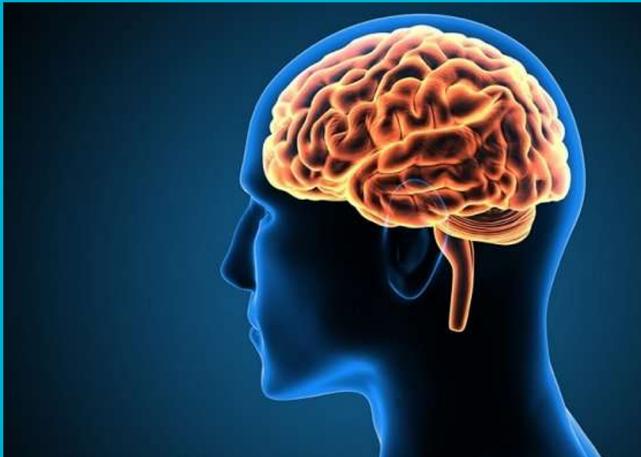


# BrainEx DashBoard MQP

## Final Presentation

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By: Vandana Anand,  
Kyra Bresnahan,  
Maggie Goodwin,  
and Sylvia Lin

# Agenda

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- Preview of Final Deliverables
- A Term Accomplishments
- B Term Accomplishments
- Final Deliverables
- Future Development
- What we learned

# Preview of Final Deliverables

The screenshot shows the BrainEx homepage. At the top left is a brain icon and the text "BrainEx Version 1.0.0". To the right are buttons for "Homepage" and "Need Help?". Below this, a sidebar on the left lists "SART1", "SART2", "SART3", and "SART4" with a "Choose File" button and "Add" button. A main content area on the right contains the text: "The tool that helps find the top similar matches in fNIRS time series sequences" and a "Preprocess a new dataset" button.

Implementation

Applying HCI Design Practices to the Design of the BrainEx User-Interface to facilitate fNIRS Research

Advisors:

Professor Erin Solovey and Professor Rodica Neamtu

By:  
Vandana Anand

Working collaboratively with:  
Kyra Bresnahan  
Margaret Goodwin  
Yihan Lin



Final Paper

The image displays three sequential screenshots of the BrainEx software interface. The first screenshot shows the "Homepage" with options to "Start with a preprocessed dataset" or "Preprocess a new dataset". The second screenshot shows the "Select a Dataset" screen with a list of datasets: "Dataset 1", "Dataset 2", "Dataset 3", "Dataset 4", and "Dataset 5". The third screenshot shows the "Preprocessing Options" screen where a dataset is selected ("Dataset 5") and preprocessing parameters are set: "Number of Database Headers" (5), "Distance Type" (Euclidean), "Similarity Threshold" (0.5), and "Time-series Length of Interest" (max). A red arrow points from the "Start Preprocessing" button back to the "Homepage".

High Fidelity Mockup

# A term Accomplishments

---

- Conducted research on fNIRS, HCI, and BCIs and became familiar with the main concepts
- Learned more about the current tools being used to preprocess and analyze fNIRS in the WPI HCI lab
- Collected user and system requirements for BrainEx by interviewing the lab members
- Started putting together a rough sketch of an initial BrainEx mockup
- Submitted the Proposal

# fNIRS, HCI, and BCIs Research

---

**Goal:** Learn more about fNIRS, HCI Principles, and BCIs

**Process:** Research using online resources as well as meeting and discussing with WPI HCI Lab members about their day-to-day roles

**Outcome:** The team was able to gather more knowledge on fNIRS and BCIs and how experiments are done. They also learned more about HCI design principles such as ideation, rapid prototyping, and testing with users.

**Takeaway:** The team was able to get a solid understanding of the whole WPI workflow. They were also able to apply this info in their background section of the final MQP paper

# Current Tools in The Lab

---

**Goal:** Find current tools that members are currently using in the WPI HCI Lab and be able to apply any of the preferences and concerns to BrainEx

## **Process:**

- Prepare an interview question list and hold meeting times to ask users about the tools they have been using. Some questions about the tools included:
  - Why did you/your lab choose/use these particular BCI tools?
  - Have you ever felt at any point that certain functionalities you need are missing from this interface?
  - In the case of technical difficulties, how do you usually resolve them? Do you just google the problems you encounter? Search in their official documentation? Email the support team?
  - For a complete list of questions, please refer to Appendix G in the [final paper](#)

# Current Tools in The Lab

---

## Outcomes:

- Found that users mostly Aurora, RTFD, Matlab\_GUI, NirsLab, and Homer 2 for data analysis and preprocessing of fNIRS data
- Many of the concerns were about lack of documentation and guidance within the application and user control as there was only a set procedure to follow

## Takeaways:

- Prioritize these results in the upcoming storyboards and in the prototypes

# User and System Requirements for BrainEx

Goal: Determine the requirements for the interface

Process: Interview lab target users (6) and developers (3)

Outcome:

User Need	API Function
Data Exploration	Cluster Explorer Dataset Explorer
Investigate Data Patterns	Query Best Matches for Data Sequence
Export Database	Save Database
Export Best Matches	Save Query Results

Takeaways: Personas and Models (see B Term)

# B term Accomplishments

---

- Created User Personas to identify specific target user groups for testing BrainEx
- Created detailed models to reflect system requirements
- Iteratively designed Storyboards
- Iteratively designed Low, Mid, and High Fidelity Prototypes
- Designed Moodboards
- Tested and received feedback from users to continue to improve the prototypes
- Initial framework and functionality of BrainEx
- Final Paper

# User Personas

---

Goal: Determine the target user groups as well as effectively communicate and sharpen design focus

# User Personas

---

## Process:

- Compile interviews conducted in A term when we learned about the different tools available in the WPI HCI lab and organize into a table with user's:
  - Name
  - Age
  - Education level
  - Titles and responsibilities
  - Goals and frustration while using the application
  - Their brief background
  - Memorable quote about the application that they mentioned

# User Personas

---

## Outcomes:

- Target users range from undergraduates to graduates, with majors mostly in CS, ECE, and BME
- 3 user persona groups: novice, intermediate, and advanced
- Undergraduates = novice, Graduates/PhD = intermediate, Developers = advanced
- Common Interview Themes of the tools: Lack of documentation and guidance, not customizable, interesting graphs and visuals

# User Personas

---

## Takeaways:

- Novice users will be the focus of the BrainEx application
- Moving forward, the team will utilize the information of target user groups to schedule user testing sessions to best achieve their design goals

# Models

---

Goal: Model the BrainEx system in order to organize and understand the user requirements vs. technical requirements

## Process:

Created 4 models:

- Conceptual Model: Objects, Relationships, Operations
- Semantic Model: Details about Functions
- Syntactic Model: States and connections
- Lexical Model: Actions relating to states

# Models

---

Outcome:

Conceptual

<u>Objects</u>	<u>Relationships</u>	<u>Operations</u>
<ul style="list-style-type: none"><li>• SparkContext</li><li>• Dataset (Genex database)</li><li>• Query object</li><li>• Query results</li></ul>	<ul style="list-style-type: none"><li>• The other objects reside within the SparkContext</li><li>• Query results are subsets of dataset</li><li>• Query result is generated from query object</li></ul>	<ul style="list-style-type: none"><li>• Load database</li><li>• Build database (this does the clustering) w/ build specifications (length of interest, type of distance, similarity threshold)</li><li>• Save database</li><li>• Generate query</li><li>• Query database</li><li>• Plot query results</li><li>• Explore clusters</li><li>• Explore dataset</li></ul>

# Models

---

Outcome:

Semantic

(one function)

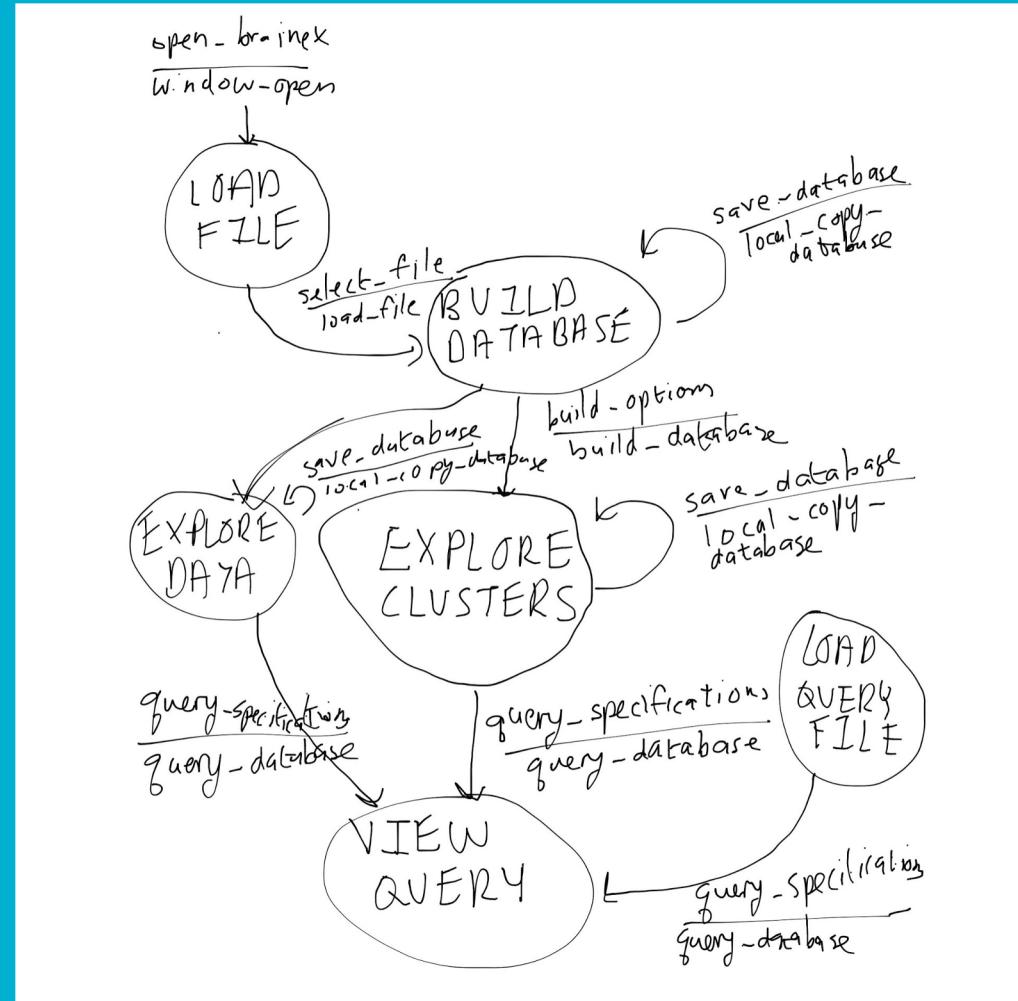
<b>Function</b>	Query database
<b>Parameters (implicit and explicit)</b>	(built) Database/self, query object, number of best matches, boolean of whether to exclude representative sequence, overlap threshold; Spark Context must exist
<b>Description</b>	Generates an object that holds results for best matches based on a given query object
<b>Feedback</b>	Display query results if query can be computed, give error message if not
<b>Error Conditions</b>	<ul style="list-style-type: none"><li>- Give error message if query object is invalid</li><li>- Limit user input to ensure best matches is a positive whole number</li><li>- Limit user input to ensure overlap threshold is a number between 0 and 1</li></ul>

# Models

---

Outcome:

Syntactic



# Models

---

Outcome:

Lexical

Action	Definition
Window_Open	Click BrainEx icon
Load_File	Browse to desired database or CSV file -> click load
Local_Copy_Database	Click save database
Build_Database	Enter similarity threshold on slider, enter length of interest in 2 textboxes, select distance type from dropdown menu -> click build
Query_Database	Navigate to query tab -> Enter number of best matches in textbox, check box of whether to exclude representative, Enter overlap threshold on slider -> click query

# Models

---

## Takeaways:

- While there aren't many types of objects to deal with, there may be many instances of objects that hold much data, so we need to pay careful attention to their handling
- Planning for error handling needs to happen early!
- There are relatively few states and actions involved, so there will probably be fewer screens than we expected

# Applying HCI Design Practices to the Design of BCI User-Interfaces to Facilitate fNIRS Research

Vandana Anand (CS), Kyra Bresnahan (CS), Margaret Goodwin (CS), Sylvia Lin (CS)  
 Advisors: Professor Erin Solovey (CS), Professor Rodica Neamtu (CS)

## Problem

The WPI Interaction Lab has created a robust tool called **BrainEx** to find best matches for time series in fNIRS BCI data. Researchers desire this capability because it helps discover patterns in their data. However, **BrainEx** is currently in need of a user-friendly graphic interface.

## fNIRS BCI



A student uses an fNIRS BCI cap while performing a task. Researchers can then use the collected data on brain hemoglobin levels to gauge the student's concentration.

## Proposed Solution

The team proposes the development of a user interface built upon the **BrainEx** API following the user-centered design process to ensure utility and usability.

## Understanding system requirements

The team interviewed 6 target users in the lab and 3 developers. They then mapped each user need to the API function that would fulfill it:

User Need	API Function
Data Exploration	Cluster Explorer Dataset Explorer
Investigate Data Patterns	Query Best Matches for Data Sequence
Export Database	Save Database
Export Best Matches	Save Query Results

## BrainEx System Model

Objects	Relationships	Operations
-Dataset (BLOB database)	-The other objects reside within the dataset	-Load database
-Query object	-Query results are both subsets of dataset	-Build database (this does the clustering) w/ build specifications (length of interest, type of distance, similarity threshold)
-Query results	-Query result is generated from query object	-Save database
-Result plot	-Result plot is a visual representation of the query results	-General query
		-Query database
		-Plot query results
		-Explore clusters

One of four models created by the team to examine the **BrainEx** system

## Iterative Prototyping

Started with storyboard to focus on flow of functions



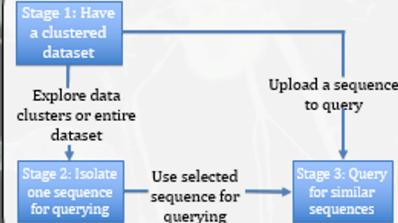
Feedback  
Created low-fidelity interactive prototype to test screen layout



Feedback  
Designed mid-fidelity interactive prototype to refine flow and layout



## Interface Flow



## Gathered Feedback

Positive	Negative
Visualization of dataset	Unclear control flow
Visualization of cluster	Jargon overuse
Display of query results	Unclear menu structure
Data filtering	Unlabeled buttons
Learnability	Inconsistent naming

Highlights from feedback on all three levels of prototypes

## Further Development

- Complete high-fidelity prototype
- Get user feedback on high-fidelity prototype
- Implement prototype using Agile methodology

## Acknowledgements

Thank you to Professors Erin Solovey and Rodica Neamtu for their work as advisors. Thank you also to the developers of **BrainEx** and students in Professor Solovey's lab for their insight into our project.

## Sources

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9330333/>

# Storyboards

---

**Goal:** Ensure that the team's understanding of and plan for BrainEx meets the user needs and accurately reflects the system behind it

## **Process:**

- Created a storyboard for each individual feature of the envisioned system (e.g. uploading a file, zooming in on a graph, etc.)
- Presented multiple versions to allow users to provide useful feedback on different ways of handling it.

# Storyboards

---

## Outcomes:

- The users expressed confusion in the representation of the data attributes in the storyboard and how they would access data in the application.
- Flaws with the team's testing methods, such as not presenting the goal of the application before beginning to ask questions.

# Storyboards

---

## Takeaways:

- The team made sure to refine their storyboards in the next iteration to solve some of the concerns
- The issues were prioritized first and taken into account when designing the low fi prototype
- The team adjusted their user testing methods to start off with a preamble explaining what the team is doing and what BrainEx is, which significantly helped users

for Mockup: focus on the parts  
we don't know how to present

query → cluster explore

Genex.

#1

Genex

○ Previous built. [Folder]

○ New dataset [CSV]

Upload.

BQ

length	50	avg	1
39	average	0.000000	0.02

AQ

30000

101

Genex - Every.

[V1,2] [V1,2] [V1,2]

#3

[load]

33

32

42

42b

J States

7883

Cancel build

Genex

#12a.

=# of identifications

length of intent

[V1,2] [V1,2]

SIM thresh

placeholder text:

between 0 and 1

dist type

V

Back.

Finish fill form

Start Build

last time

XVerbosity

Parameters in Query.

Query:

Best k:

Usage ID:

Offset:

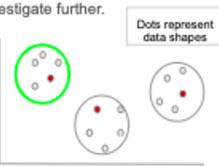
50  
51  
52

Sketch of storyboards

# Storyboards

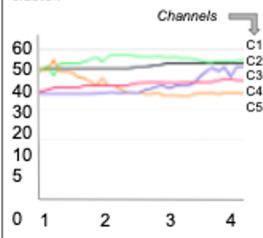
## Display Cluster Explorer

Kia is not sure what exactly she wants to query based on the selected data. She can view the following regions to get an idea of how similar the data are in particular clusters, grouped by the length of the time series data within the cluster, and then select a cluster to investigate further.



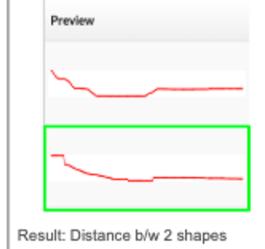
Kia chooses to view the cluster selected in green

Kia can view a cluster that looks very unique and needs more attention. She can view a graph of the different points in the selected cluster.



Kia chooses to view the cluster selected in green

Kia can also view the list of shapes of the graphs in a table which she can then pick and choose to investigate more closely.



Kia chooses to investigate the data shape selected in green

## Choosing a cluster from the data viewer - p1

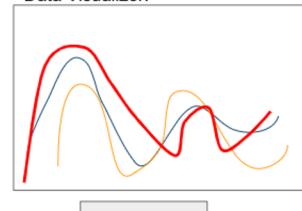
Kyra selects cluster 5 in the data viewer.

Data Viewer:

ID	Length	size (# of sequences)	shape
1	50	100	(thumbnail)
2	50	85	(thumbnail)
3	51	117	(thumbnail)
4	51	44	(thumbnail)
5	51	200	(highlighted thumbnail)
6	52	15	(thumbnail)
7	53	64	(thumbnail)

The cluster is highlighted in the data visualizer. She decides she wants to view the contents of this cluster and selects "view cluster" on the screen.

Data Visualizer:



Version 1

Version 3



# Low Fidelity Prototype - Utility Refinement

---

**Goal:** Create an initial prototype that focuses on the dataset explorer and query result page. Have the current prototype meet user needs and accurately reflect the backend capability. Have an easily understandable structure within the prototype.

## **Process:**

- Brainstorm ideas for the prototype in team meeting using our HCI knowledge to create designs and building on top of backend capabilities
- Design on Balsamiq
- Confirm with Leo the feasibility of the features for implementation purposes
- Team members perform heuristic evaluations individually
- Conduct User Testing
- Wrote UARs to consolidate the user result information

# Low Fidelity Prototype - Utility Refinement

---

## Result overview:

- A low-fi prototype that provides a clear, more simplistic structure than Genex.
- Demonstrates a control flow and interactive capabilities to simulate the real application.
- Team members gave reviews to focus on error prevention and documentation.
- Users mentioned control flow and clarity needs improvement.

# Low Fidelity Prototype - Utility Refinement

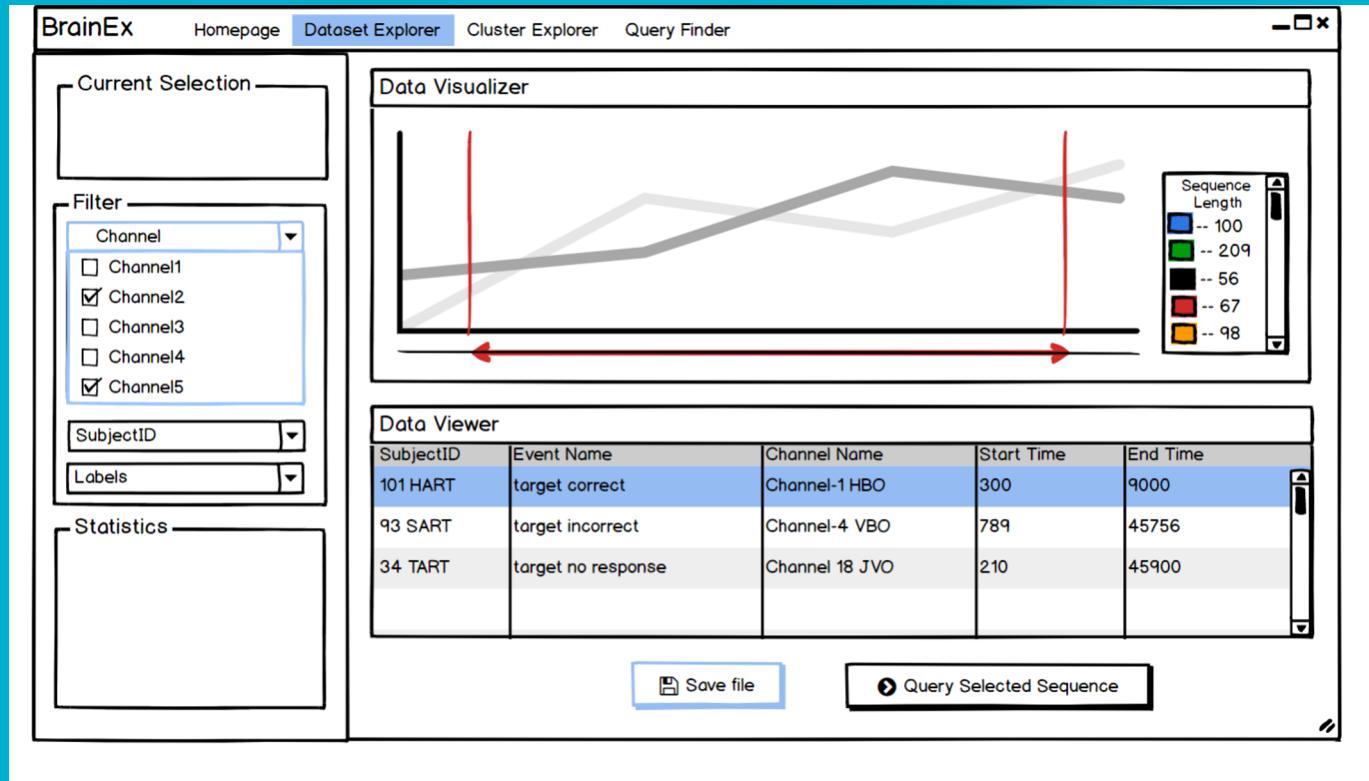
---

## Takeaways:

- Shift our perspective from the developer's point of view to the user's point of view while taking into account the capability of the backend.
- Use site maps to help us solidify the overarching structure of the design.
- Current version of design excels at giving user control and freedom. However, this might not be as desirable to novice users.
- The most confusing aspect was the navigation from screen to screen and something we did well are the data visualizations and the providing useful filters



Sketch of query finder page low-fidelity BrainEx prototype



Query finder page from low-fidelity prototype

# Mid Fidelity Prototype - Usability Refinement

---

**Goal:** Make sure control flow is as intuitive as possible before moving onto high-fi design where we can include more design elements. Allow users understand/navigate through the system without much external guidance.

## **Process:**

- Started with 2 different versions to test the user response in regard to the control flow
- Made major changes to combine the strengths in both versions
- Fixed small details based on heuristic evaluation results

# Mid Fidelity Prototype - Usability Refinement

---

## Outcomes:

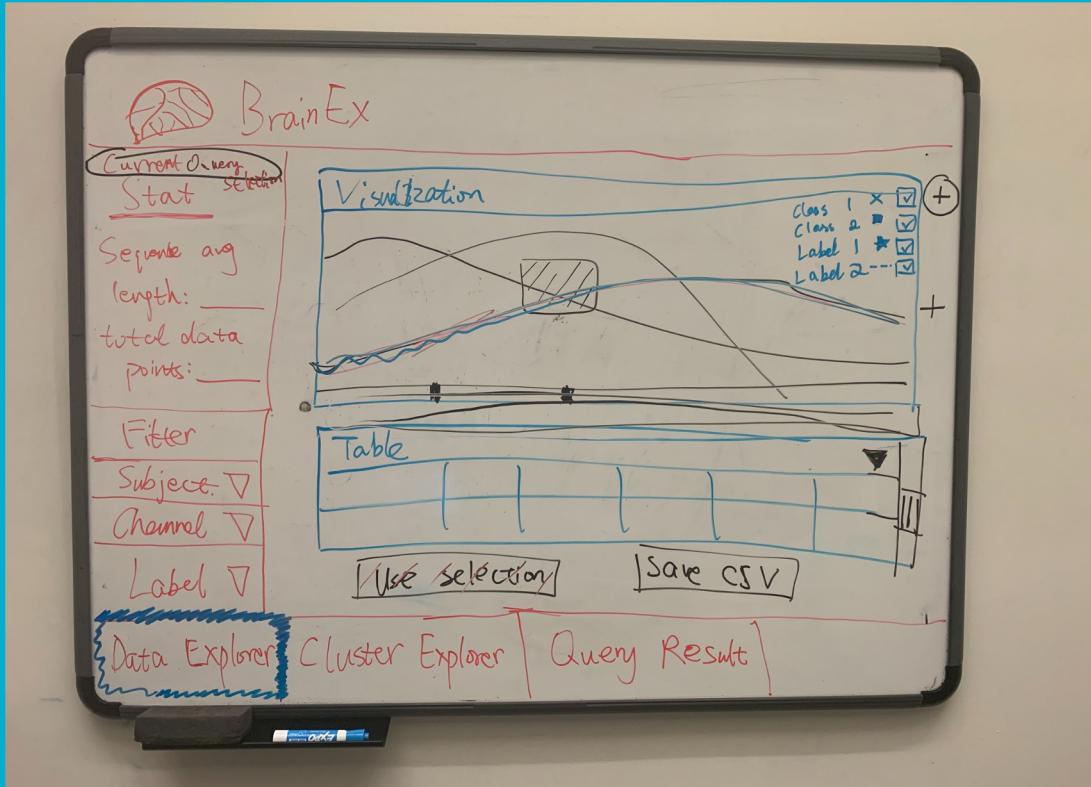
- This time we made sure to fix anything either 1) important or 2) can be done quickly; to address any issues ASAP before another user testing.
- According to the team, areas that need focus are error prevention and flexibility (shortcuts).
- A total of 5 subjects that tested the application overall gave positive feedback. There were not many concerns with this prototype other than adjusting control flow and users said this version was better than the low fi

# Mid Fidelity Prototype - Usability Refinement

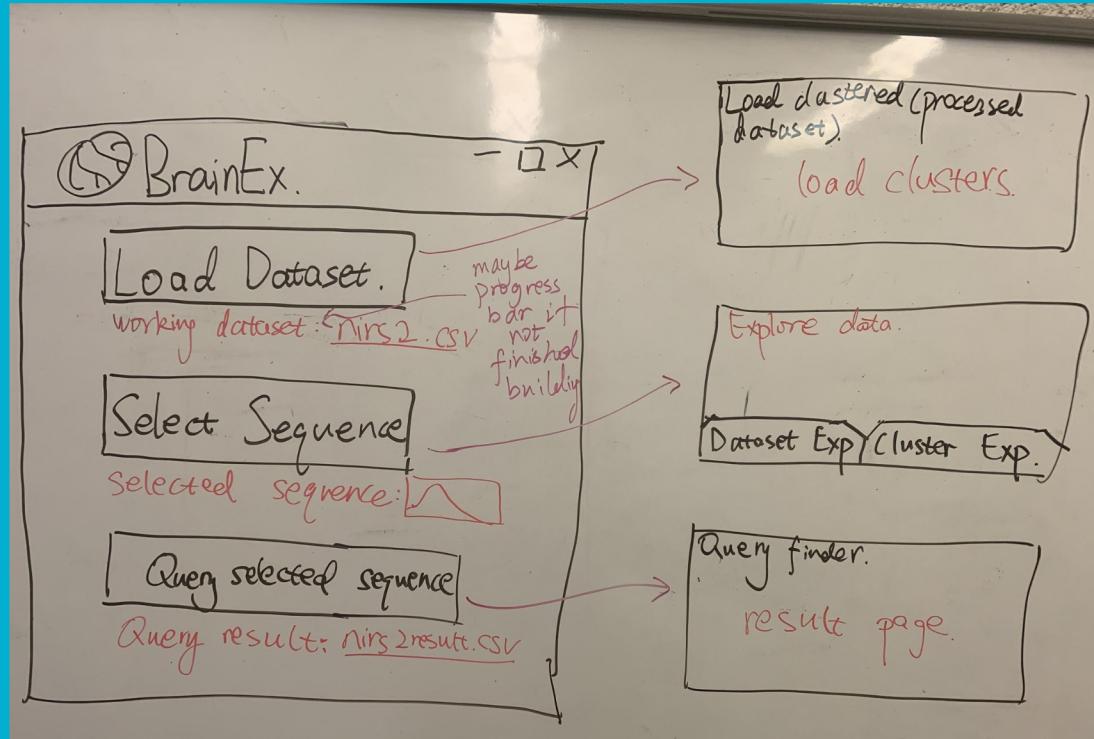
---

## Takeaways:

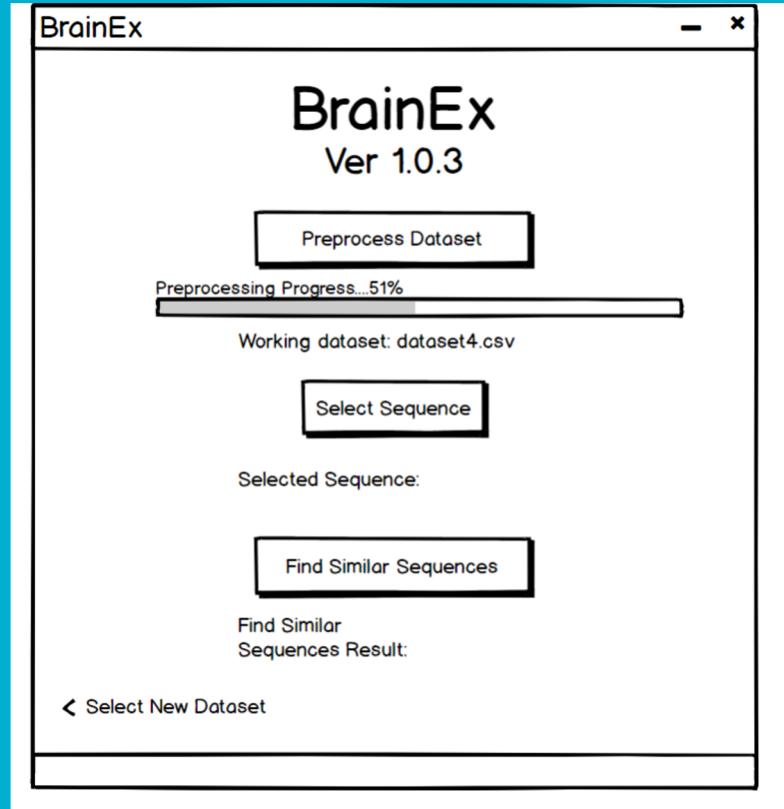
- Continue being adaptable. Apply changes quickly unless the issue needs a serious discussion among the group.
- Moving forward, we will have to make tradeoffs to address issues for specific users. Prioritization will be necessary.
- User tasks should be worded more clear and concise, which will be addressed in the high fidelity prototype
- Start moving our mockup to Invision to gradually shift our focus to usability by including more visual elements that are more difficult to achieve with Balsamiq.



Sketch of mid-fidelity BrainEx prototype Ver.1



Sketch of mid-fidelity BrainEx prototype Ver.2



Mid-fidelity BrainEx prototype Ver.2

# Moodboards

---

**Goal:** Articulate the correct tone for the users' demographic and map out the team's potential choices of font, color, and styles that the team can use when creating the final prototype.

## **Process:**

- Used Adobe to find appealing color schemes, fonts, and pictures to emulate the style of BrainEx that the team envisioned
- Collected feedback from five users in total and asked their preference on the two following moodboards.

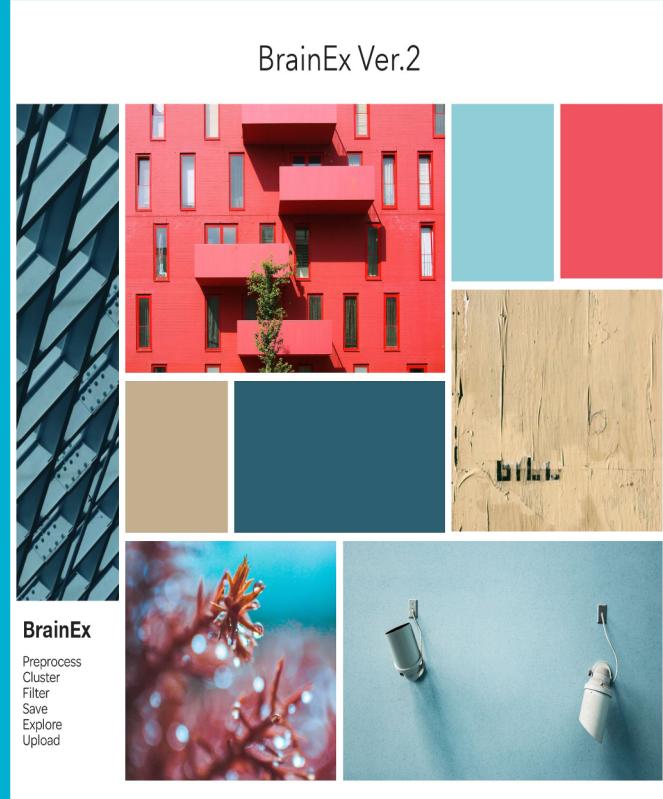
# Moodboards

---

BrainEx Ver.1



BrainEx Ver.2



# Moodboards

---

## Outcomes:

- 4 out of 5 users preferred Version 1 - the blue color scheme
- The team decided to adopt a blue color scheme and font choices of Open Sans (for texts) and Lora (for headers).

## Takeaways:

- It was interesting to see during the process of designing the moodboards how different color choices and fonts can instill essentially different themes or “moods” throughout the application

# Final Deliverables

---

- High Fidelity User Mockup
- Implementation of initial framework and functionality of BrainEx
- Final Paper

# High Fidelity Prototype - UX Refinement

---

**Goal:** Incorporate more details and interactions into the design and center the design around previously defined user tasks to gather the most useful feedback. Have a fully designed and interactive prototype.

## **Process:**

- Quickly tested multiple tools including FluidUI, Proto, and Adobe XD to determine the most effective tool to create the screen designs
- Implemented the mockup on Adobe XD, which was later transferred to Invision to enable the navigation and interactivity
- Tested the prototype with 3 users in the HCI Lab

# High Fidelity Prototype - UX Refinement

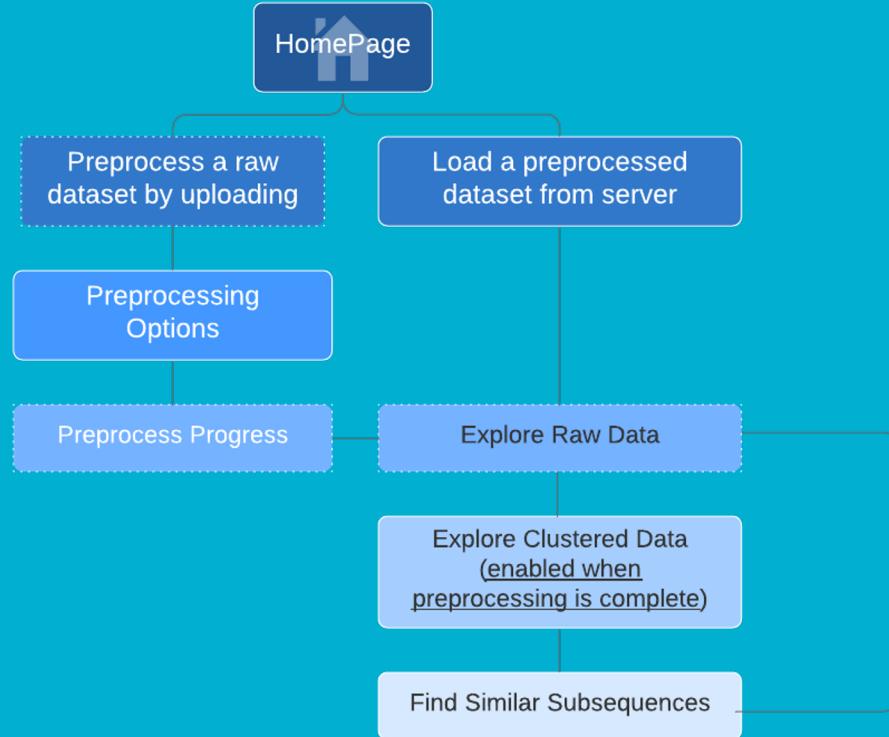
---

## Outcomes:

- A very detail-oriented prototype design.
- Addresses previous issues such as inconsistent and confusing label names.
- Most of the user feedback were not any major concerns in the application, but rather about aesthetics, designs, and placement of content on the page.

## Takeaways:

- At this point, some decisions that we try to make do not have “correct” answers as it is largely based on user opinions and preferences.
- There will have to be tradeoffs and we will need to weigh the user feedback in order to make the final design choice.



Site map for high-fidelity prototype

---

Demo!

# Implementation

---

**Goal:** Set up an initial framework and functionality of BrainEx so that the team can immediately pick up implementation in C term.

## **Process:**

- Consult the backend developers on how to run through the BrainEx command line
- Look at tutorials and online resources about creating a React application as well as uploading files to the server
- Show the progress to the team and advisors for feedback
- Improve the previous version based on user feedback

---

Demo!

# Implementation (Part 2)

---

## Outcome/Accomplishments:

### Initial Framework

- Configuring React, Bootstrap, Express/Axios Server, Backend in one frontend project
- Developing all the page components and templates of each screen in the high fidelity prototype
- Adding Navigation/Routers/Buttons to all the page components

### Design

- Creating the frontend of the homepage screen
- Creating most of the frontend for the CSV Data Viewer screen

# Implementation (Part 3)

---

## Outcome/Accomplishments:

### Documentation

- Added documentation to the frontend and server code
- [Hosted on Github](#) to enable easier version control
- Wrote a [tutorial](#) for those who would like to further work on the program

### Server

- Wrote and tested the Express Server to acquire and process client side info. For now, the info includes the files uploaded to the UI by the user
- Adding the BrainEx backend created by the developers to the frontend project directory. Ran through the command line and the gxdb object has been created.
- Completed the functionality to allow the user to upload files to the homepage screen and server. Multiple csv files can be added on the UI, which then get added into a data folder in the project directory
- Error Checking: The only files that get uploaded are “.csv” files. All other files, such as image files, will not be added to both the UI and server

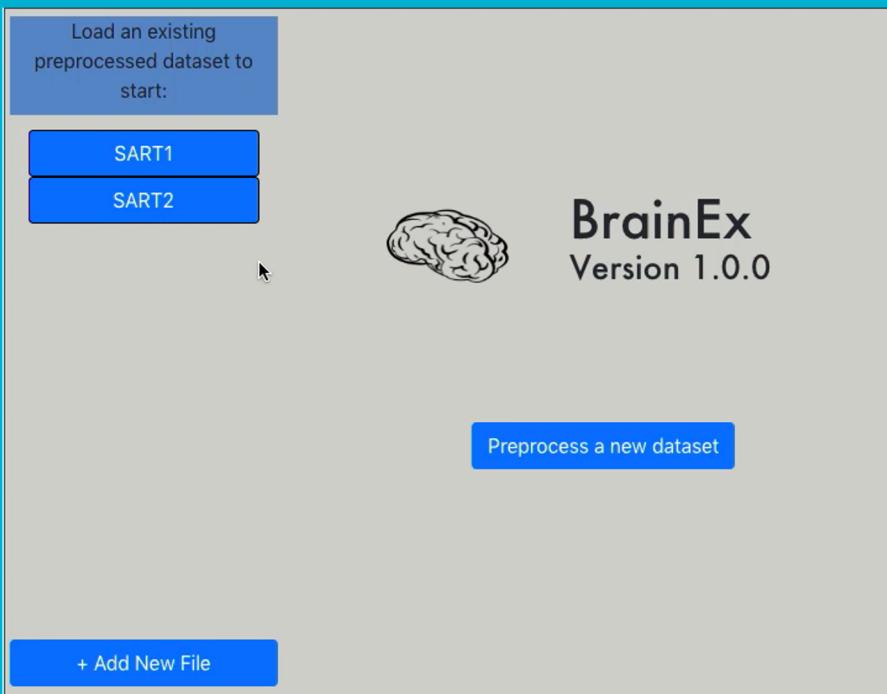
# Implementation (Part 4)

---

## Takeaways:

- Quickly being able to learn and integrate different technologies
- Implement aesthetically appealing designs in the frontend
- Know who to go to for help and be able to solve errors in the app
- Presenting and communicating the work being done
- Collecting, prioritizing, and applying feedback to improve BrainEx
  - Some feedback in the first implementation included getting rid of the background interface container in gray
  - Improving the homepage UI to look more professional
  - Making sure buttons and text are aligned
  - Determine a better color scheme

# Implementation (Part 5)



Before

The screenshot shows the optimized state of the BrainEx application. The overall layout is cleaner. The top navigation bar includes a "Homepage" link and a "Need Help?" link. The main content area has a blue header with the text "Start with an existing preprocessed dataset:" followed by four blue buttons labeled "SART1", "SART2", "SART3", and "SART4". Below this is another section with the text "Load another preprocessed dataset:" and a "Choose File" input field showing "No file chosen" and an "Add" button. At the bottom right is a blue button labeled "Preprocess a new dataset". A descriptive text box on the right side states: "The tool that helps find the top similar matches in fNIRS time series sequences".

After

# Future Development (Prototypes)

Items not addressed in the mockups:

- For a previously preprocessed dataset, navigate straight to preprocessing options screen and don't need to show the csv file in CSV Data viewer
- Make BrainEx more consistent with other tools in the lab, such as the Matlab Gui, in that the user inputs and selections can be on the right side of the screen instead of the left
- For the help button, don't use a long readme document and instead have tooltips/question mark buttons with descriptions and some examples of the feature that is being elaborated if the user wants it
- For more items that were tabled, please refer to [this document](#)

# Future Development (Implementation)

---

Items to be addressed during implementation (C term):

## Homepage

- Dynamically adding a button with the file contents every time the user uploads a csv file and clicks on “Add”
  - Error Checking: User should not be able to add the same file again and check if the files have already been preprocessed
- Add a pop up window/content for the “Need Help” button

# Future Development (Implementation)

---

Items to be addressed during implementation (C term):

## CSV Viewer

- Determine how to add the “choose file” functionality on two separate components in react (home screen and CSV Viewer) -> specify in the express server that the files uploaded on the two separate pages go into different folders in the project
- Preview the CSV file when, for example, the user clicks on the dataset1 button

# Future Development (Implementation Pt 2)

---

Items to be addressed during implementation (C term):

## Preprocessing Options

- Clean up the user inputs to make sure the labels and actual user inputs are on the same line
- Add pop ups/content to the question mark buttons next to each user input
- Have a double range bar for the length of interest option
- Add feature number as a user input parameter
- Retrieve the user inputs from the client side using Javascript and then pass them to the backend to proceed with preprocessing

The rest of the screens, such as the progress bar to show the status of clustering the data, explorer screens for viewing raw data and clusters, and the find similar sequences screen need to be implemented from scratch.

Technologies:  
React,  
Bootstrap,  
Express

UI/UX  
Design and  
HCI  
Principles

Work  
together as  
a team

Develop  
interview  
skills

fNIRS, BCI,  
brain data,  
time series

Being  
organized  
and  
managing  
our time

What we  
learned

Communication  
is key

Taking  
constructive  
feedback