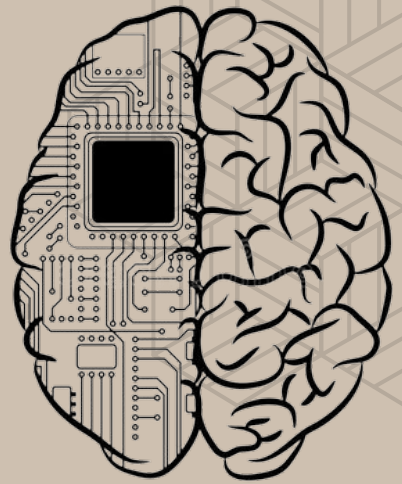
It’s Easy as ABC Framework for User Feedback



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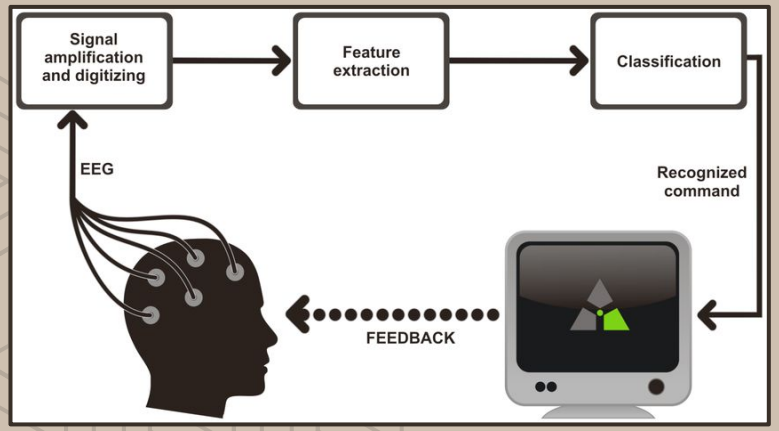
Motivation



- Key use cases for BCIs:
  - Assessing neurological disorders
  - Stroke rehabilitation
  - Communication device for locked-in patients
  - Detecting human drowsiness

- Solving the reliability issue for BCIs
  - Data Classification
  - User Training & Feedback

Research Questions

01

What is the most effective interface for providing user training and feedback for BCIs?

02

How can one incorporate pedagogical methods into beneficial feedback for users of BCIs?

Literature Review

Design Principle	Source	Implementation
(1) Positive feedback for inexperienced user and more honest feedback for experienced users	Lotte and Jeunet (2015), Lotte et al. (2013)	Ask the user for their level of experience – provide differing feedback accordingly
(2) Low-anxiety users provide the best result when given feedback with negative bias	Mladenovic et al. (2021)	Ask the users for their anxiety levels and provide biased feedback accordingly
(3) Learners benefit from actively thinking about the strategies they are implementing	Narciss et al. (2004)	Inform users about the classification methods being used for them to better understand the strategies they need to employ during training

Our interface: ABC Framework

A - attuned to the user

B - biased user feedback

C - classification algorithm descriptions

Research Process

01

Interface Creation

Created user interface for providing feedback during BCI data collection and ML algorithm descriptions

02

Survey

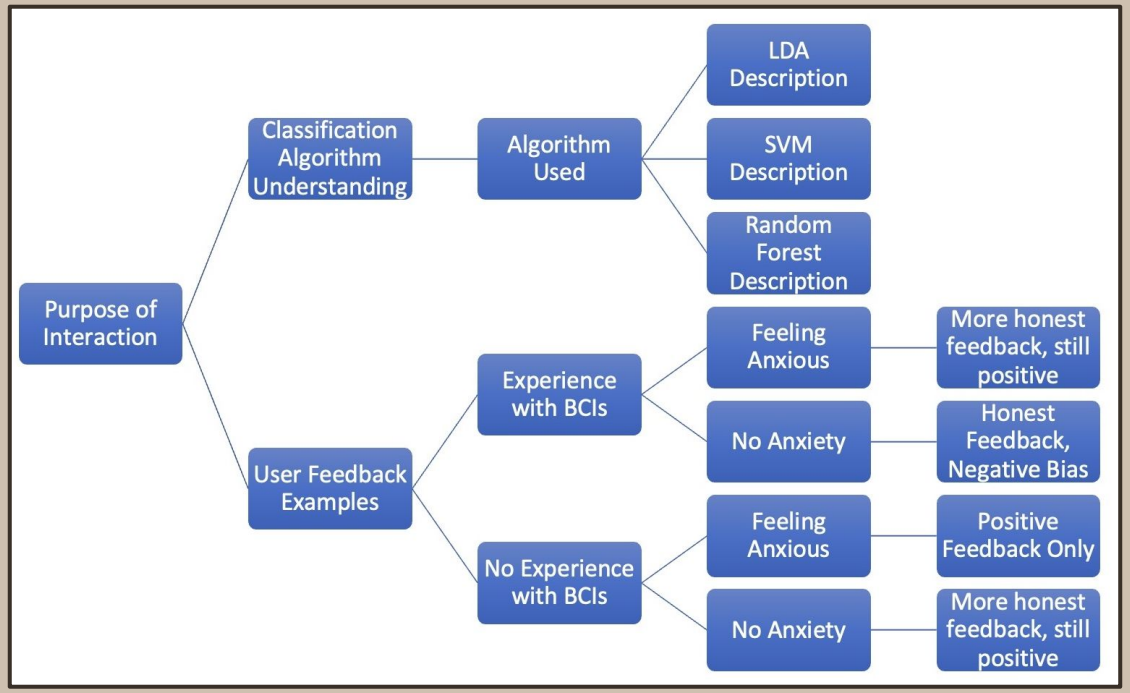
Created a survey to measure the effectiveness of the interface

03

Analysis

Analyzed survey results to provide a basis for future work

Interface Design



How the Interface Works

```
1. Data Collection User Feedback
2. Classification Algorithm Explanations
3. Quit

Enter integer corresponding to your choice

your choice --> 1
Do you have experience with brain-computer interfaces?     Yes (Enter 1) or No (Enter 0):  0
Are you feeling anxious? Yes (Enter 1) or No (Enter 0):  1

We understand you are an inexperienced user with some feelings of anxiety.

Your signal looked great, fantastic job! Keep doing what you're doing.
```

Feedback Provided

Anxiety Level	Experience Level	Bias Framework	Feedback Given
Feeling Anxious	Experience with BCIs	Honest feedback, positive bias	**Strong signal**: Your signal looked great. Keep doing what you're doing. **Weak signal**: Your signal wasn't quite right. Good try and keep going.
Feeling Anxious	No experience with BCIs	Positive feeback only (positive bias)	**Strong signal**: Your signal looked great, fantastic job! Keep doing what you're doing. **Weak signal**: Good try. We think you will improve with practice.
No Anxiety	Experience with BCIs	Honest feedback, negative bias	**Strong signal**: Good job, your signal is strong but can always be improved. Keep focusing on the task at hand. **Weak signal**: Your signal wasn't clear. Try changing up your strategy.
No Anxiety	No experience with BCIs	Honest feedback, positive bias	**Strong signal**: Your signal looked great. Keep doing what you're doing. **Weak signal**: Your signal wasn't quite right. Good try and keep going.

Sample Classification Description

```
Which classifier did you use in your data analysis?

1. Linear Discriminant Analysis (LDA)
2. Support Vector Machine (SVM)
3. Random Forest

Enter integer corresponding to your choice

your choice --> 3

        Random Forest uses results from a combination of decision trees to
        classify signals. Decision trees can be thought about in a similar
        manner to a flow chart. This flow chart uses various characteristics
        of the input to determine which classifier the signal falls under. In
        order to classify the output based on the decision trees, random forest
        uses the majority voting classifier. Majority voting classifier chooses
        the classification that the majority of the decision trees outputted.
        For example, imagine 100 decision trees are used to classify a dog or a
        cat. If 65 of them output dog, then the Random Forest classifier will
        output Dog. This is why it is called Random Forest and not Random Tree:
        we use many trees to make classification decisions.
```

Key Points of Survey

Experience Level

User’s experience with CS, ML, and BCIs

Motivation

User’s desire to continue learning about BCIs before and after using interface

Algorithm Understanding

Before and After reading descriptions

Helpfulness of Feedback

Whether use believes they would find feedback helpful while training with a BCI

Clarity

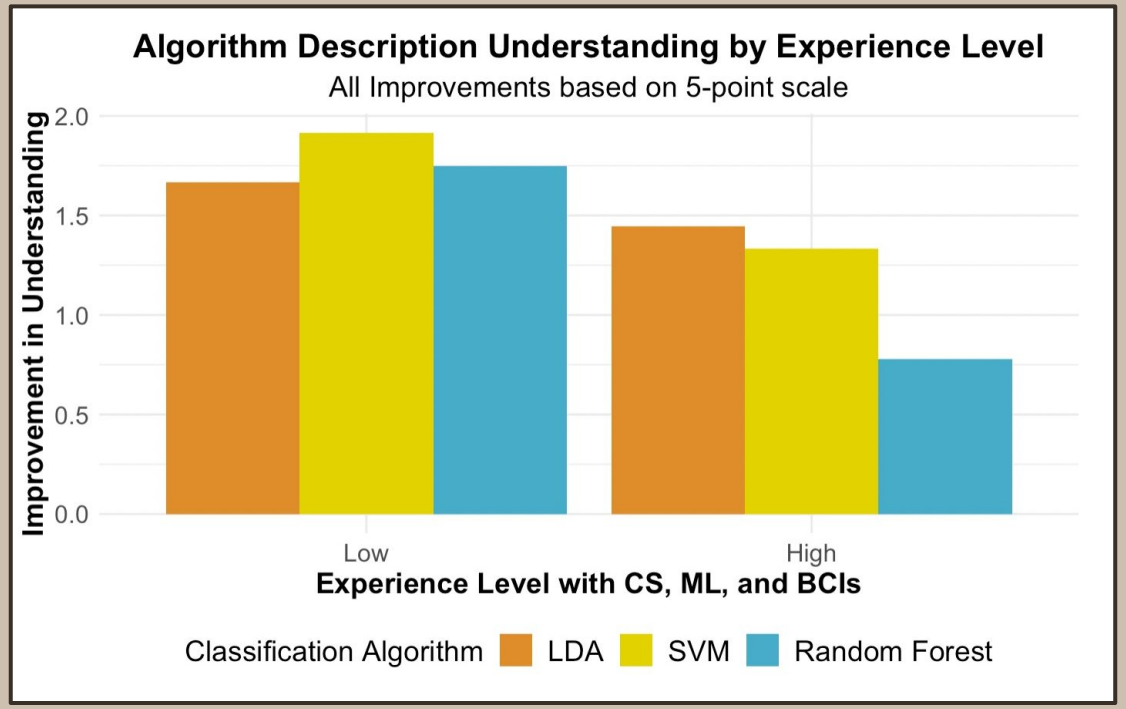
Clarity of algorithm descriptions and user feedback

Ease of Use

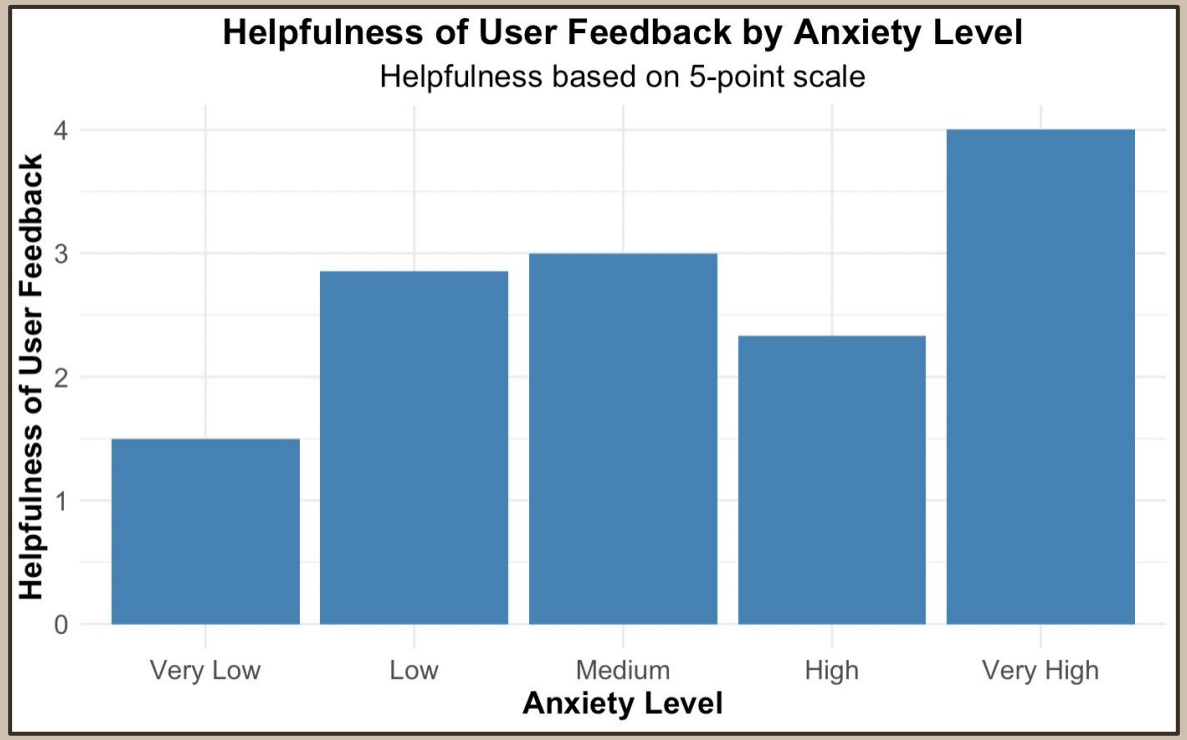
Whether interface was easy to use

Results

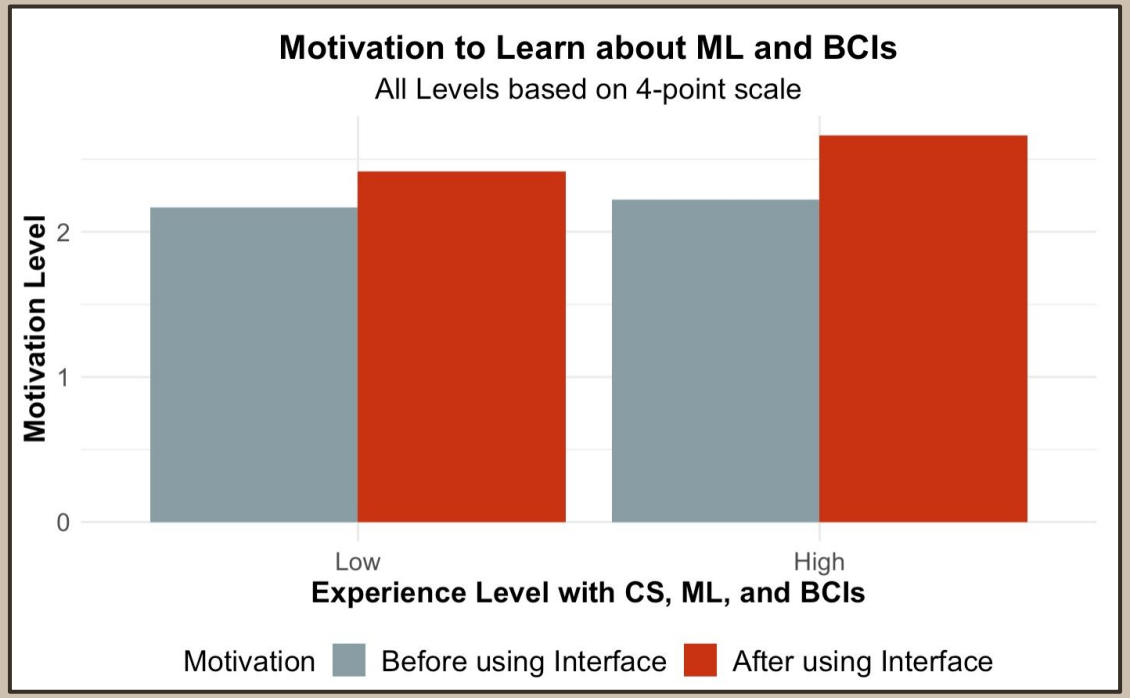
Did Users Improve in their Algorithm Understanding?



Did Users Find Feedback Helpful?



Did the interface improve user motivation?



Motivation and Ease of Interface

- Asked more motivated: average score of 2.857 (median 3) on a 4 point scale
- Statistically significant increase in motivation ($p = 0.008$, $t = 2.65$, $df = 20$) - limitations of this measurement
- Ease of interface - the average reported score was 4 (mean 3.905) on a 5 point scale

Limitations & Future Work

- As our research was conducted during a one-semester undergraduate course, our work was subject to time and complexity limitations.
    - Lack of Access to a Brain-Computer interface / EEG data
    - Simplified Classification Algorithm Descriptions / User Feedback