Quantifying Bradykinesia in Patients Undergoing Deep Brain Stimulation Surgery

Dominique Dang

July 30, 2021

DukeREP Final Presentation

Agenda

01 Introduction

02 Methodology

03 Results

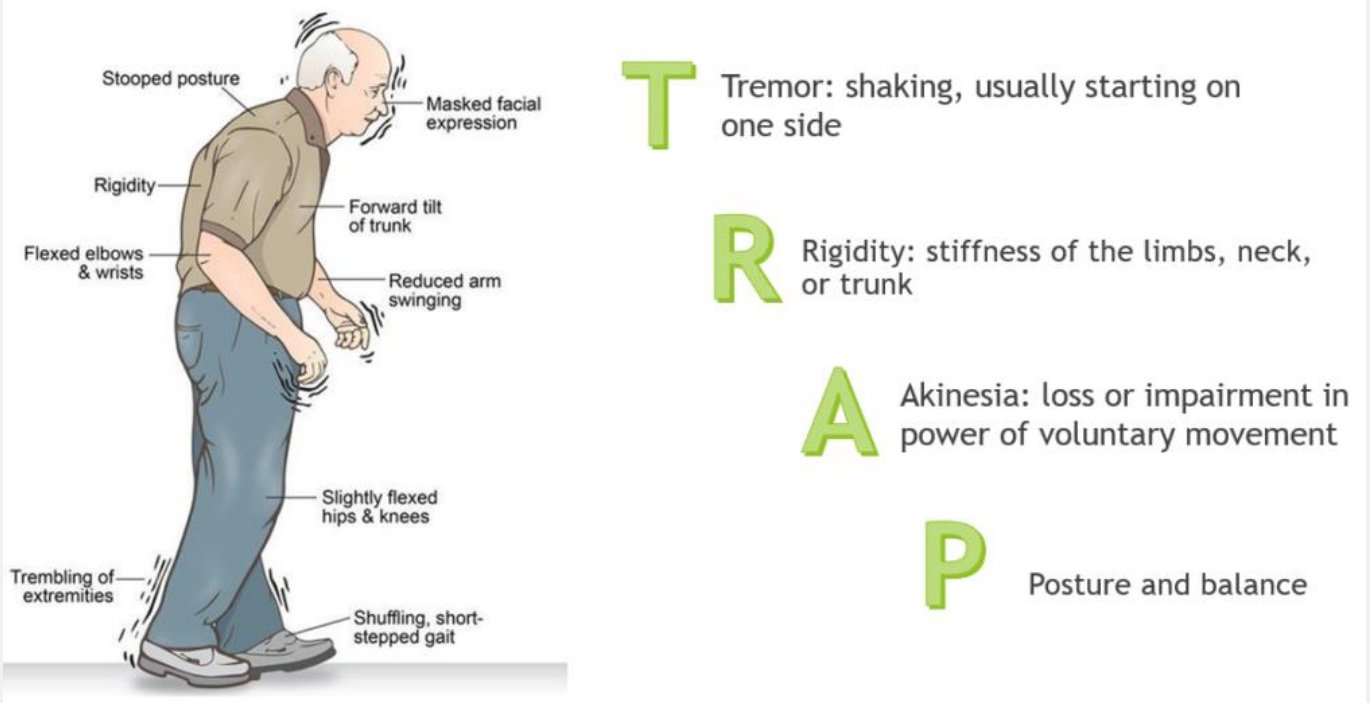
04 Next Steps

05 Conclusion

Agenda

Parkinson's Disease

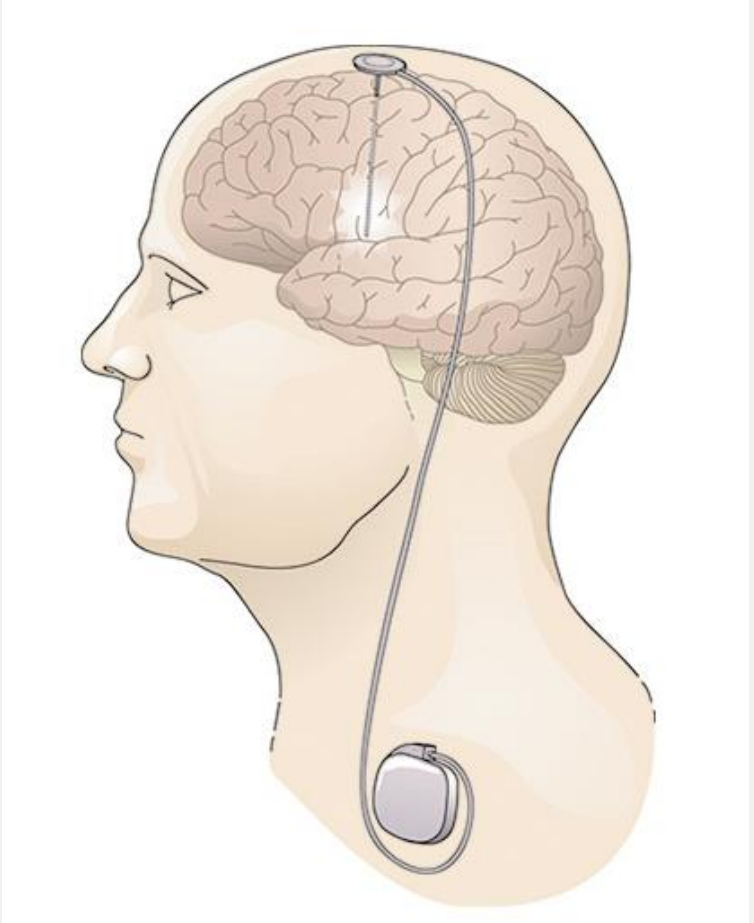
- Neurodegenerative disease of the basal ganglia
- The neurotransmitter, dopamine, is not produced in the brain which leads to symptoms of:
  - Tremor
  - Rigidity
  - Akinesia & Bradykinesia
  - Postural instability



parkinsonsnebraska.org/understanding-parkinsons-disease/

Deep Brain Stimulation (DBS)

- Delivering high frequency stimulation pulses inside the brain
- DBS lessens motor symptoms of stiffness, slowness, and tremor but not gait, imbalance, and other non-motor symptoms
- During the DBS surgery, patients' motor symptoms are tested for efficacy



https://www.ninds.nih.gov/About-NINDS/Impact/NINDS-Contributions-Approved-Therapies/DBS

Agenda

01 Introduction

02 Methodology

03 Results

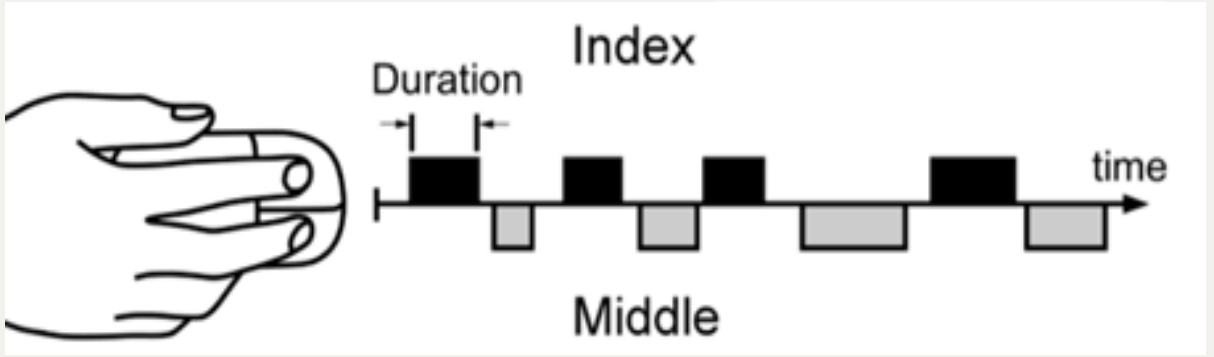
04 Next Steps

05 Conclusion

Methodology & Variables

Score Calculation for 15 datasets:

- Higher the score: worse clicking trial → more bradykinesia
- Lower the score: better clicking trial → less bradykinesia

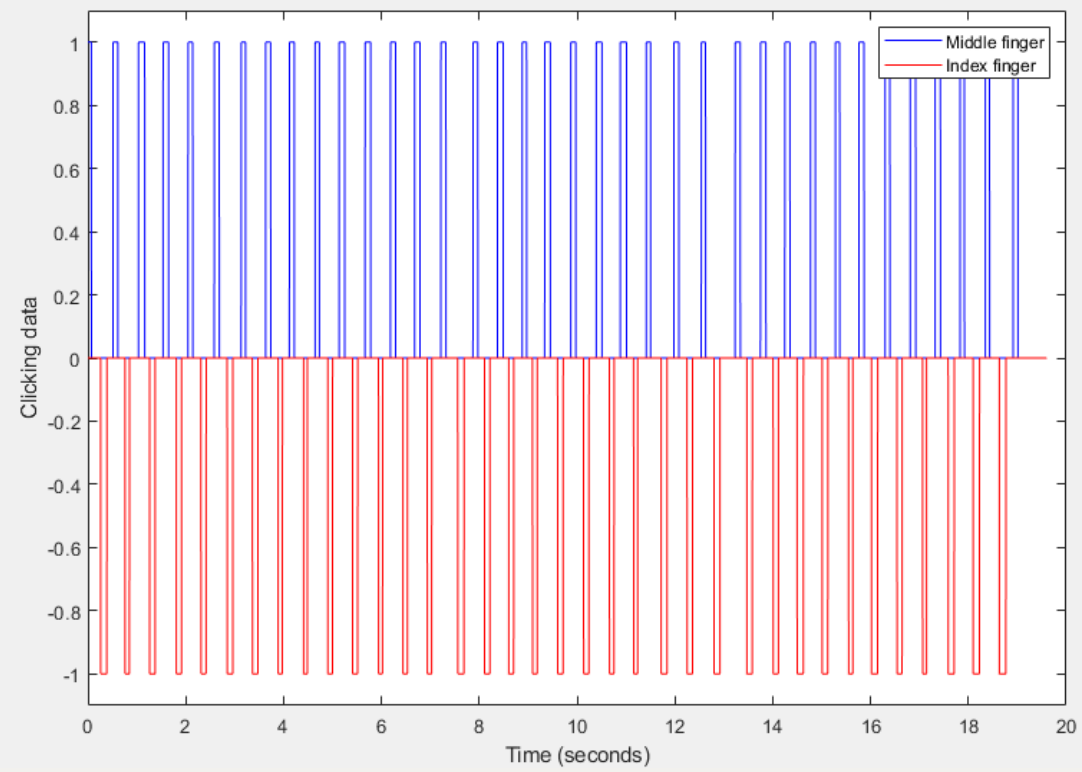


DukeREP Module 1 Kay Palopoli

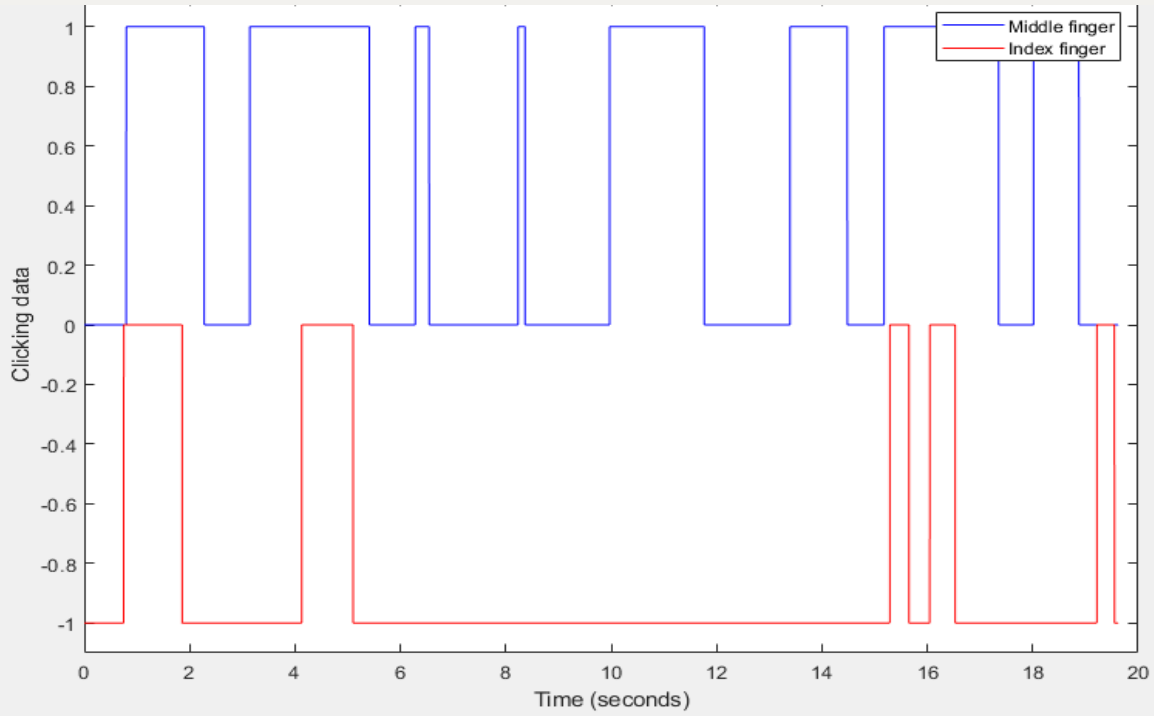
Score Factors:

- Click variation: measuring the relative dispersion of data points around the mean
  - Higher click variation: worse clicking trial → more bradykinesia
  - Lower click variation: better clicking trial → less bradykinesia
- Clicks per second: measuring the speed of the clicks (will subtract this value)
  - Higher clicks per second: better clicking trial → less bradykinesia
  - Lower clicks per second: worse clicking trial → more bradykinesia

Hypothesis



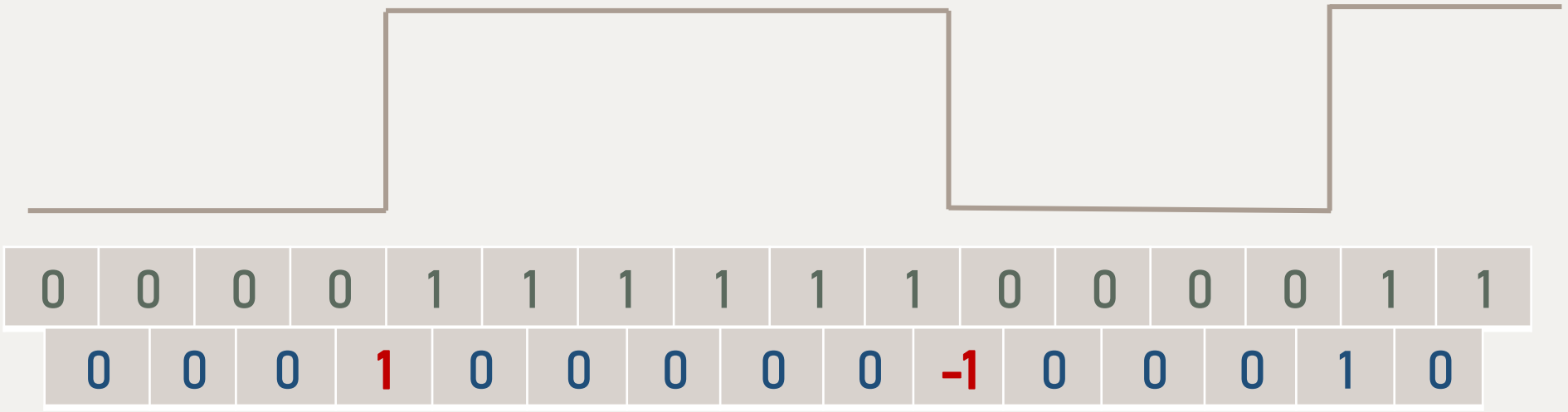
Dataset 3



Dataset 6

- Dataset 3 has the most steady clicks and the most clicks → less bradykinesia
- Dataset 6 is not as regular nor as fast as Dataset 3 → more bradykinesia

Measuring Click Variation



$$Click\ variation = \frac{standard\ deviation\ (durations)}{mean\ (durations)}$$

Equations & Code Example

$$bradykinesia\ score = (middle\ finger\ CV + index\ finger\ CV) - (middle\ finger\ CPS + index\ finger\ CPS)$$

```
x = [];
y = [];
cpsGraph = [];
scores = [];

for i = 1:15
    fileName = "clicking_dataset_" + i + ".mat";
    totalMClicks = 0;
    totalIClicks = 0;
    indivScore = 0;
    load(fileName)
    x = [x i];

    time = data.time;
    middle = data.middle;
    index = data.index;

    differenceM = diff(middle);
    durationMiddle = [];
    durationMStart = 0;
    durationMEnd = 0;

    for t = 1:(length(differenceM))
        if (differenceM(t)) > 0
            %difference is > 0, the start of the patient pressing the mouse
            durationMStart = time(t);
        end
        if (differenceM(t)) < 0
            %difference is < 0, the end of the patient pressing the mouse
            durationMEnd = time(t);
            durationMiddle = [durationMiddle, (durationMEnd - durationMStart)];
            totalMClicks = totalMClicks + 1;
        end
    end

    %calculating variation for middle finger click
    middleSTD = std(durationMiddle);
    middleMean = mean(durationMiddle);
    middleVariation = (middleSTD/middleMean);


    %start of Index finger calculations
    differenceI = diff(index);
    durationIndex = [];
    durationIStart = 0;
    durationIEnd = 0;

    for d = 1:(length(differenceI))
        if (differenceI(d)) > 0
            %difference is > 0, the start of the patient pressing the mouse
            durationIStart = time(d);
        end
        if (differenceI(d)) < 0
            %difference is < 0, the end of the patient pressing the mouse
            durationIEnd = time(d);
            durationIndex = [durationIndex, (durationIEnd - durationIStart)];
            totalIClicks = totalIClicks + 1;
        end
    end
```

Agenda

01 Introduction

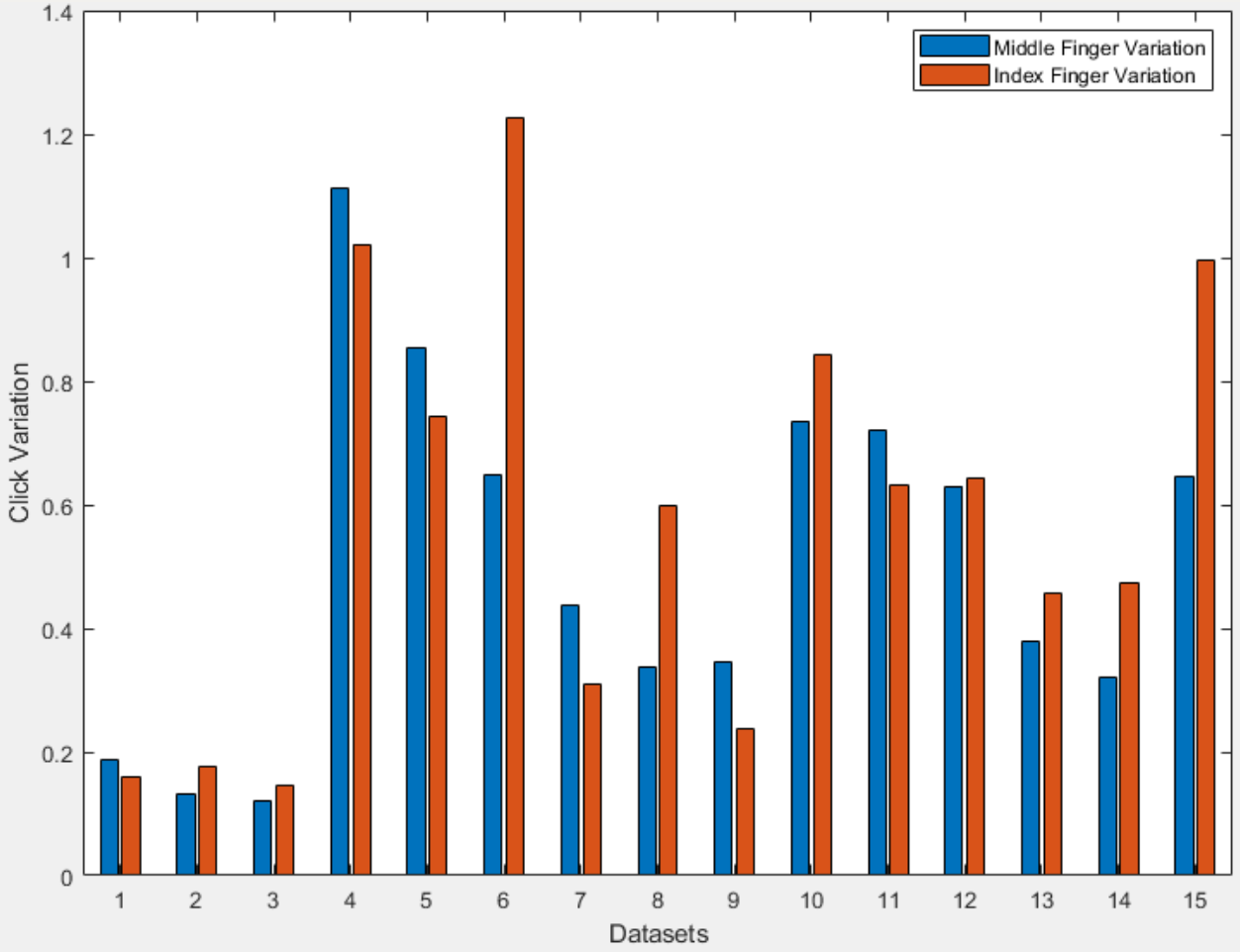
02 Methodology

03 Results

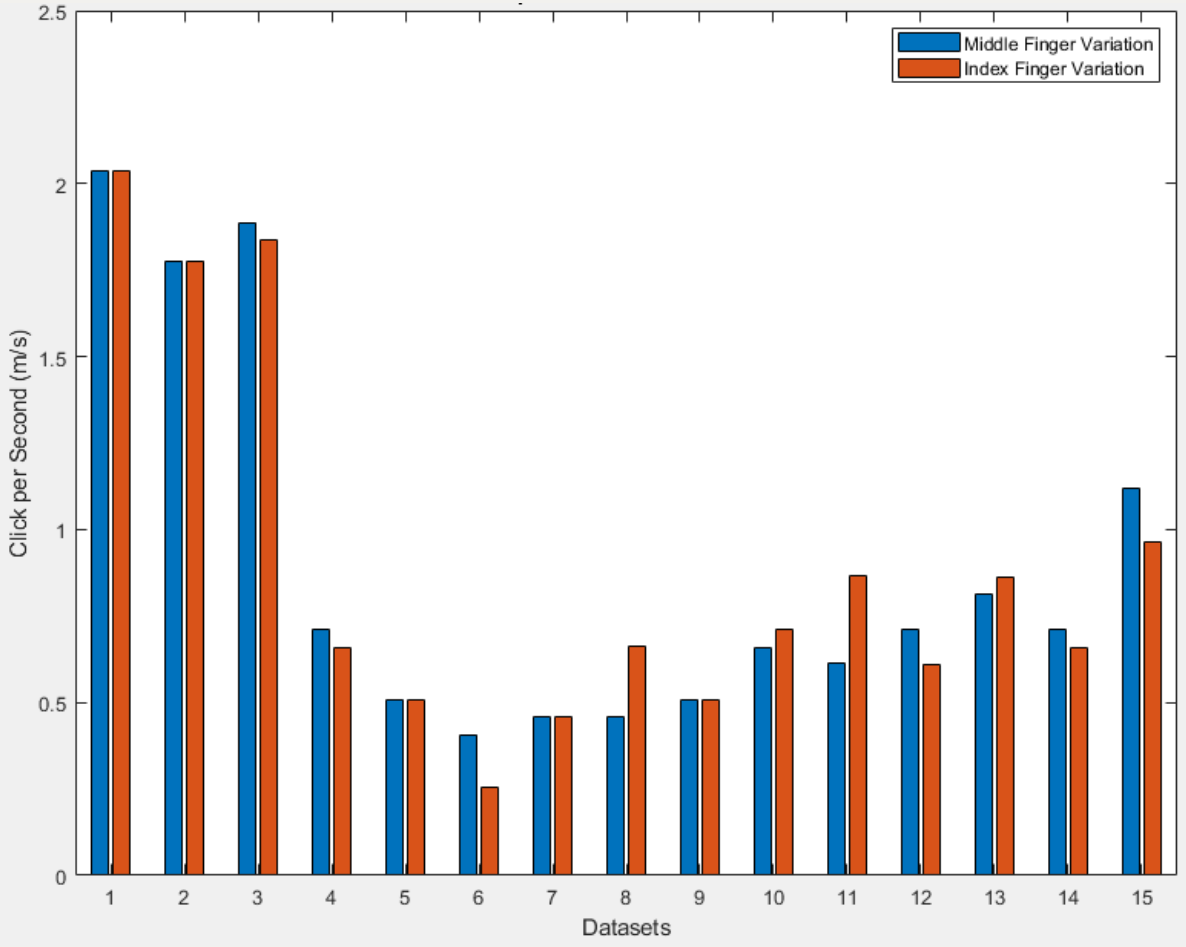
04 Next Steps

05 Conclusion

Click Variation and Click Speed for the 15 Datasets support hypothesis

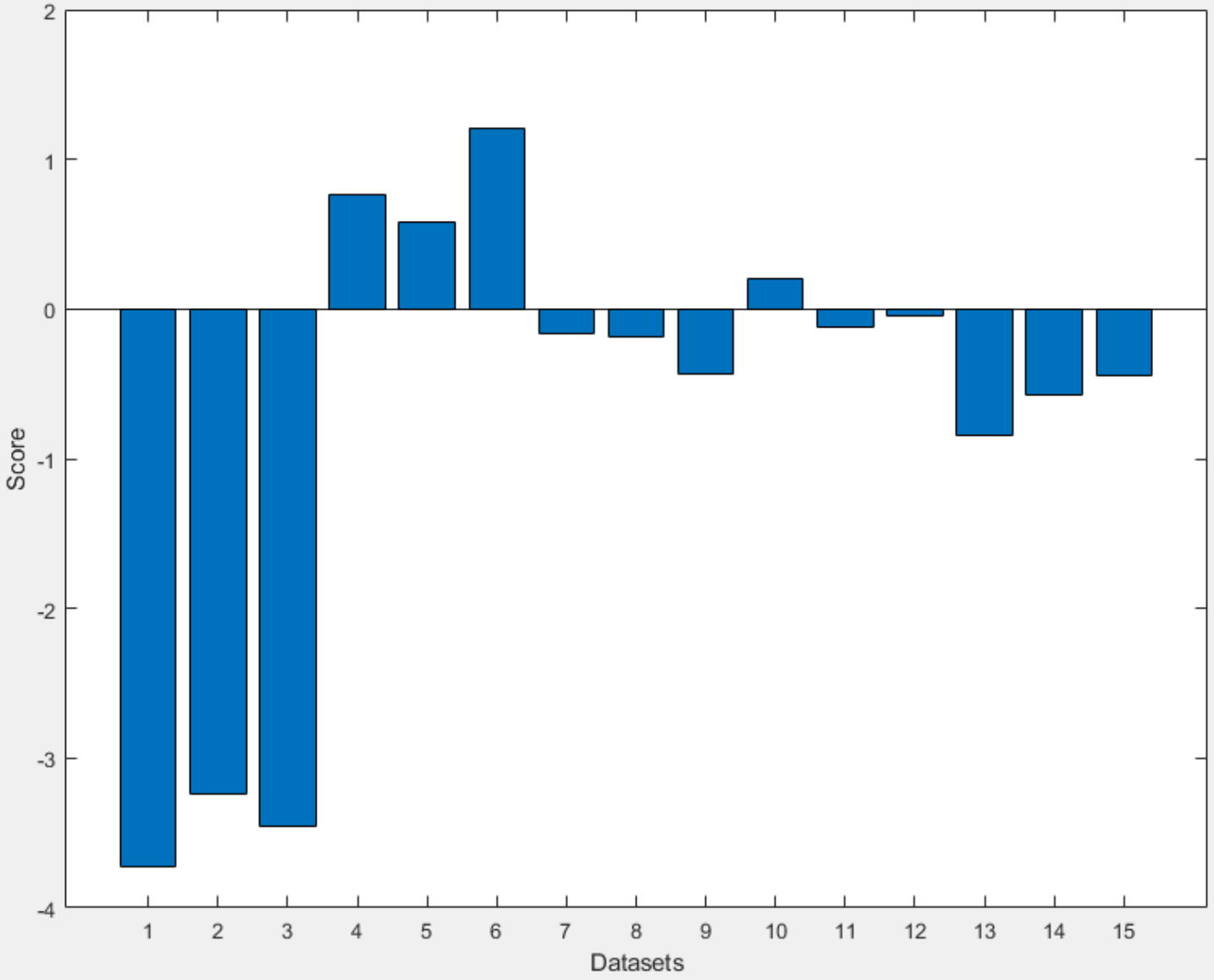


Click Variation



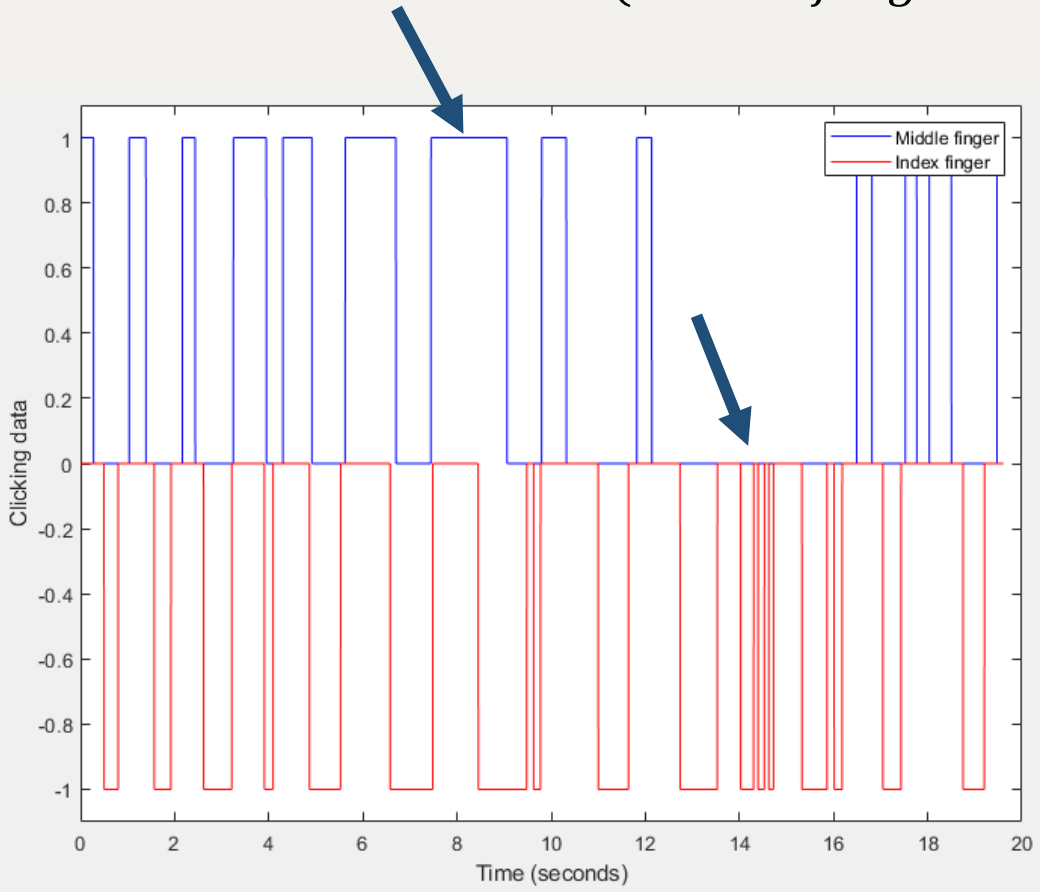
Clicks per Second

Overall Scores for the 15 Datasets

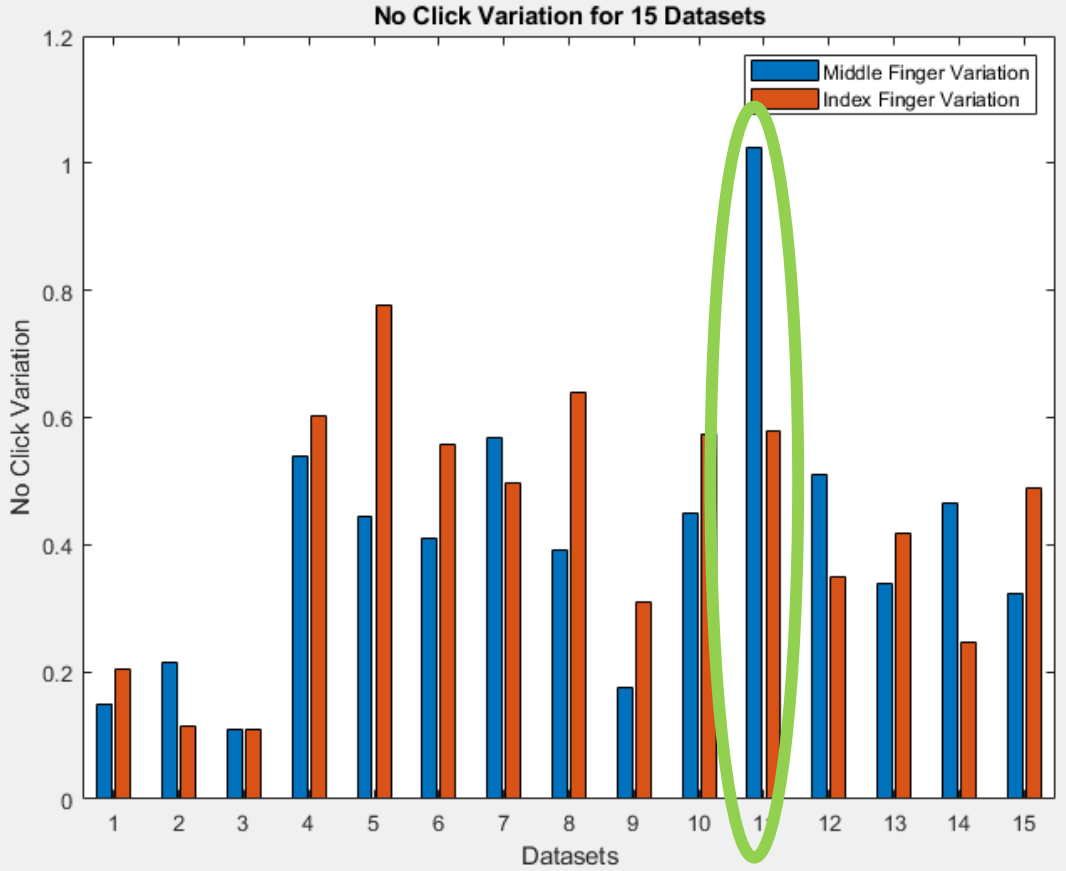


What about **NOT** clicking?

$$bradykinesia\ score = (middle\ finger\ CV + index\ finger\ CV) + (middle\ finger\ NCV + index\ finger\ NCV) - (middle\ finger\ CPS + index\ finger\ CPS)$$

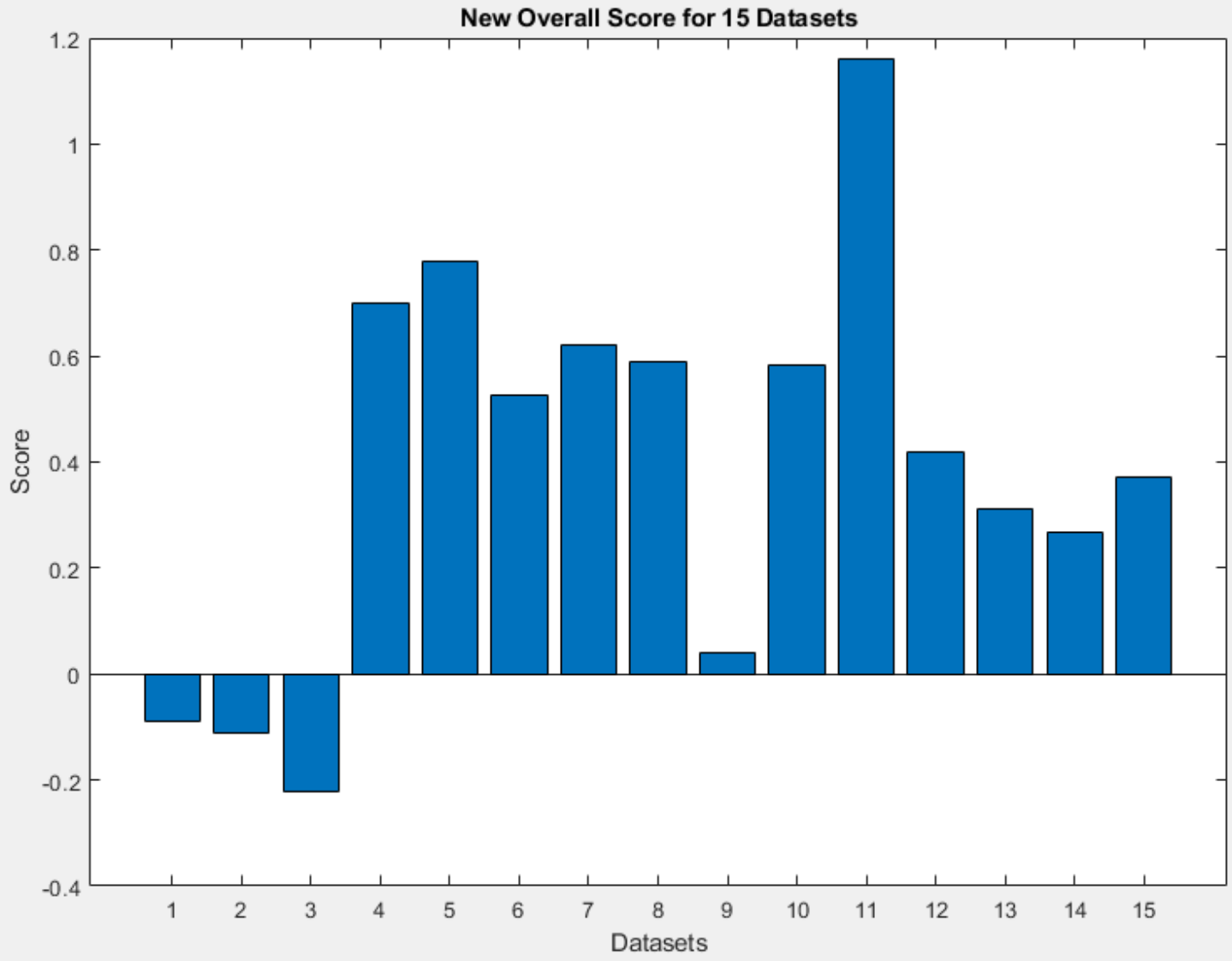


Dataset 11



No Click Variation was taken into account in new calculation

Revised Overall Scores for the 15 Datasets



Agenda

01 Introduction

02 Methodology

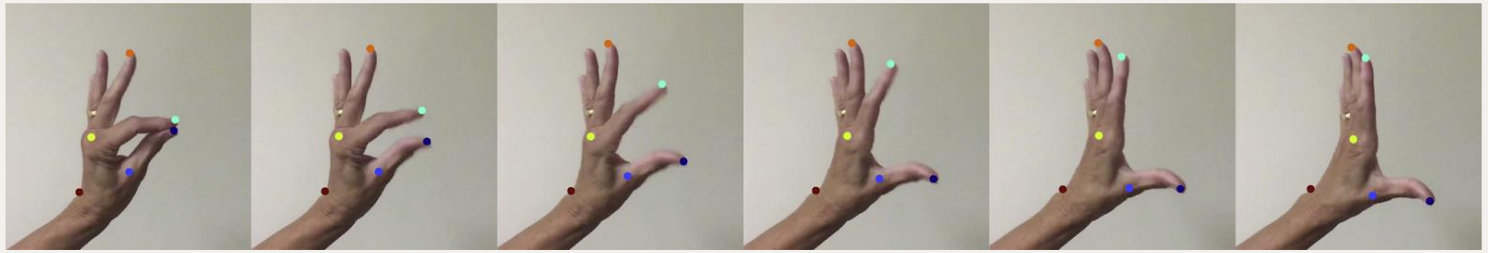
03 Results

04 Next Steps

05 Conclusion

Next Steps

- Add additional factors of clicking data and/or DBS patients and establish weights
  - All the factors were assumed to be of equal importance
- Comparing clicks between different fingers not just in one finger
- Create more datasets to continue testing the code and gather statistical data
- Implement an AI model to calculate and determine the score or if patient is benefitting from DBS



Dai H, Lin H, Lueth TC. Quantitative assessment of parkinsonian bradykinesia based on an inertial measurement unit. *Biomed Eng Online*. 2015;14:68. Published 2015 Jul 12. doi:10.1186/s12938-015-0067-8
Williams, S., Zhao, Z., Hafeez, A., Wong, D. C., Relton, S. D., Fang, H., & Alty, J. E. (2020). The discerning eye of computer vision: Can it measure Parkinson's finger tap bradykinesia?. *Journal of the neurological sciences*, *416*, 117003. https://doi.org/10.1016/j.jns.2020.117003

Agenda

01 Introduction

02 Methodology

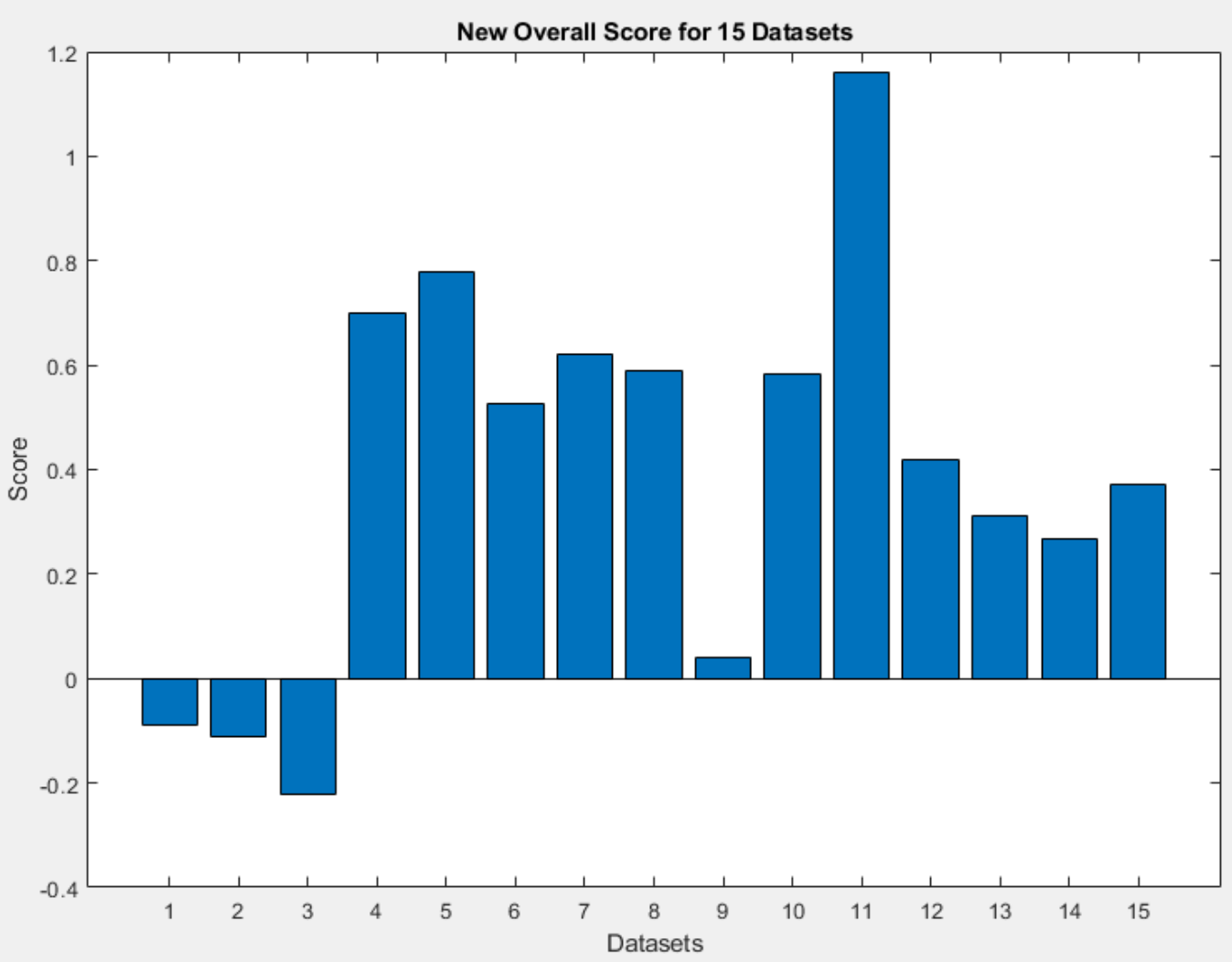
03 Results

04 Next Steps

05 Conclusion

Conclusion

- Designed and tested a formula to quantify bradykinesia in patients undergoing DBS surgery
- Learned about ongoing research conducted about Parkinson's Disease, deep brain stimulation, and computational biology
- Learned how to code and analyze data in MATLAB



Acknowledgments

- DukeREP staff and mentors
- Special thank you to Kay Palopoli!