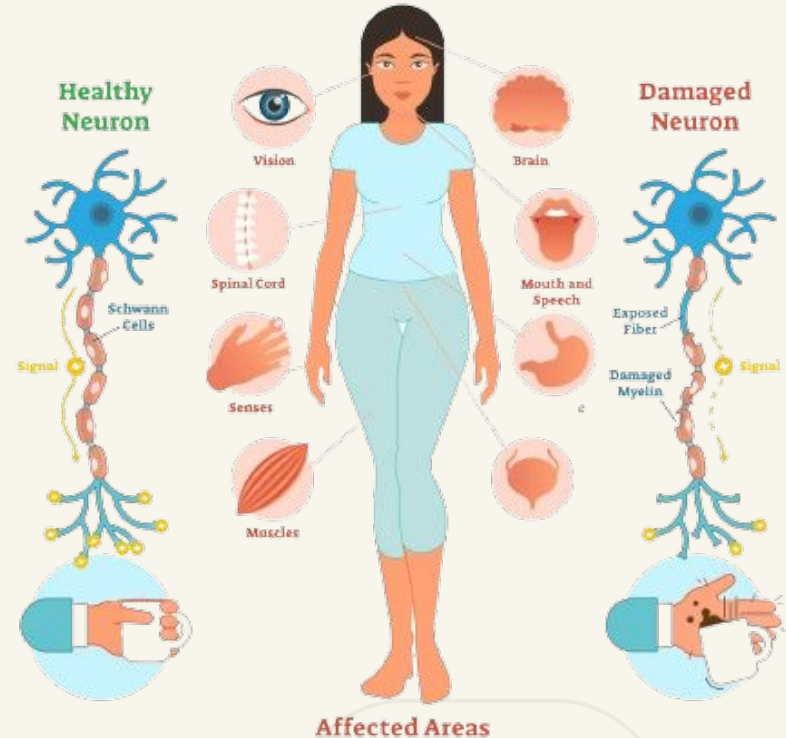
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Section 01:

Problem Overview

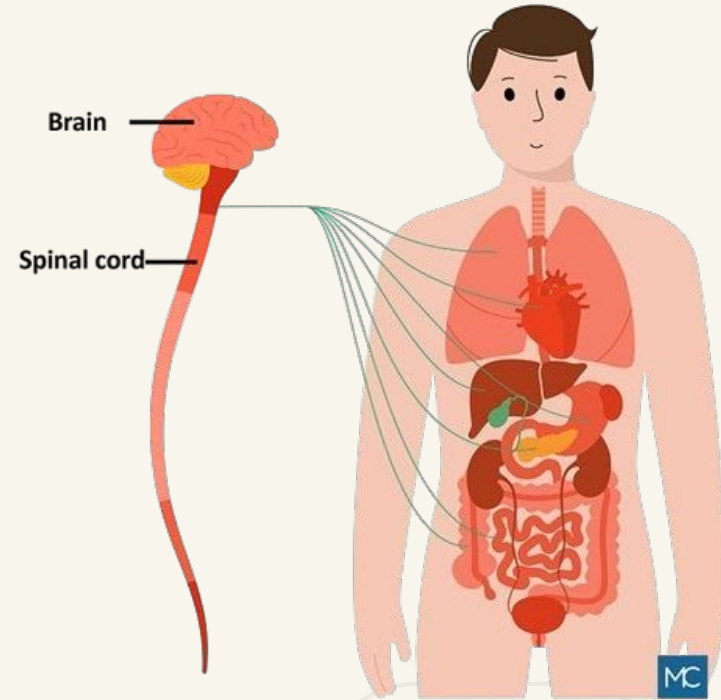
Multiple Sclerosis (MS)

- Autoimmune Disorder of the Brain and Spinal Cord (Central Nervous System)
- Involves Degradation of Myelin Sheath which Insulates Transmission of Signals
 - Affects 3 Million People Worldwide
- Classified Based on Stages of Progression:
 - *Clinically Isolated Syndrome*
 - *Relapsing-Remitting MS*
 - *Secondary Progressive MS*
 - *Primary Progressive MS*



The Vagus Nerve

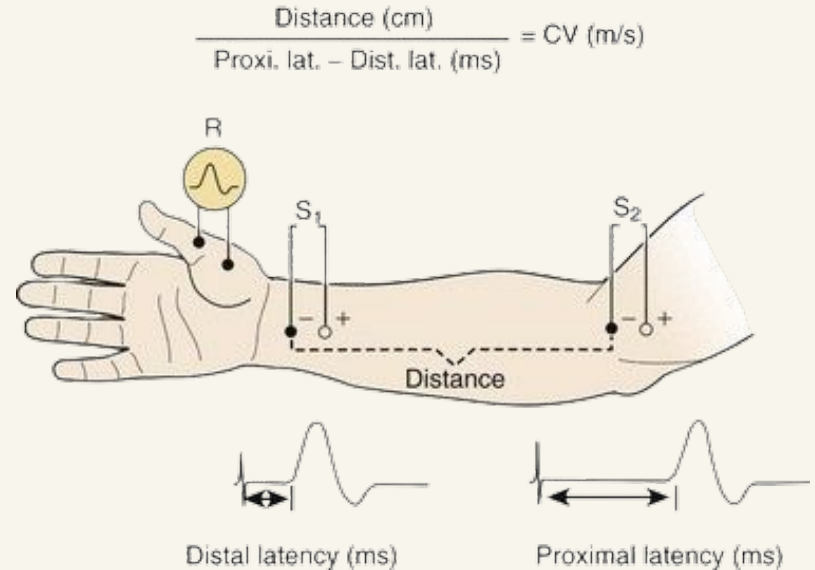
- Cranial Nerve X. within the Autonomous Division of the Nervous System
- Essential Component of the Sympathetic and Parasympathetic Involuntary Reflexes
- Longest Peripheral Nerve in the Body, Extends from Brainstem to Vital Abdominal Organs via the Spinal Cord:
 - *Heart*
 - *Lungs*
 - *Liver*
 - *Digestive Tract*



<https://myacare.com/blog/the-vagus-nerve-what-is-it-and-what-issues-affect-it>

ElectroNeuroGram (ENG)

- Diagnostic Technique for Understanding Neural Health with Clinical Applications:
 - *Assessing Nerve and Muscle Function*
 - *Characterizing Neurological Disorders*
 - *Monitoring Nerve Regeneration*
- Involves Applying a Short Stimulus of 100V and Recording the Action Potential
- Measured from Peripheral Nerves using either Surface, Cuff or Needle Electrodes



<https://clinicalgate.com/the-electrodiagnostic-examination/>

Section 02:

Project Goal

Research Question & Hypothesis



Research Question:

- (1). What quantifiable effect does Multiple Sclerosis (MS) have on the vagus cranial nerve?
- (2). How can this be harnessed using clinical methods in neurophysiology such as an electroneurogram (ENG) to fully characterize the disease progression?



Null Hypothesis:

- (1). The effect of Multiple Sclerosis (MS) on the vagus cranial nerve can be sufficiently quantified.
- (2). Relevant clinical methods in neurophysiology such as an electroneurogram (ENG) can be implemented to fully characterize the disease progression.

Section 03:

Research Timeline

Progression of Technological Developments

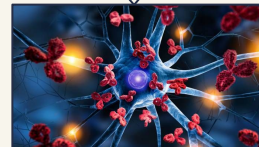
<https://www.news-medical.net/health/Relapsing-Remitting-Multiple-Sclerosis-Diagnosis.aspx>

<https://www.qps.com/2020/07/15/new-research-neurofilament-light-chain-is-a-biomarker-with-high-translational-value/>

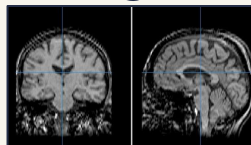
1940s - The Lumbar Puncture Procedure was Established to Assess Cerebrospinal Fluid for MS Symptoms by Elvin Kabat



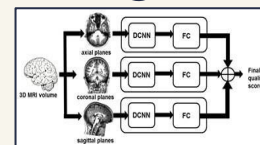
1990s - Neurofilament Light Assaying was Developed as a Biomarker of Neuronal Damage by Karlsson and Rosengren



1860s - First Attempt to Treat Multiple Sclerosis with Electrical Stimulation and Aphrodisiacs by French Neurologist Jean Charcot



1980s - First Pictures of the Brain are Generated from Magnetic Resonance Imaging (MRI) to Positively Diagnose MS



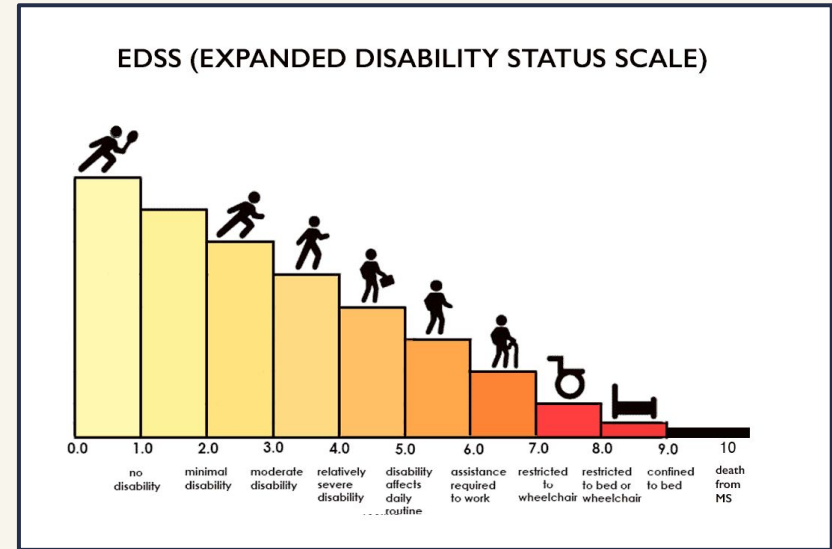
2010s - Artificial Intelligence Tools like Bayesian Networks are Implemented to Segment Lesions in the Brain with MS

Section 04:

Current Landscape

Ability Based Measurement Methods

- Kurtzke Expanded Disability Status Scale
 - 1 - 10 Rating Based on 8 Functional System Scores
- Neurostatus, Multiple Sclerosis Functional Composite, Self Reported Quality of Life
- Common Issues
 - Evaluator Dependent
 - No “Gold Standard” Test
 - Bias Towards Certain Abilities
 - Ambiguous Definition Functional Systems



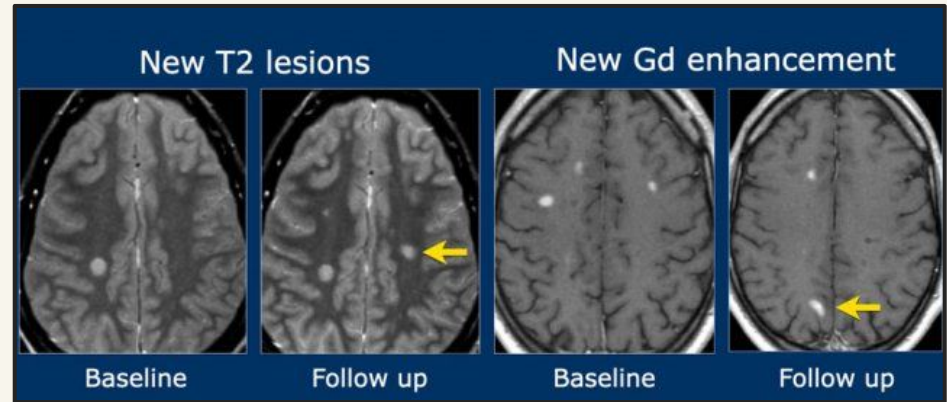
<https://www.hsctstopsms.com/hsct-for-ms/edss-scale/>

Pathophysiological Progression Methods

- Features Associated with MS are used to Gauge Disease Progression
 - Demyelination, Inflammation
- Key Features for Different Stages of MS Progression
 - Relapsing MS: Plaques of Active Demyelination
- Common Issues
 - Difference in MS Attributes between Patients
 - Individual Heterogeneity is not Guaranteed
 - Time Dependent

Pathophysiological Progression Methods

- Use of Biomarkers to Characterize Disease State
- Molecules that Appear in the Blood at Different Stages of MS
- Ex: T2 Biomarker to Determine Topography of Lesions on Spinal Cord



<https://radiologyassistant.nl/neuroradiology/multiple-sclerosis/diagnosis-and-differential-diagnosis-3>

Key Takeaway #1.

**“No reliable, universal
method to track MS
progression”**

MS, The Vagus Nerve, & ENG

- Using Ultrasonography to Image the Vagus Nerve and Diagnose MS
 - There is a Well-Researched Connection between MS and the Vagus Nerve
- ENG is an Industry Standard Technique to Stimulate the Vagus Nerve for Epilepsy
 - Vagus Nerve can be Interfaced with Using ENG
- Induced Seizures were Detected based on ENG Data from Vagus Nerve in Rats
 - ENG may be able to Detect Changes in the State of the Vagus Nerve in Humans

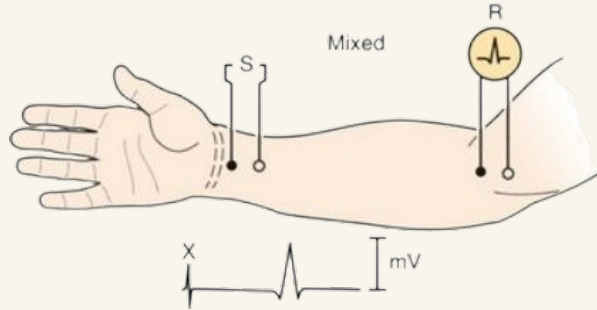
Key Takeaway #2.

“ENG has not been used to detect vagus nerve signals in the context of MS”

Section 05:

Proposed Solution

Proof-of-Concept for Clinical Applications



<https://clinicalgate.com/the-electrodiagnostic-examination/>



<https://www.wpiinc.com/nce-nerve-cuff-electrodes.html?sg=D&source=editors&ust=1709930503129777&u sg=AOvVaw0G4pJ810RQQRIRe2ibTOL>

- Cuff Electrodes are Attached to the Vagus Nerve Bundles
 - Stimulates and Records Impulses of the Peripheral Nerve
- Listens from 2 Separate Points
 - S1 and S2
 - Nerve Health can be Estimated by Comparing its Latency to a Healthy One

Proof-of-Concept for Clinical Applications

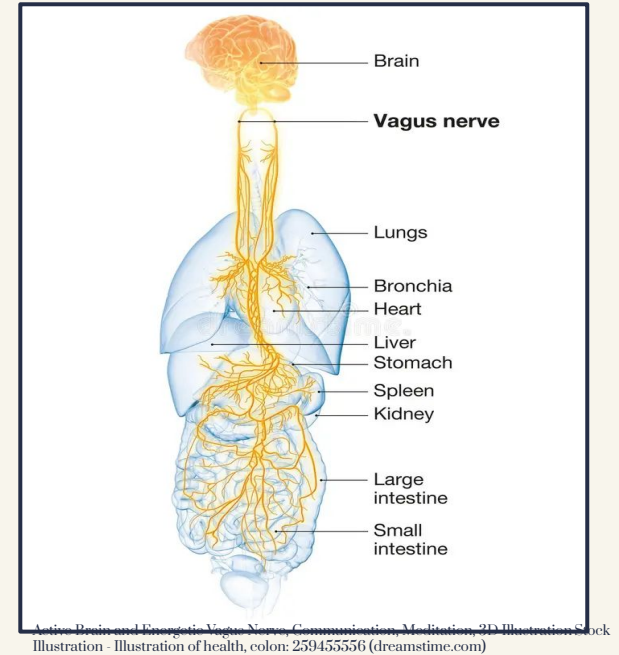
- For Diagnostic Purposes, Being Able to Isolate Nerve Fibres is Beneficial:
 - Beamforming (BF)
 - Increase SNR, Direct Signal to Location - Allows for Identification of Clusters of Nerve Fibres
 - Discriminative Field Potential
 - Used to Calibrate Beamforming Process
 - Identifies Difference between Physiological Condition (Muscle Contracted vs Relaxed)
 - Discrimination Index Calculated

Section 06:

Limitations

Shortfalls of the Technical Design

- Nerves are Difficult to Completely Isolate
 - Interference from Surrounding Nerve Impulses
- The VN Spans a Large Portion of the Body
 - Difficult to Isolate Signals in Larger Distances
 - Limited to Measuring Shorter Segments
- The VN Sits Deep within the Body
 - Invasive Approach is Required



Section 07:

Future Work

Potential Areas for Improvement

- Minimally Invasive Procedures
 - Laparoscopic Instruments
 - AI/Robotics
- Improved Signal Isolation
- Increased Safety and Access to Different Regions of the VN



<http://drjuimandke.com/minimally-invasive-surgery/>

Conclusion

Multiple Sclerosis (MS) is a neurodegenerative disease that can potentially be characterized and diagnosed by the neuromodulation technique of **ElectroNeuroGram (ENG)** although questions about its invasiveness and efficacy need to be adequately addressed to ensure effective implementation within clinical settings.

Section 08:

References

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Thank You!
