Exploring Electrodermal Activity Through Genetic Algorithms as a Proxy For Engagement in Learning Activities

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The University of Iowa | College of Public Health

NIH National Heart, Lung, and Blood Institute

Overview

- Learning and engagement
- The study
- Genetic algorithms
- Intellectual humility and entropy
- Future directions

Learning and Engagement

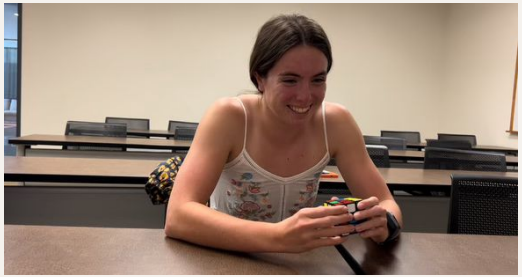
- Education researchers interested in quantifying engagement in a learning environment
- Investigations of the validity of electrodermal activity as a way to quantify engagement
- We define engagement as a heightened emotional response
- This research could improve learning accessibility and engagement in classrooms

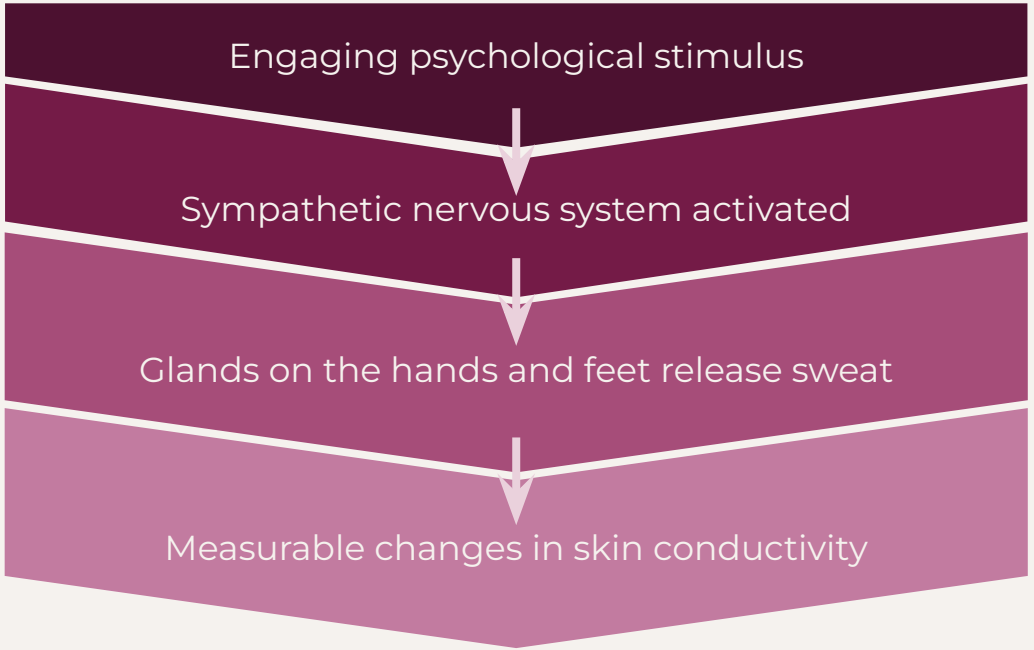
The Study

Objective: To validate the use of EDA as a proxy for engagement

Using EDA to Detect Engagement

Electrodermal Activity (EDA) - changes in skin conductivity resulting from sweat production on the hands and feet in response to a psychological stimulus





Methods

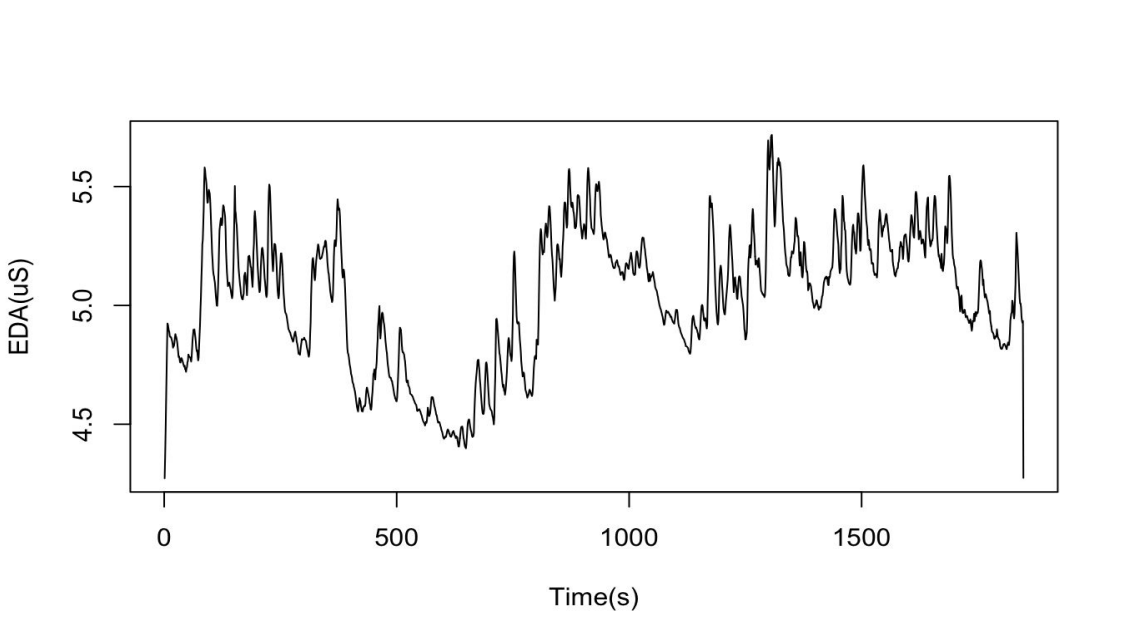
- UI Department of Psychological and Quantitative Foundations
- 20 participants
- 3 activities:
  a. Ordering rule of three number series (e.g. 2, 4, 6)
  b. Compound nouns (e.g. potato, tooth, heart)
  c. Right hand Rubik's cube algorithm
- Reflection questions and breathing between tasks
- EDA monitored
- Sessions video recorded

Genetic Algorithms

Objective: Assess if the genetic algorithm is effective in detecting significant structural breaks

Structural Breaks

(Lee, 2021; Cain and Lee, 2022)



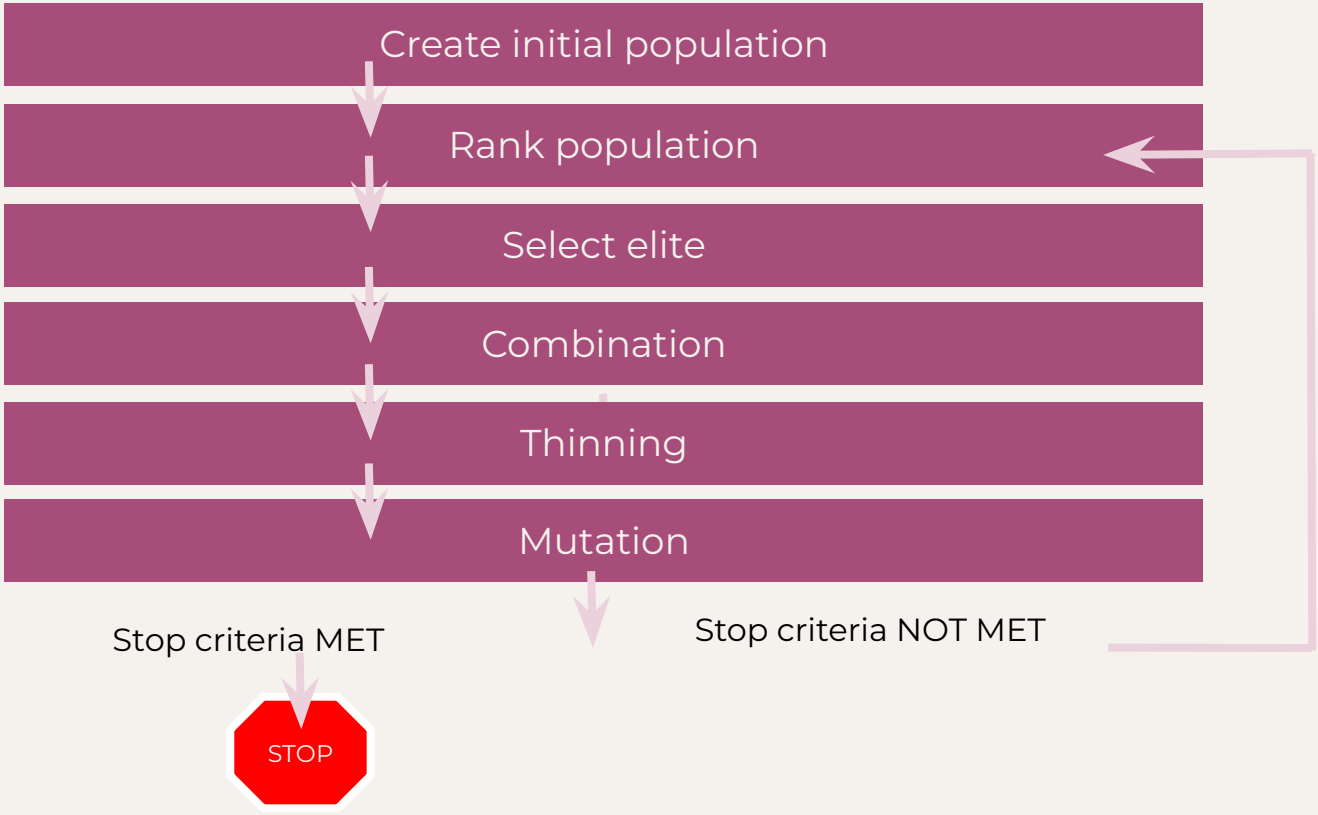
- Structural breaks - places where trends in time series have a prominent change
- If EDA is a good proxy for engagement, trends in EDA data should be associated with heightened emotional responses

Genetic Algorithms

(Li and Lund, 2012).

Genetic algorithms solve optimization problems using the principles of natural selection

Genetic Algorithms (Li and Lund, 2012)



Video Analysis

- Focused on 20 second intervals around a breakpoint
- Analyzed post activity reflections to help in the determination of meaningfulness

Assessing the Genetic Algorithm

What are the potential triggers?

- Thinking
- Anticipation
- Frustration
- Positive or negative feedback
- Fidgeting

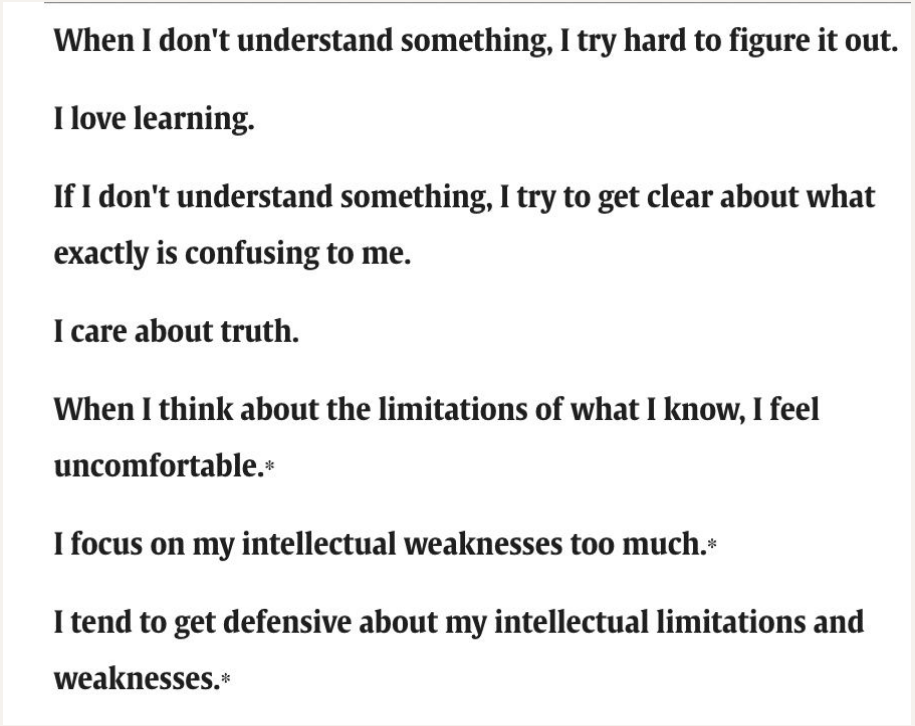
Where are breakpoints happening?

- **45%** of activities **contain** breakpoints, **55%** of activities **do not contain** breakpoints
- **36%** of breakpoints **are in** an activity, **64%** of breakpoints **are not in** an activity

Intellectual Humility and Entropy

Objective: Determine possible relationship between intellectual humility and entropy

Intellectual Humility



When I don't understand something, I try hard to figure it out.

I love learning.

If I don't understand something, I try to get clear about what exactly is confusing to me.

I care about truth.

When I think about the limitations of what I know, I feel uncomfortable.*

I focus on my intellectual weaknesses too much.*

I tend to get defensive about my intellectual limitations and weaknesses.*

- Intellectual Humility: An individual's willingness to own the limitations of their knowledge
- Calculated through a survey, prior to participation
- Subjects assigned a composite score out of 9

Entropy

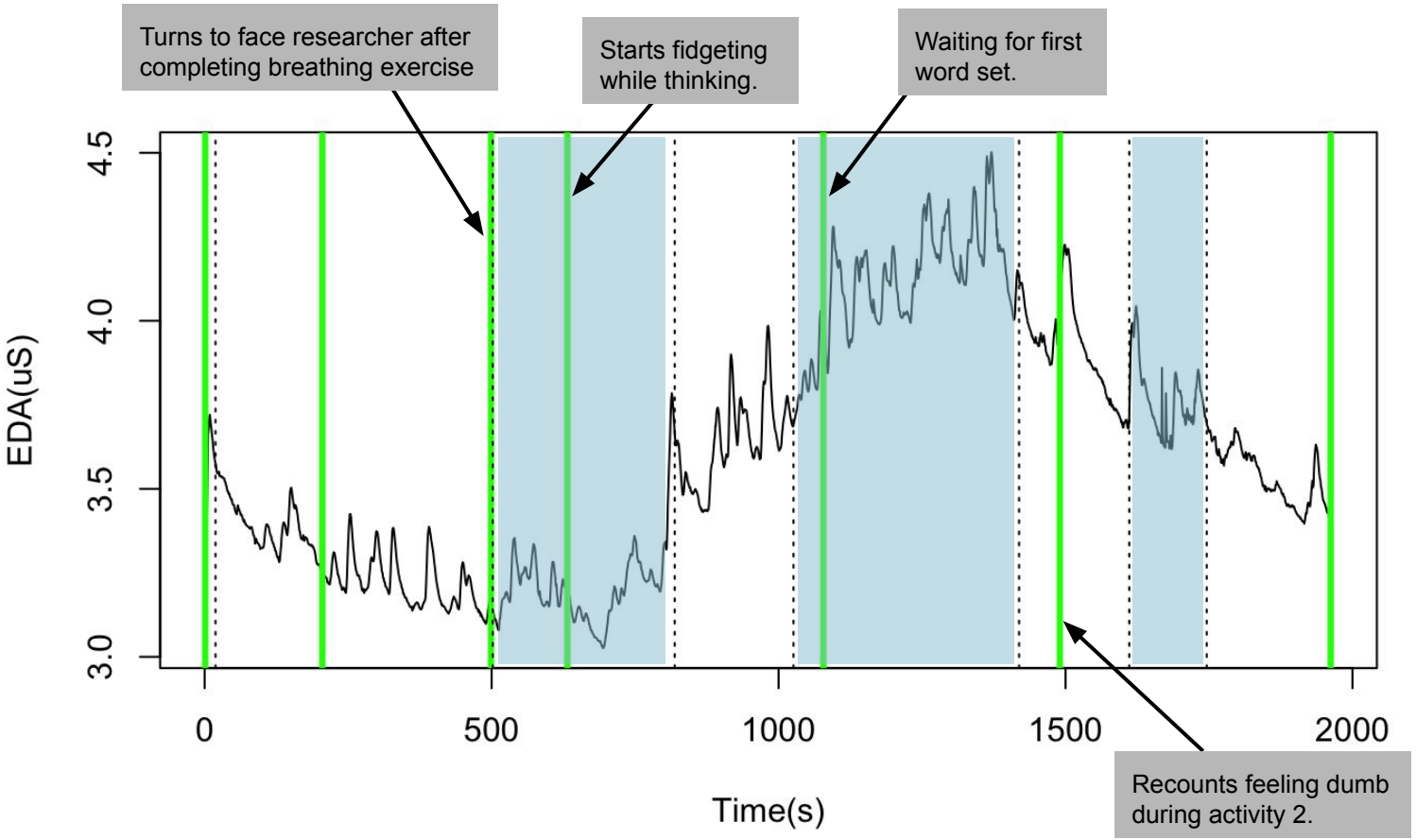
- Entropy: Quantifies unpredictability of time series data (Delgado-Bonal and Marshak, 2019)

$$H(X) = -\sum_{x \in X} p(x) \log p(x).$$

Low Entropy → {0 1 0 1 0 1 0 1 0 1 0 1 0}
High Entropy → {0 0 1 0 1 1 1 1 0 1 0 0 0}

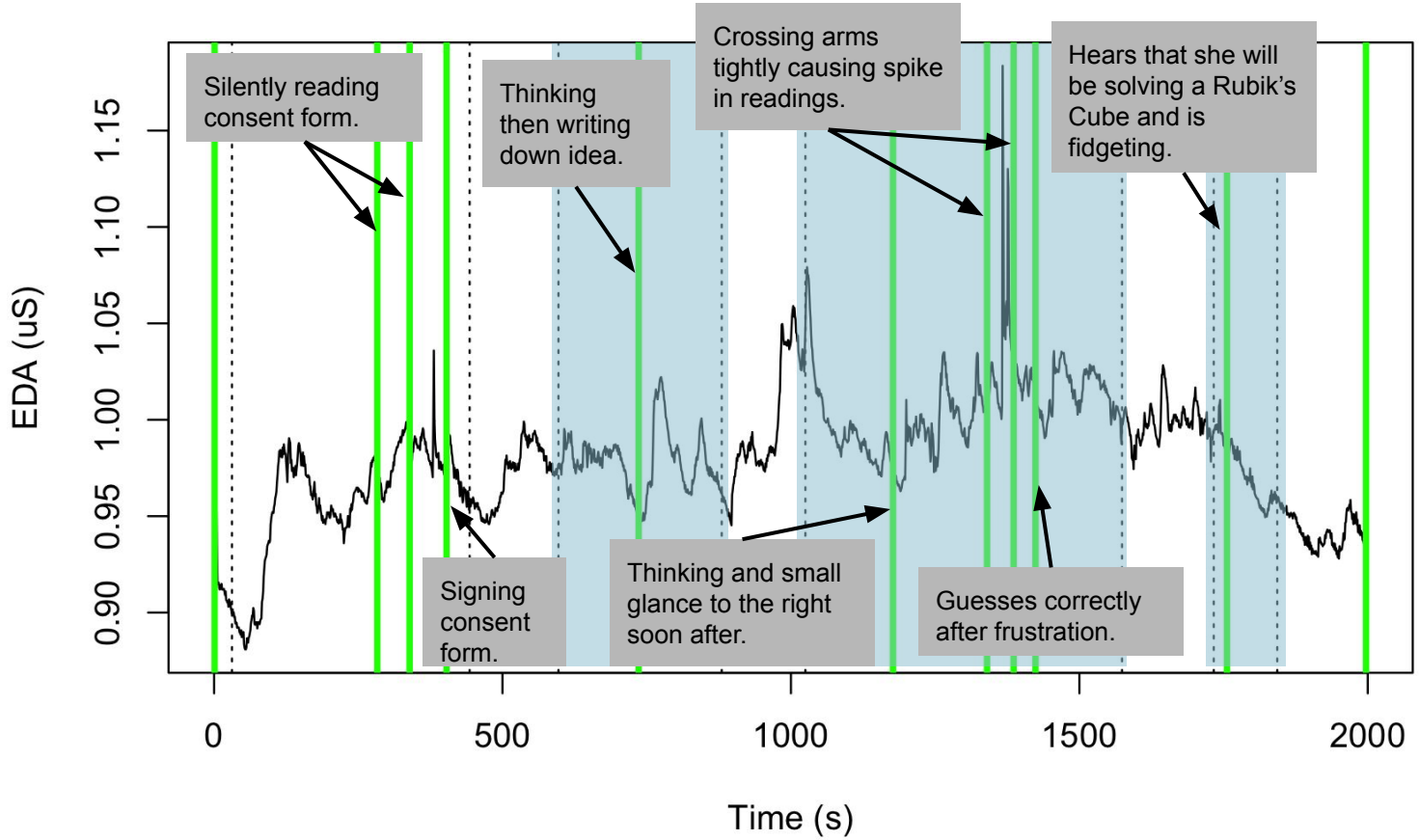
Subject 4

Approximate Entropy - 1.22
Intellectual Humility - 6.17/9



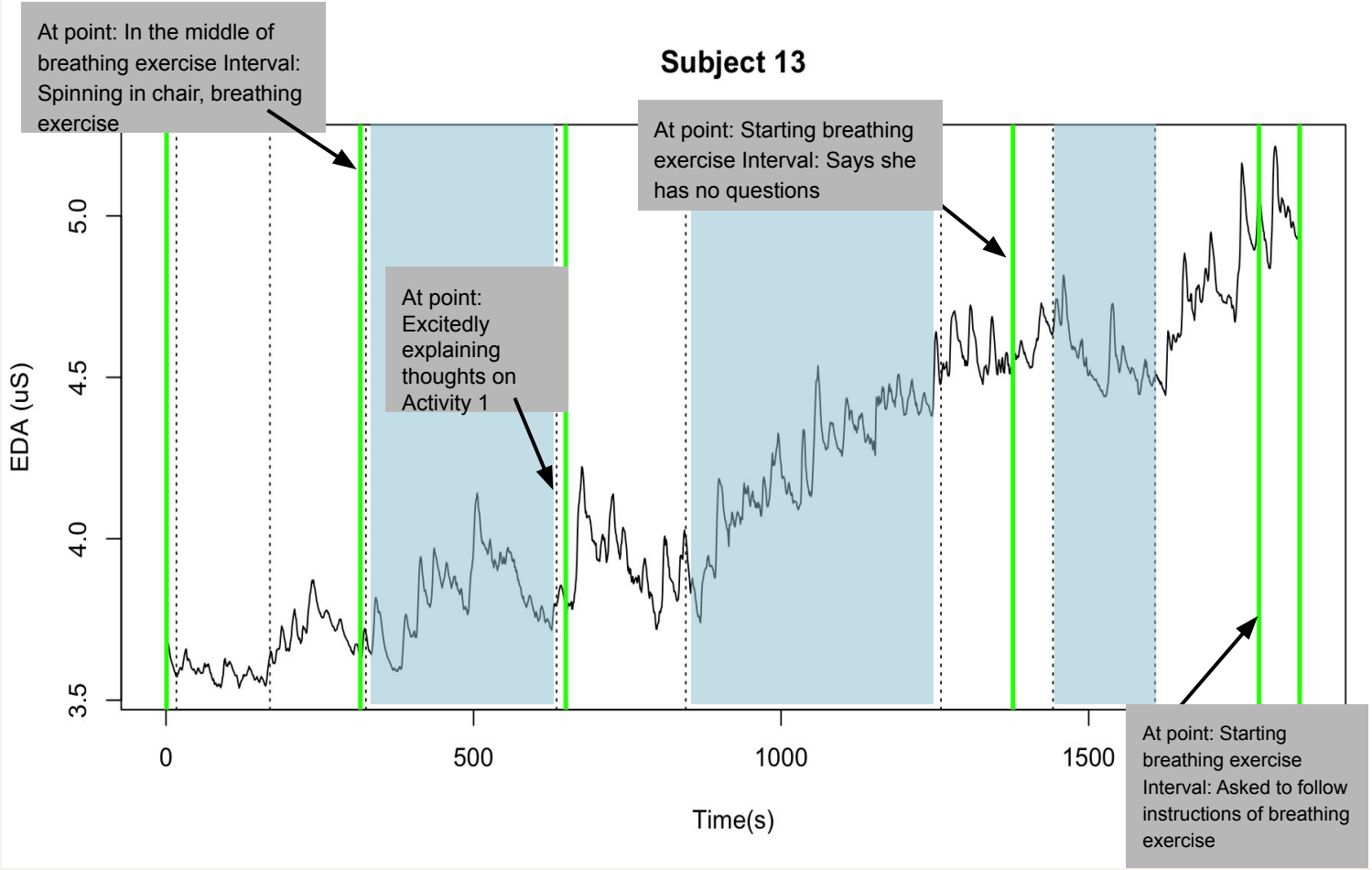
Subject 10

Approximate Entropy
- 1.49
Intellectual Humility
- 6.33

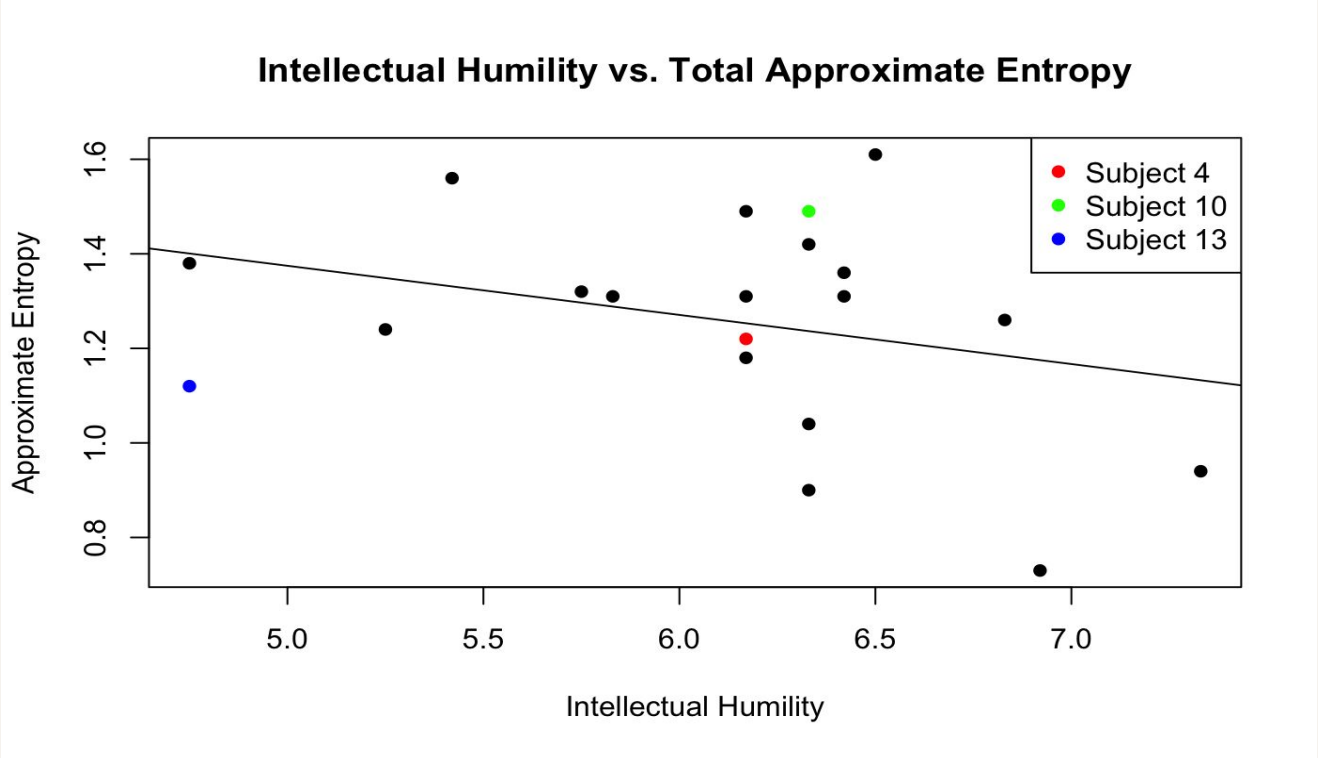


Subject 13

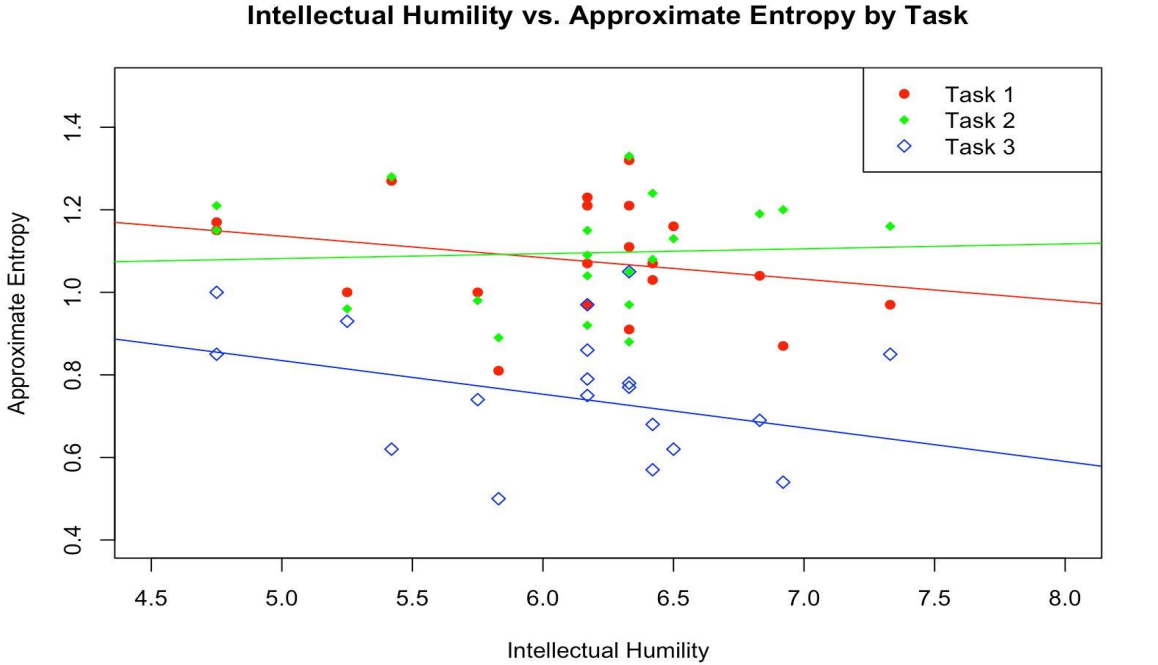
Approximate Entropy
- 1.12
Intellectual Humility
- 4.75



Intellectual Humility and Entropy



Intellectual Humility and Entropy



Future Directions

- Explore the reasons for scale variation and subjects lacking breakpoints
- Investigate why the relationship between Intellectual Humility and Approximate Entropy varies between math and language tasks
- Identify any differences between familiar tasks (ie. Rubik’s Cube) and new tasks

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Questions?