

# Neuropathy Simulation : Natural Language Processing

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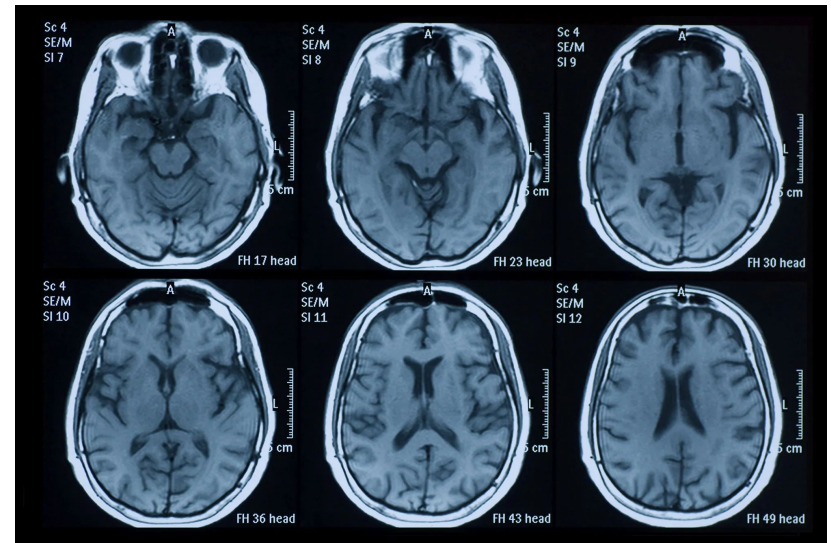
# Traumatic Brain Injury: Defining the Problem



- Traumatic Brain Injury (TBI) is an alteration in brain function caused by an external force
- Diagnosed with neurological examinations in conjunction with radiology
- Majority of graduating medical students uncomfortable performing neurological examinations due to:
  - Lack of clinical exposure
  - Lack of practice <sup>(1)</sup>

# Traumatic Brain Injury: Defining the Problem

- Over-reliance on radiology
  - No significant correlation between CT / MRI abnormalities and TBI severity <sup>(2,3,4)</sup>
- TBI misdiagnostic rate
  - Up to 56% for mild TBI
  - <sup>(5)</sup> Up to 51% for severe TBI <sup>(6)</sup>



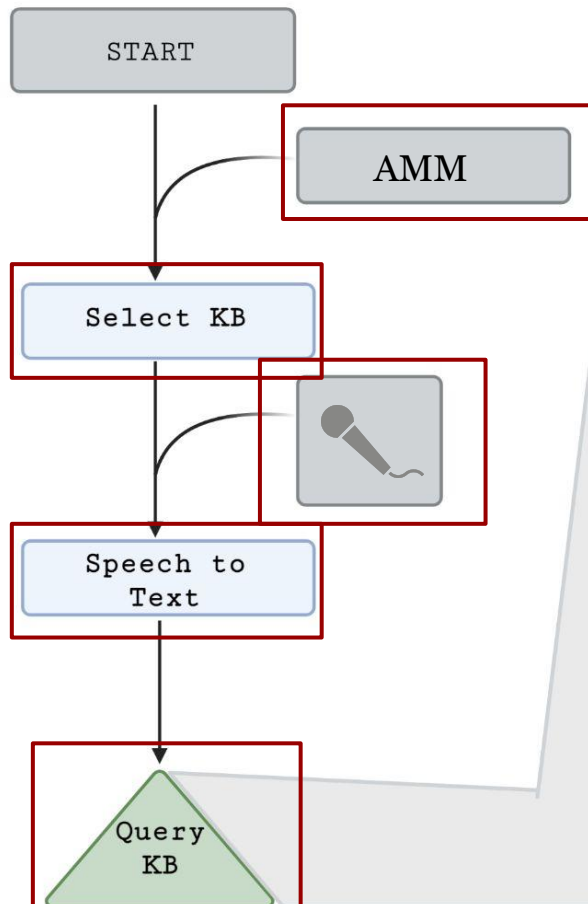
# Project Goal / Deliverables

**Goal :** *Increase physician competence performing neurological examinations by establishing interactive natural language processing capabilities specific to neuropathies in a medical training manikin by UW CREST (Advanced Modular Manikin).*

## **Deliverables :**

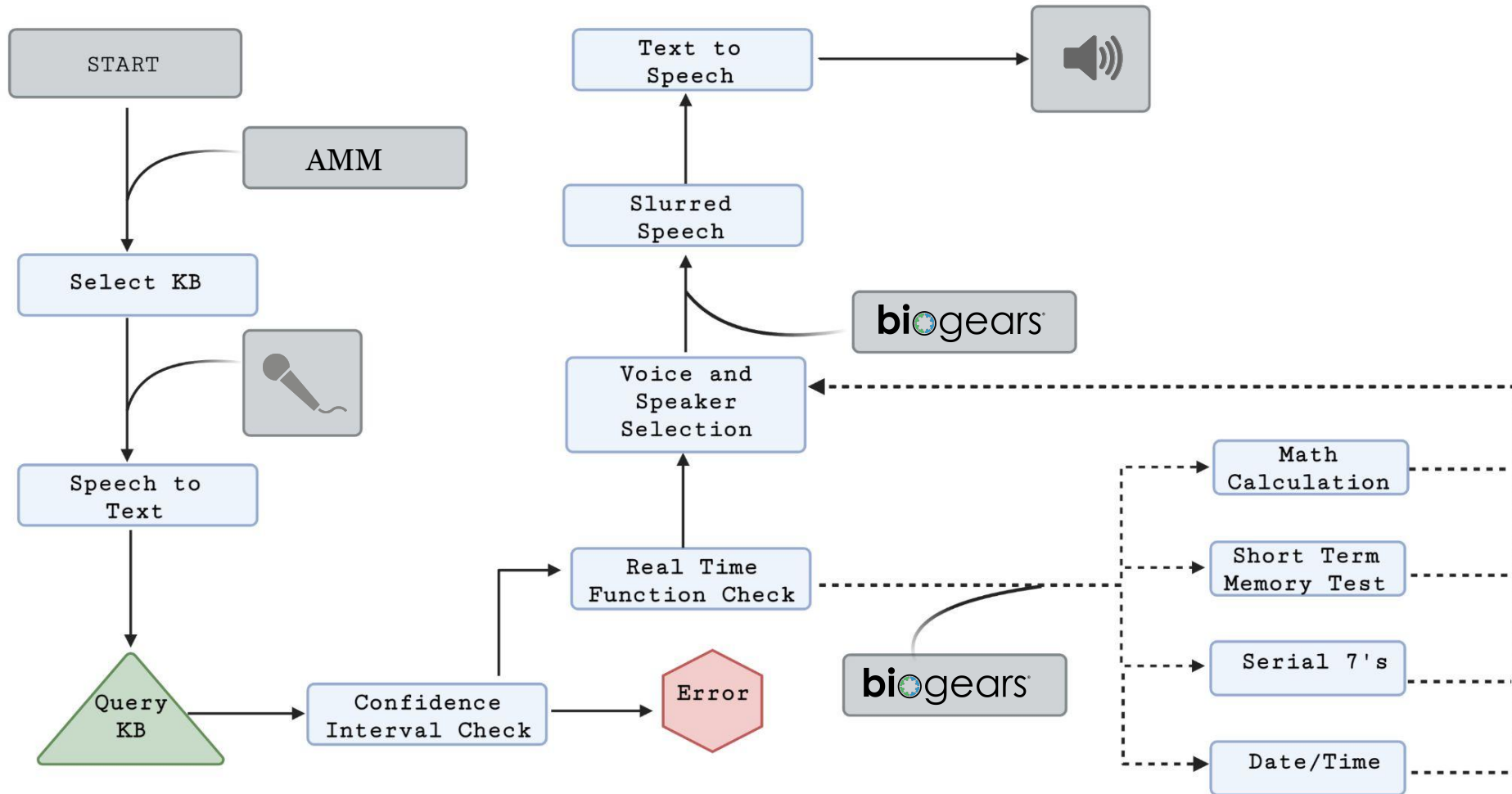
- Natural Language Processing Program
- Neuropathy-specific simulation capabilities

# Natural Language Processing Program

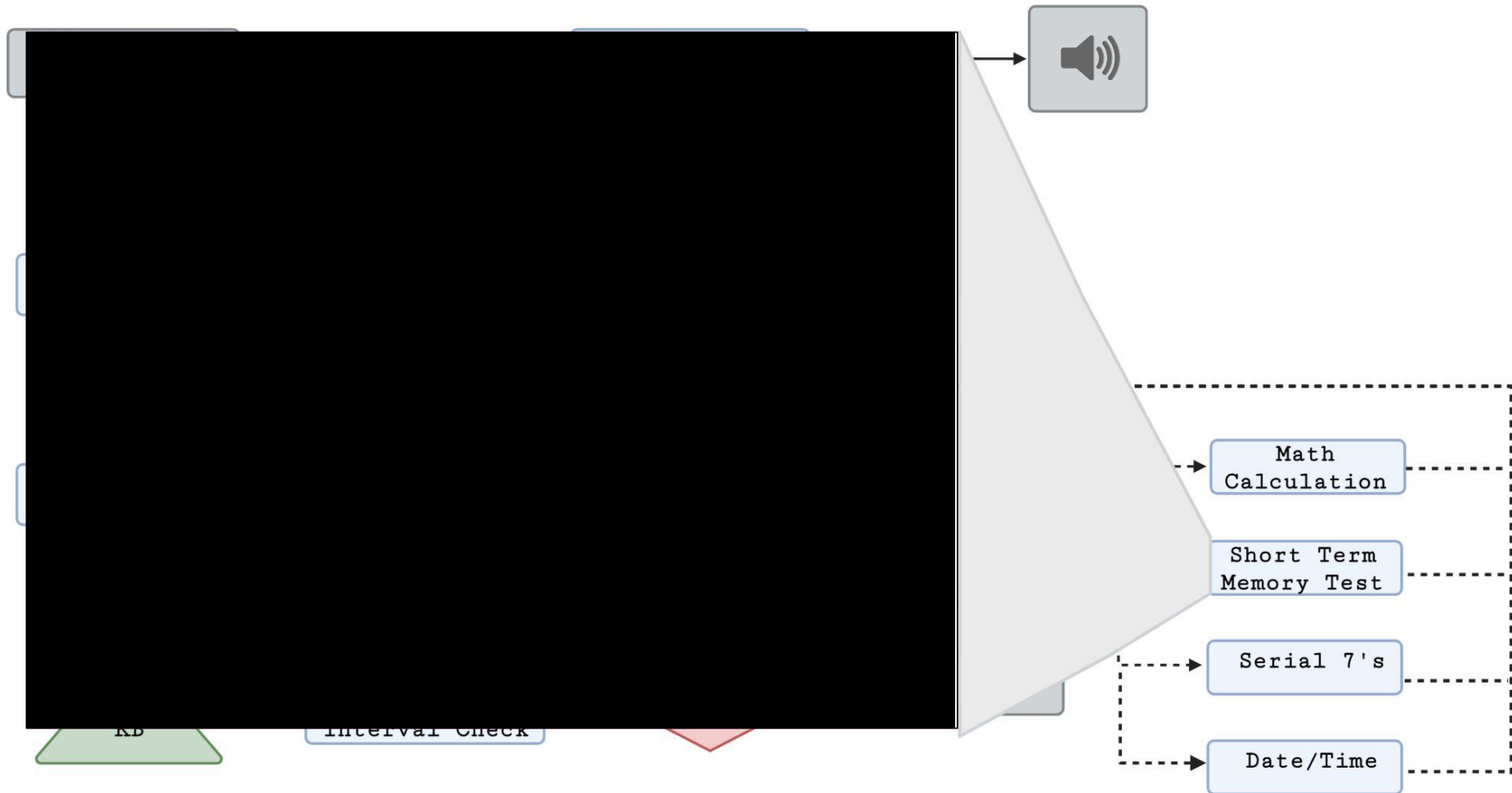


<u>Question</u>	<u>Answer</u>
When did your symptoms begin?	.....
Do you know where you are right now?	.....
How are you feeling?	.....
Please remember the following words:	.....

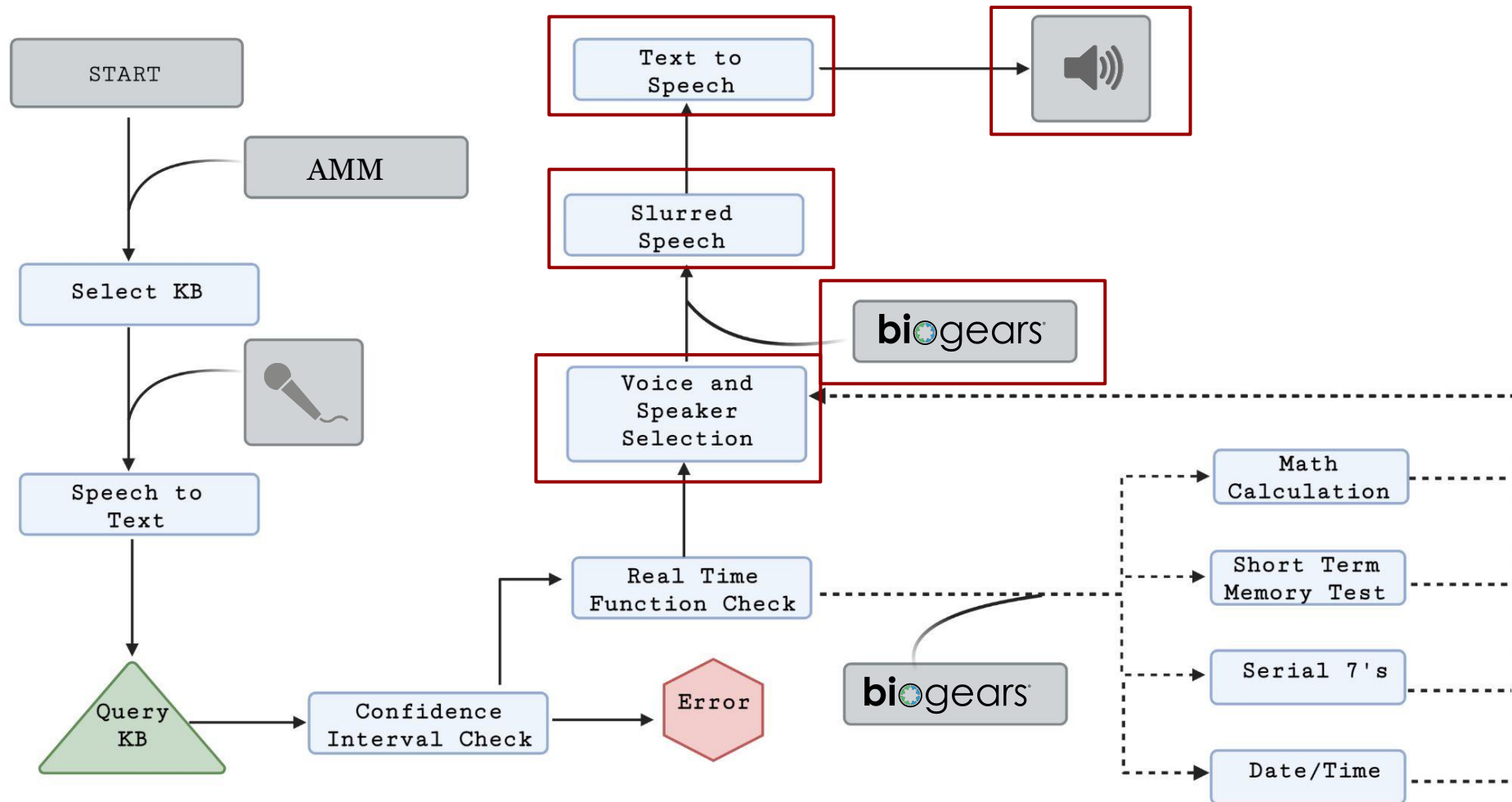
# Natural Language Processing Program



# Natural Language Processing Program

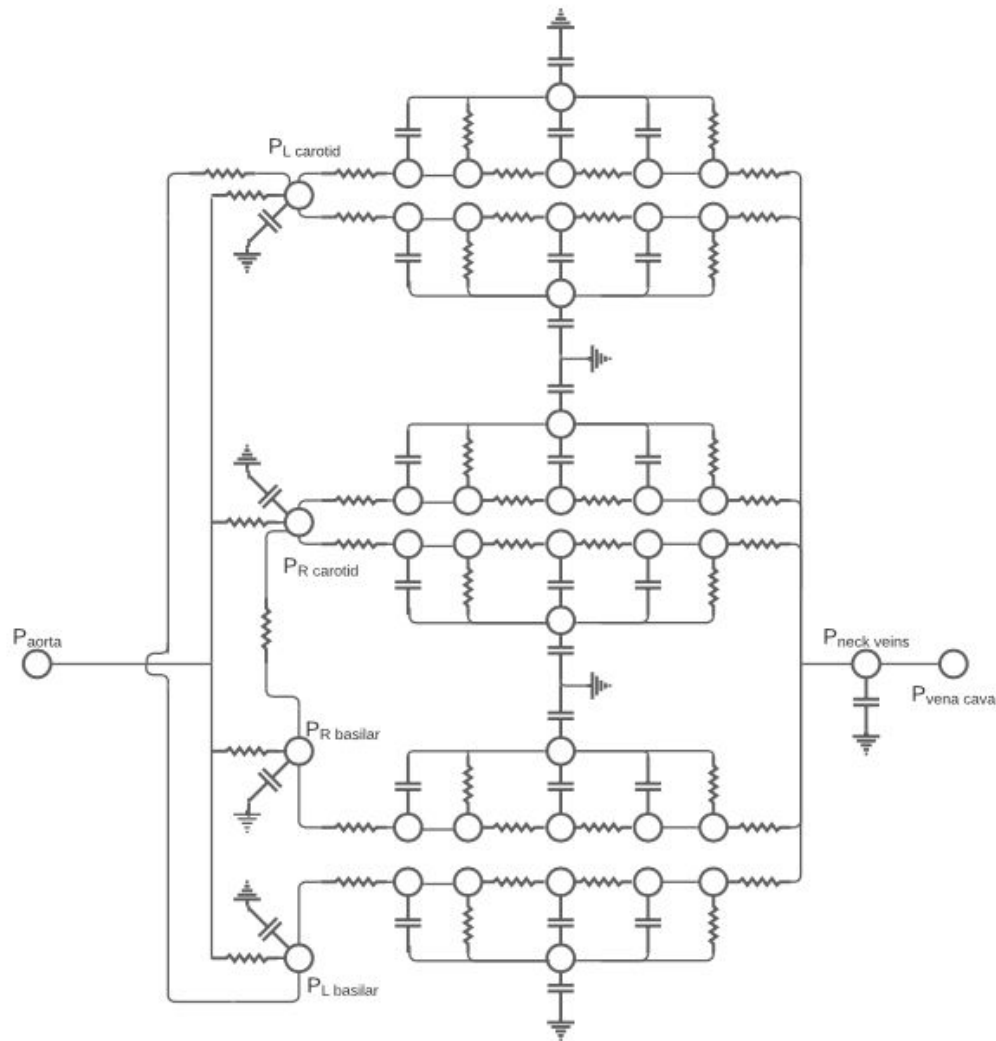


# Natural Language Processing Program

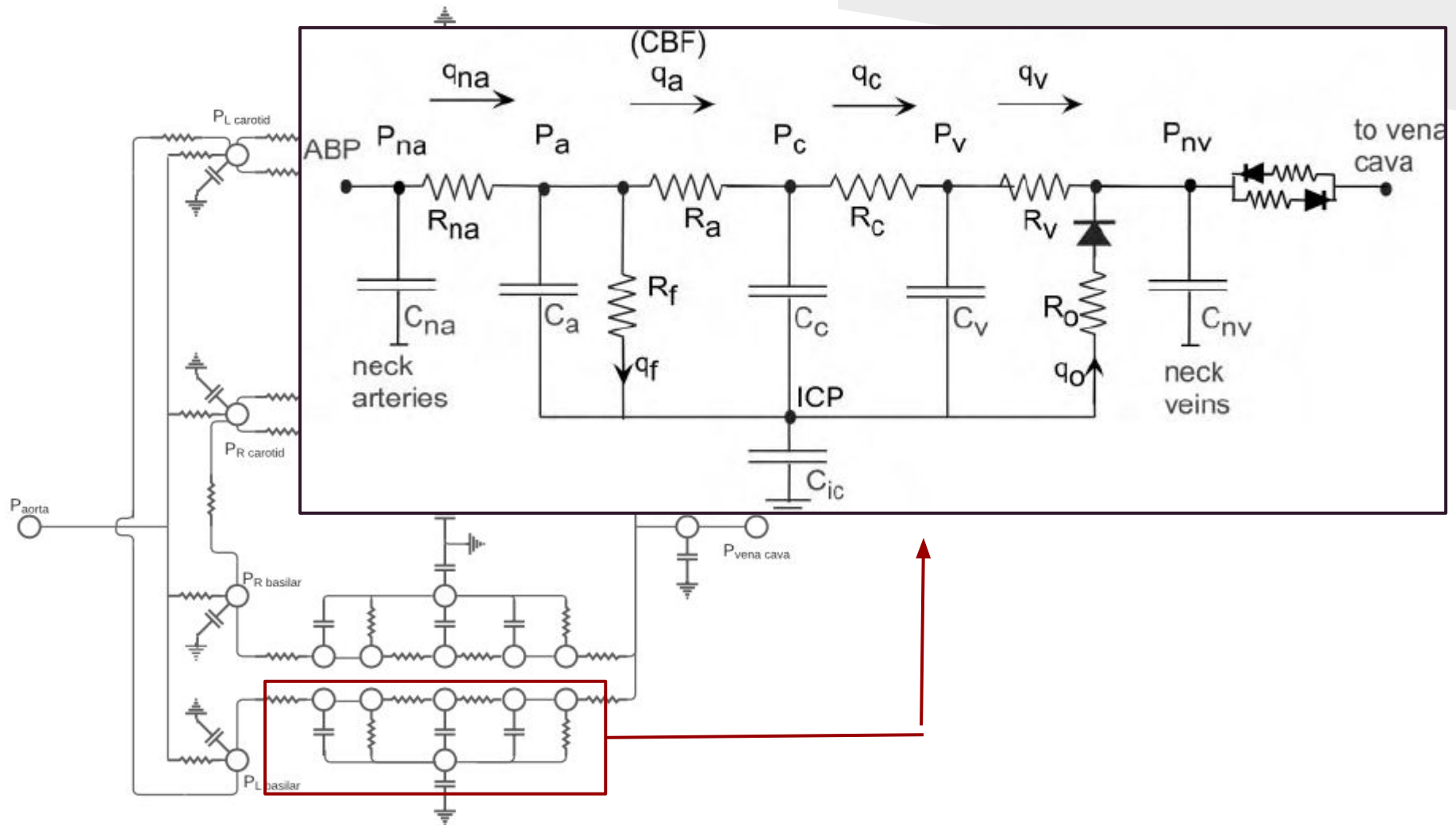




# Advanced Cerebral Circuit



# Advanced Cerebral Circuit



# Usability Design Elements

Medical Personnel,  
Students

Programmers,  
Software Developers,  
Engineers

# Usability Design Elements

- Basic console interface for adding, deleting, or altering knowledge bases

```
Welcome to the Knowledge Base Manager. The following knowledge bases exist:
```

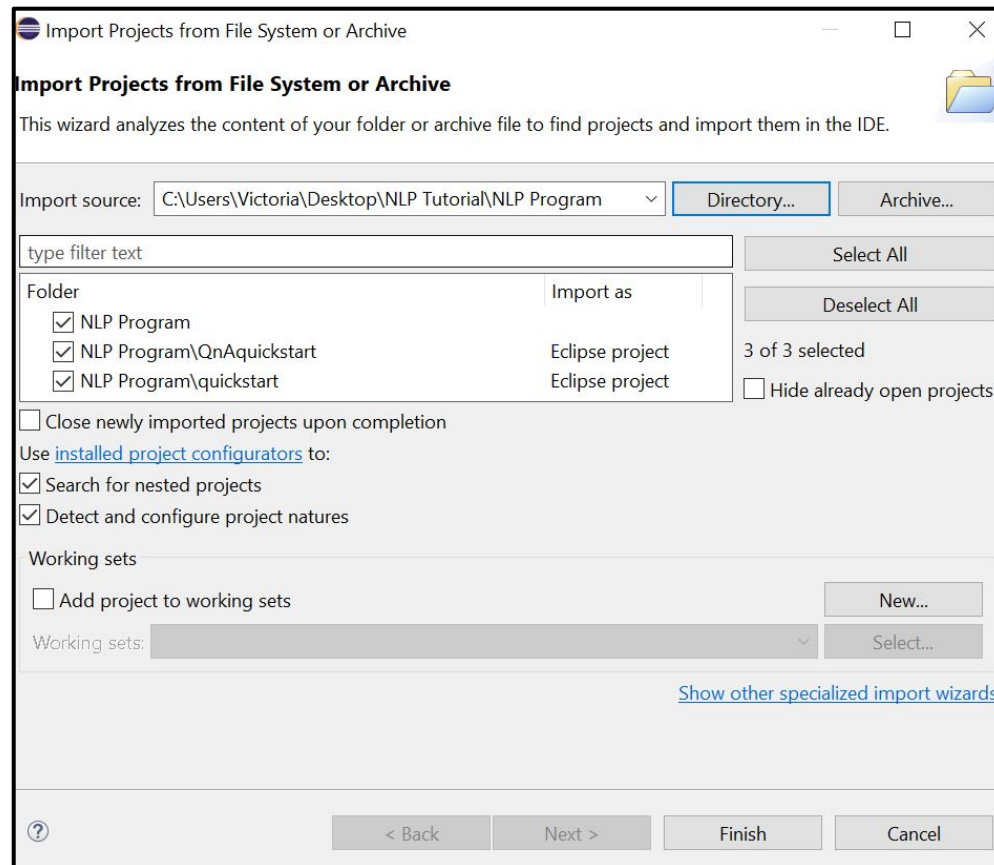
Name:	Knowledge Base ID String:
Right Parietal Stroke Patient	4b65e5d7-f218-4c32-88a7-e225d89abcca
Healthy Patient	7576efa7-985b-40b0-8de7-d694e8cf8409
Practice Healthy Patient	7be066cc-2c48-42c2-b6c5-e66c6103e2d1
Sepsis Patient	94a5387f-f2a5-4a96-8f7b-9af8034761bc
Left Parietal Stroke Patient	a4f57396-e1a5-4704-8c44-6dab18949d44
Occipital Stroke Patient	e7dc1d06-f0c8-4706-aada-d8ae59ec3136

```
Enter the number of the operation you would like to perform, or 0 to quit:
```

1. Create .xlsx file summary of an existing knowledge base.
2. Update an existing knowledge base.
3. Create new knowledge base.
4. Delete a knowledge base.

# Usability Design Elements

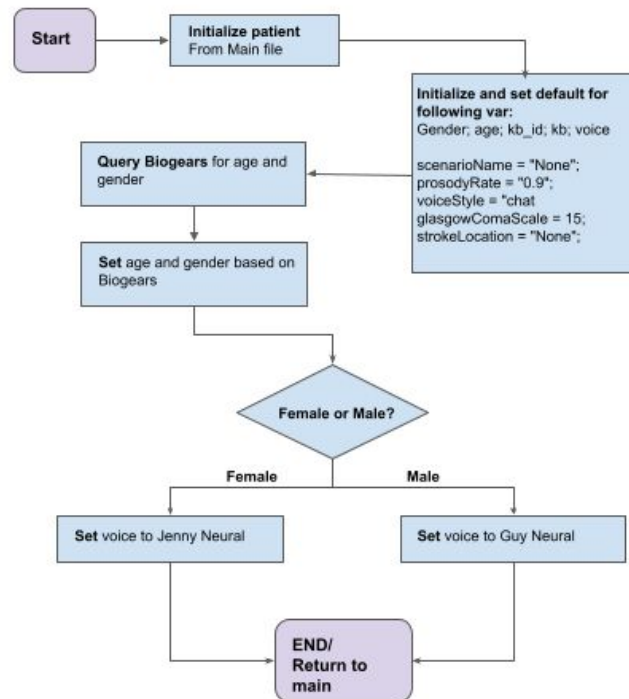
- Visual graphics instructional file as optional download



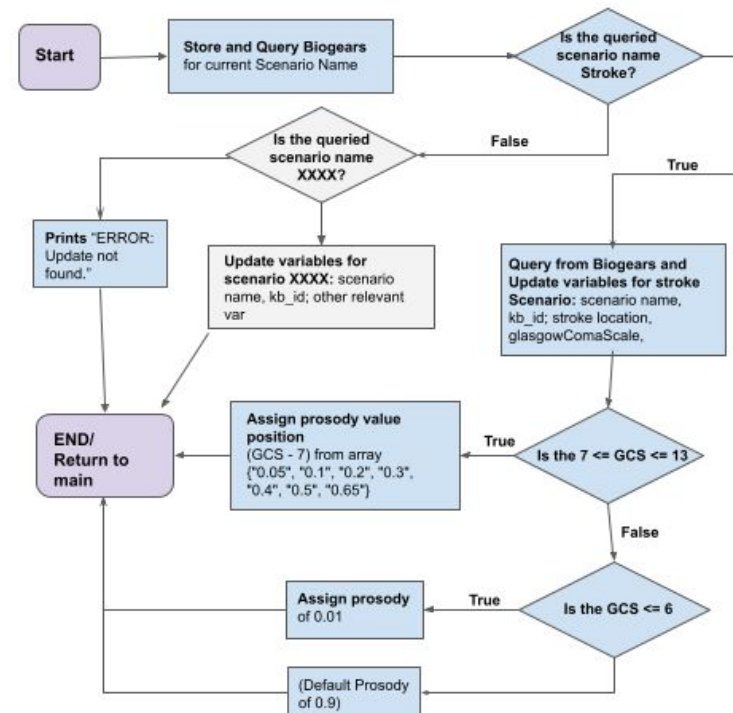
# Usability Design Elements

- Visual graphics instructional file as optional download

Patient Constructor Initialization (1st time)



Patient Update Function



# Usability Design Elements

- Instructional file included in program download package
  - Summary of program & functions
  - Types of variable inputs and outputs available
  - Program dependencies
  - 'How-to' instructions
- Commented Code
- Streamline code editing process

# Measurements for Success



**Accuracy**



**Usability**



**Authenticity**



# Numbers to Meet

**90%**

Intent & Query  
Correctness

**90%**

Student and Software  
Engineer Task Completion

**< 3 seconds**

Response Time

**90%**

Neurologist Content  
Satisfaction

# Program Accuracy - Summary

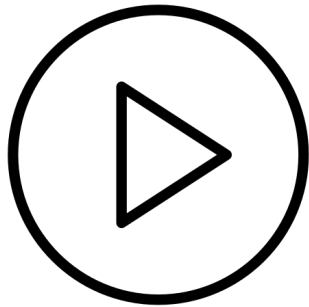
## *Correct Response Frequency (CRF)*

	<b>Verbatim KB Questions</b>	<b>Synonymous KB Questions</b>	<b>Non-KB Questions</b>	<b>Overall</b>
<b>Average CRF</b>	100%	92%	93%	95%

## *Response Time*

	<b>Trial 1</b>	<b>Trial 2</b>	<b>Trial 3</b>	<b>Overall</b>
<b>Average Response Time (s)</b>	2.732	2.854	2.814	2.800

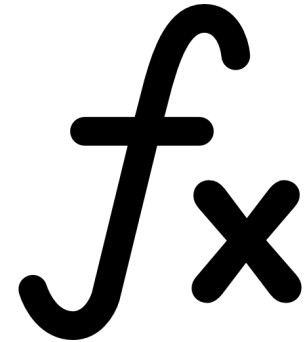
# Student Usability Study: Defining Tasks



Run NLP  
Program

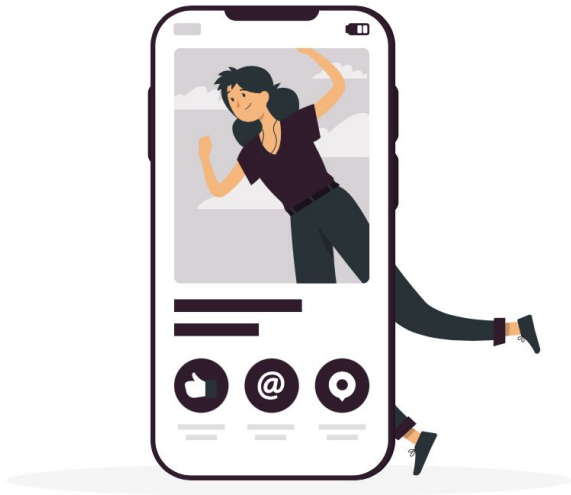


Add new  
Knowledge Base

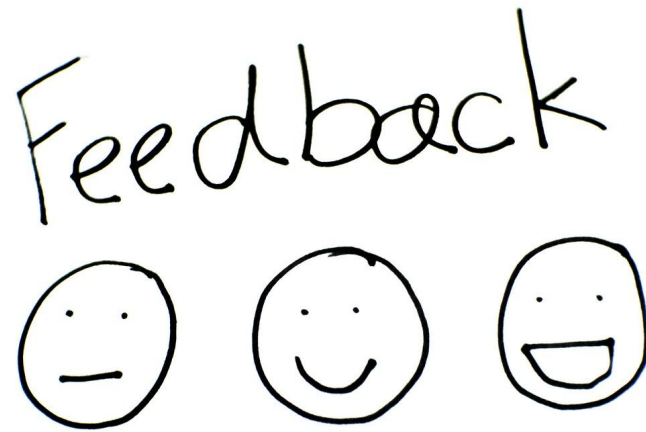


Add a new  
Function

# Results - Student Usability Study

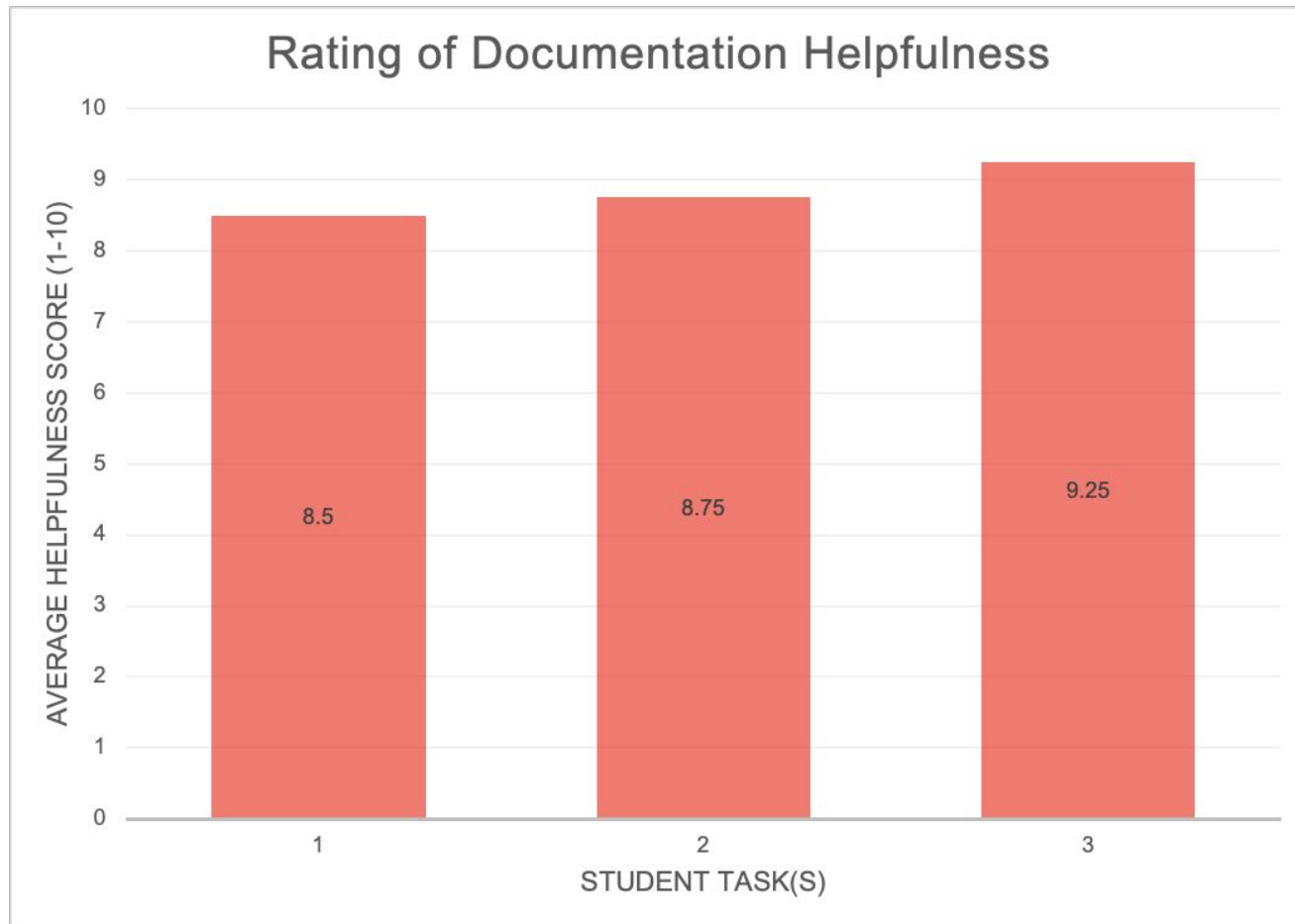


User Profile



User Feedback

# Results - Student Usability Study



# Ongoing Testing - SE and Neurologist

## Usability - Software Engineers (SE)

- Assess and provide feedback for NLP program
- Tasks: Program set-up, knowledge bases, and function alterations, etc.

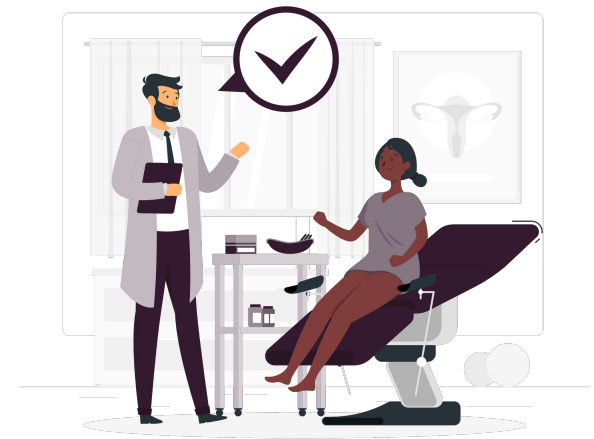
## Authenticity - Clinical Validation

- Assess and provide feedback for response content
- Task: Diagnose different stroke locations and GCS from simulated patient interaction



# Future Works

- Feedback from usability study
- Expand the current questions and answers
- Addition of dynamic functions
- Addition of more scenarios
- Adapt patient response with more than one scenario
- And more...



# Acknowledgements

Thank you to David Hananel, Alex Gong, Austin Baird, Doug Raum, Chris Neils, Alyssa Taylor, and 405 class for your continuous support!





# References

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<https://doi.org/10.1212/WNL.0b013e3181a92be6>
- (2) Goldberg, Charlie. (2018). Practical Guide to Clinical Medicine: A comprehensive physical examination and clinical education site for medical students and other health care professionals. UCSD School of Medicine.
- (3) Dikmen, S., Machamer, J., & Temkin, N. (2017). Mild Traumatic Brain Injury: Longitudinal Study of Cognition, Functional Status, and Post-Traumatic Symptoms. *Journal of neurotrauma*, 34(8), 1524–1530. <https://doi.org/10.1089/neu.2016.4618>
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- (5) Jacobs, B., Beems, T., Stulemeijer, M., van Vugt, A. B., van der Vliet, T. M., Borm, G. F., & Vos, P. E. (2010). Outcome prediction in mild traumatic brain injury: age and clinical variables are stronger predictors than CT abnormalities. *Journal of neurotrauma*, 27(4), 655–668.
- (6) Powell JM, Ferraro JV, Dikmen SS, Temkin NR, Bell KR. Accuracy of mild traumatic brain injury diagnosis. *Arch Phys Med Rehabil*. 2008 Aug;89(8):1550-5. doi: 10.1016/j.apmr.2007.12.035. Epub 2008 Jul 2. PMID: 18597735

Questions?

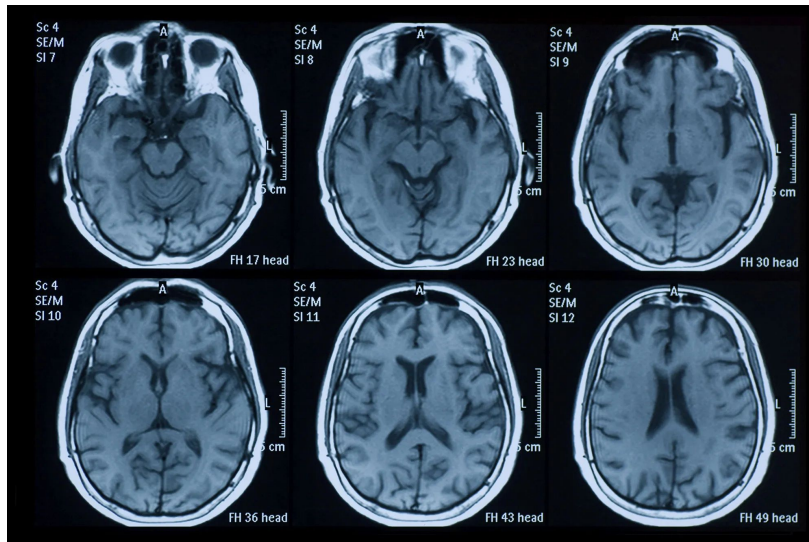
# Appendix

# Traumatic Brain Injury: Defining the Problem





- Traumatic Brain Injury (TBI) is an alteration in brain function caused by an external force
- TBI is considered the **leading cause of death** and disability among children and young adults in the United States
- The average cost of medical malpractice is **\$668,000 per case** with annual costs ranging from \$1.56 billion to \$5.6 billion

# Current Diagnostic Methods

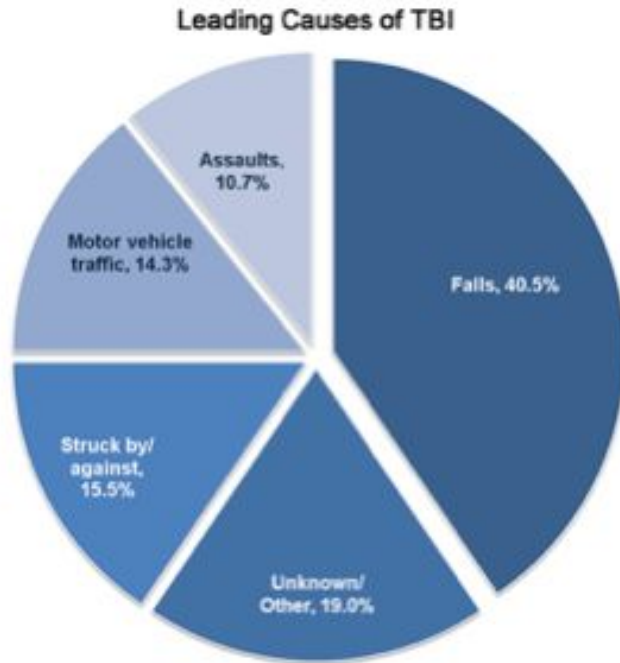


## Glasgow Coma Scale

EYE OPENING		VERBAL RESPONSE		MOTOR RESPONSE	
					
Spontaneous	> 4	Orientated	> 5	Obey commands	> 6
To sound	> 3	Confused	> 4	Localising	> 5
To pressure	> 2	Words	> 3	Normal flexion	> 4
None	> 1	Sounds	> 2	Abnormal flexion	> 3
		None	> 1	Extension	> 2
				None	> 1
GLASGOW COMA SCALE SCORE					
Mild		Moderate		Severe	
13-15		9-12		3-8	

- Imaging Tests: Computerized Tomography (CT), Magnetic Resonance Imaging (MRI)
- Nerve Function Test
- Blood tests
- Glasgow Coma Scale
- Speech and language tests

# Medical Errors + TBI



- Misdiagnosis
  - Approximately **12 million people** in the U.S. seeking outpatient medical care experience some form of diagnostic error
  - Fifty-six percent of mild TBI cases identified by study personnel did not have a documented mild TBI-related diagnosis in the ED record.
- Associated cost
  - The average cost of medical malpractice is \$668,000 per case with annual costs ranging from \$1.56 billion to \$5.6 billion

# Ongoing Testing - Program Accuracy

- **Average Response Time**
- **Methodology:**
  - Ask a set of 20 randomized verbatim questions
  - Set timer in program
    - Start: Question received
    - End: Response begins
    - Print times

$$t = \sum T / N$$

t = Average time per response

T = time for response

N = 20 questions

# Ongoing Testing - Program Accuracy

- **Methodology:**
  - Ask a set of 20 questions and calculate CRP%
- **Categories**
  - Verbatim Questions (Baseline)
  - Synonymous Questions
  - Random Questions

$$\text{CRP \%} = \text{C} / \text{N} \times 100\%$$

C = Number of Correct Response  
N = 20 questions



# Planned Assessment

Usability - SE	Authenticity - Neurologist
<ul style="list-style-type: none"><li>● Percentage of task completion</li><li>● Mean ratings and standard deviation for documentation clarity</li><li>● Number of reported errors</li></ul>	<ul style="list-style-type: none"><li>● Percentage of error of diagnosed GCS</li><li>● Percentage of correct stroke location diagnosis</li><li>● Bernoulli trial for expected error question</li></ul>
<ul style="list-style-type: none"><li>● Summary of future improvements and errors</li></ul>	