Comprehensive Creative Technologies Project: Migraine Tracking and Visualisation

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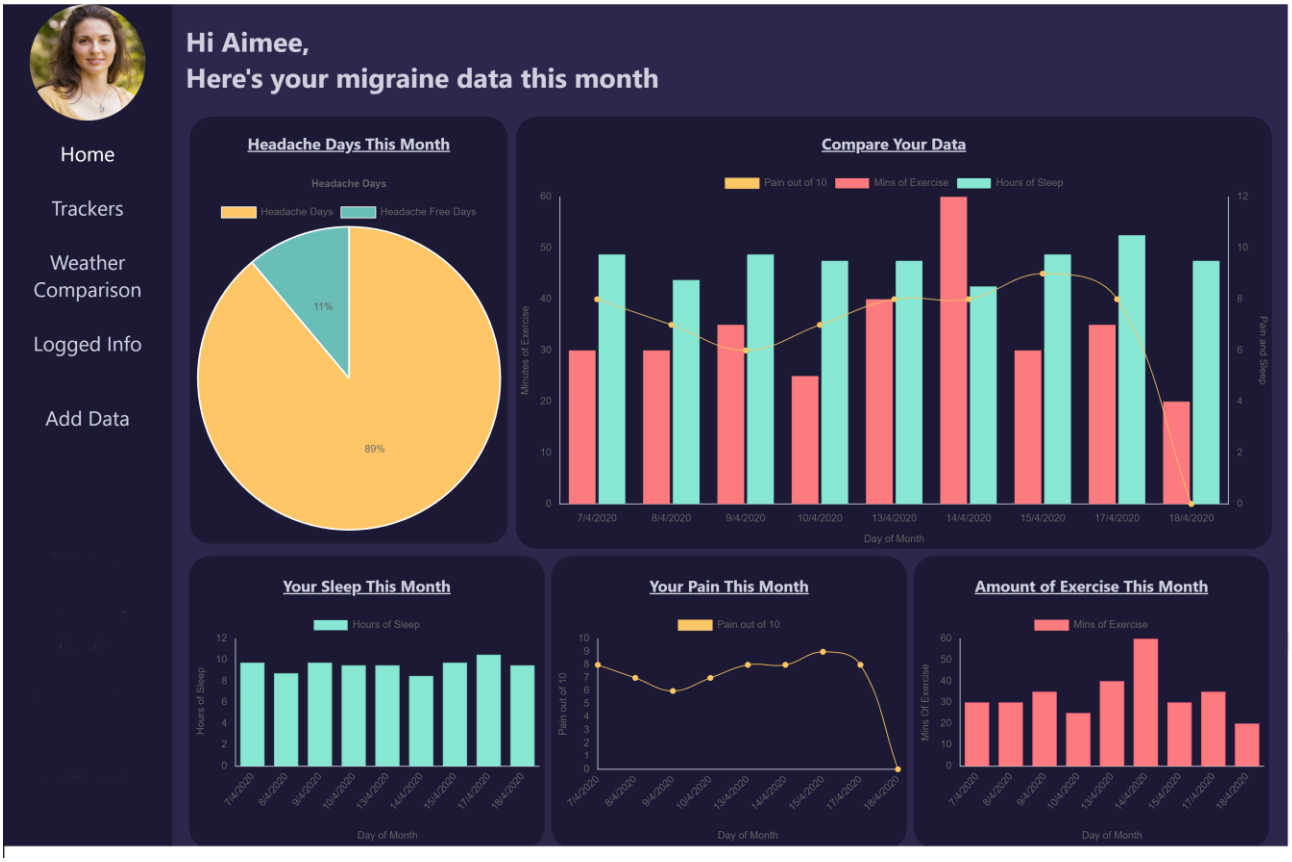

Abstract

This project develops a migraine tracking web application that visualises user's data to allow meaningful insights into their health to be made. This application allows migraine sufferers to discover trends and anomalies in their health, looking at how different elements correspond with the aim of uncovering the cause of their migraine. The web application is developed using JavaScript libraries Chart.js and Node.js, to build an adaptable, user-friendly tracker that solves the problem of no existing, migraine specific health trackers that are simple to use and provide user with valuable insights and visualisations to understand their health.

Keywords: data visualisation, migraine, data tracking, health tracking, insights

Brief biography

Aimee has a keen interest in data visualisation, she enjoys working with coding languages to create interesting visualisations that allow the reader to understand an otherwise complex, boring set of data that might be tricky to read. She enjoys the challenges of working with new coding languages to problem-solve and challenge herself. The project was inspired through personal experience with chronic migraine, Aimee wanted to user her existing skills to develop an application that would help others in daily life.

How to access the project

Live Project:
https://aimeeholdsworth-cctp-migrainetrackingapplication.glitch.me

GitHub Code:
https://github.com/aimeeholdsworth/cctp_migraineTrackingApplication

1. Introduction

The aim of this project is to use data visualisation as a way of communicating migraine data to the user, allowing them to gain meaningful insights to improve or manage their health. Roughly 1 in 7 people suffer from migraine (Migraine Trust, 2020) and there is no easy way to determine what triggers a migraine attack. To be able to manage migraine you need to be able to identify what is making it worse. This project allows the user to gain clear insights with the aim of spotting a trigger.

This project is important as there are currently no useful migraine tracking apps on the market that allow the user to personalise their experience to best suit them. Migraine affects each person differently and there is no one cure for migraine, meaning that there isn't one best way to track migraine data. Users need to be able to choose what data matters to them so that they can get the best out of the product and use something that will aid them in controlling their health rather than just mindlessly tracking data with no outcome.

This application seeks to answer how a range of aspects of life affect different people in different ways. For this project an initial prototype has been created, because of this the author decided to choose which trackers to use for testing functionality with the aim that in the future the prototype can be further developed to be personalisable. These trackers were chosen after research identified them as the most prominent ones that affect the majority of users. Through the use of this web application users can see how different trackers such as sleep, exercise and pain affect each other. Visualisations allow the data to be better understood in comparison to a list, which can be overwhelming and difficult to pick out key information. Graphs simplify the data and allow the user to see trends and patterns at a glance without spending hours analysing the data. When using this application users will be looking to better understand their own health and hopefully identify what is causing their migraines.

Project Objectives:

- Develop a web application that eases the process of tracking a migraine and provides valuable insights
- Link to a weather API to give storm/pressure alerts
- Design an easy to use and view interface that succinctly visualises data

Key Deliverables:

- A responsive high-fidelity prototype that is hosted online allowing users easy access
- Save user entered data to a database where it can be accessed to create graphs and report back key insights such as averages
- Provide the user with a range of useful, easy to read visualisations based on their entered data

2. Literature review

Initial stages of this project's development included researching migraine and current practices of tracking health data. This research was completed to gain a deeper understanding of migraine, allowing a user-friendly application for migraine tracking to be developed.

Key terms were used when researching, using this key criterion would allow relevant data to be uncovered. These phrases were chosen as key terms because they related to the topic of this project of tracking migraines, however, they were broad enough that they would uncover paths of research that might otherwise not be considered. All the key terms relate to each other allowing relevant, connected research to take place.

- "Migraine"
- "Health tracking"
- "Self-tracking"
- "Fitness tracking apps"
- "Data tracking and analysis"

Research allowed the project to progress with a clear understanding of the current best knowledge surrounding the subject matter. It became clear that data tracking holds many different purposes, but the goal of using a tracker is always to find something out. Lupton (2016) says that data tracking is not a new process, but it's the methods we use to track which are ever changing and this is how we generate new insights and forms of data.

Data tracking is about empowering the user by providing them with motivation through meaningful data to improve their life (Lomborg and Frandsen, 2014). Self-tracking is a method of communicating and identifying health issues, however, specific data needs to be tracked to do so. Self-tracking works when the user is tracking key, specific details opposed to a broad range of every element relating to their life. This allows the user to go in-depth and uncover meaningful insights.

People use self-tracking as a search for visibility and as a way of translating their daily life. By using visualisations it is possible to uncover daily rhythms (Ruckenstein, 2014). Walker (2014) shows that users can grow as humans by gaining a deeper understanding of themselves, by realising how the data affects their day to day life the user's perspective changes, encouraging positive changes in their lifestyle. However, there needs to be a balance in what data is collected and how detailed the information is. Rhodes (2015) discusses the delicate balance between collecting detailed information to gain insights and demotivating the user because the application is requesting too much data for entry. This is also discussed by Ackerman (2013), the tracking process needs to promote motivation, usually with a personal reason. If users are working towards discovering a goal this will keep them interested and motivated.

Ackerman (2013) also discusses platform types for trackers, most trackers are available as mobile applications, this is the easiest, most convenient platform for users to access but is less adaptable for viewing on a range of larger devices. How the tracker communicates with the user is very important, both to represent the data it is tracking and to remind the user to track. Users don't want to be harassed with reminders to enter their data but for the application to be useful it is important they have a reason to use it, a goal to work towards as a way of motivating themselves to enter data. A reminder or notification service can be useful, as long as the user isn't overwhelmed. Visualisation of a problem is the best way to understand it (McCurdy, 2019), clear design choices need to be made to best interpret the data to translate data into a readable format.

Data scales can be understood differently from person to person, as such it is important to use quantified scales, what one person might consider as good could be considered bad to another. Data needs to be quantitative for consistency and to allow the data to be represented visually. (McCurdy, 2019).

3. Research questions

Through initial research a set of questions arose that needed to be answered to provide users with a product that suited their needs and would help to solve the problem set out by this project (that there is currently no easy, flexible way to track and analyse migraine data to spot trends and or triggers).

Key Research Questions:
(Appendix 1)

- Why do users want to track their health data? Or, why don't they want to track their data?
- What data needs to be tracked? What is the best way to visualise this?
- What features need to be included to successfully track and visualise migraine data in a succinct way?
- How does migraine affect different people?

These questions arose when investigating theories surrounding health tracking and the ways of self-tracking that already exist. People that track their health are doing so in a search for visibility, they want to use this information as a translator to learn more about themselves, to create a successful web application this project required discovering what migraine sufferers were trying to find out about themselves so that trackers could be developed to provide the user with this information.

Talarska (2016) identified that migraine is different from person to person, no two people will suffer in the same way with migraine. This realisation leads to the question of "how does migraine affect different people?". To be successful this project needs to identify how it can work for many users in many different ways, the project needs to be adaptable to suit user's needs, to do this it is vital to find out how migraine challenges people's day to day life.

It became clear that graphical visualisations would be needed in this project, a key question then became how the data would be visualised. Ramirez (2012) discusses how seeing visualised data not only makes the doctors life easier as they can quickly get an understanding of the patients health but that lifestyle changes can be reinforced if the user can see that the changes have been working. Graphical representation shows the user their actions are paying off in a way that makes understanding data clear and simple. Visualising a problem is the best way to understand it, as such the correct visualisation needs to be chosen to clearly represent each set of data so that the data isn't misinterpreted (McCurdy, 2019).

4. Research methods

To answer the research questions, it was necessary to undertake several forms of research, these included:

- Semi-Structured Interviews
- Analysis of Current Systems
- Primary Research into migraines and the surrounding area
- Developing Personas
- Informal Interview with an Expert

Interviews

The main focus of research was Semi-Structured Interviews, by talking directly to migraine sufferers an in-depth understanding of the users' needs was gained allowing a solution for this problem to develop. The interviews were conducted in an informal, semi-structured manner to put the participants at ease and to discover paths of conversation that may have otherwise been missed. Unstructured interviews were avoided as the researcher had some specific questions that needed to be answered and it would be easy to forget about these when having a general conversation.

The purpose of conducting interviews was to discover how migraine affects different individuals, through gaining a deeper understanding into the condition and the way it impacts daily life. To develop a tracker that would aid users it was necessary to complete interviews to uncover what would motivate people to use a tracker and what the users needed from the tracker.

During the interview stage of research, 3 participants of varying ages, backgrounds and gender were sat down with individually. It was vital to interview a range of people even with a small participant group, this was to access a broader spectrum of people's experience with migraine and to gain a deeper understanding of the condition as it doesn't impact everyone's life in the same way. The participant group was kept small to allow the researcher enough time to analyse the results during the short timeline of this project. Using thematic analysis, the data was broken down and organised via journaling methods and creating mind-maps to show connections. This allowed themes such as participants attitudes, user needs and migraine data to be revealed.

For the interviews, a set of qualitative and quantitative questions were developed, these were to act as a basis for the conversation to get it flowing but the interviews were open to changing direction. It was important to get qualitative information as a way of accessing deeper insights into participants' experiences, whilst the quantitative questions would provide statistics and numbers that gave a numerical view on how badly migraine affected participants' lives. (Appendix 2)

To make sure that interviews were conducted ethically and professionally participants were given a consent form and information sheet before interviews were conducted. This explained that they would remain completely anonymous during this process and informed them how they could pull out of the project should they wish. (Appendix 3 and 4)

Analysis of Current Systems

Competitor analysis was completed as a way of determining what worked well in practice and what didn't. The researcher used two different existing migraine tracking applications for 1-2 weeks each to monitor their own health, Nomie (2019) and Migraine Buddy (2020).

Nomie is a web-based application for "tracking your mood and everything else". It is a basic application that allows the user to choose from a list of predefined trackers or create their own tracker, this provides the user flexibility allowing them to adapt the application to best suit them. Migraine Buddy is a mobile app specifically for tracking migraine related data, it has a set list of data that the user must enter to track their migraine.

Expert Interview

An unstructured interview was completed with a medical informatics expert to apply some of their knowledge on health tracking to this project. It was useful to sit down with the expert as this was a way of extracting expert, in-depth relevant information surrounding the topic. To develop a successful application, expert information needed to be applied to the user's needs. This research method brought to the forefront of the project what needed to be included to create a successful tracker, without access to expert knowledge it would've taken longer to get this understanding and uncover this information.

5. Research findings

The key findings from research were:

- The app needs to be a flexible and personal experience as migraine is different for everyone
- List of potential trackers
- Users would use the app with the purpose of understanding the cause of their migraine
- A dark colour scheme needs to be used

Interview Findings
Completion of research confirmed that every migraine is different, meaning the web application needs to allow personalisation. Users need to decide what data matters to them and be able to track this, the application can't fulfil its purpose if it pre-determines what information is tracked. Different people are interested in using the application in different ways, not everyone wants to track the same information. Interviews identified a list of potential trackers (Figure 1) that participants thought were the most important and relevant to the majority of migraine sufferers. It was decided that although the users need a flexible experience, pain needs to always be tracked. Without tracking pain, it would be impossible to see how different lifestyle factors are affecting the users' migraine.

(Appendix 5 - 25/11/19)

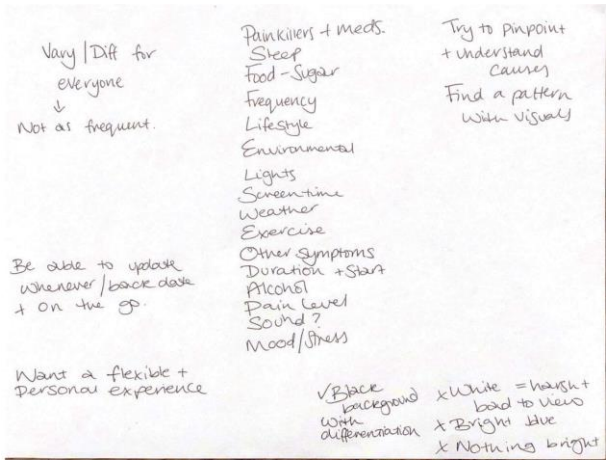

Figure 1- Key Research Findings

To offer users an adaptable and personalisable experience, the app needs to work around them, not the other way around. To allow this, participants stated that they would like to be able to track data when they wanted and that allowing the backdating of entries would be vital. If a user is in the middle of a bad attack, they won't want to be looking at a screen and focusing on logging data. This information influenced the data entry section of the project, a key feature would be allowing the user to input old data when it was convenient to them.

Conducting interviews confirmed the aim of the application, participants said that they would use the application with the purpose of gaining a better understanding of their health, but more specifically to find out what is triggering the migraines and if there are any patterns in their health. This identified how important visualisations would be to the project, the visualisations allow the user to spot patterns they may have otherwise not realised existed. This influenced the project by developing how the graphs linked together, to be able to easily spot correlations more than one set of information will need to be shown on the same graph. Through this the multi-tracker graph was developed, on this graph the user can see all their trackers next to each other and they can turn on/off data to get a closer look at different links.

Interviews identified eye strain as a migraine factor and how colour affects migraine. Participants said that bright colours, specifically a white background is difficult to view and makes their migraine worse. Further research was completed into what else can cause unnecessary strain on the user's eye, this application needed to be as easy as possible to view and avoid anything that could make the users migraine worse. It was concluded that a dark colour scheme would be used to reduce the brightness and glare and that font size needed to be increased and a sans-serif

font should be used. This reduces the amount of time the user needs to stare at one spot to take in the information.

Quantitative questions were useful in identifying how the application could fit into users daily lives, participants said that they were negatively effected my migraines at least once a week, often several times, showing that there is need for the application on a day to day basis. It identified that this application would be particularly useful for chronic migraine sufferers who have pain most days of the month.

Existing Systems Findings

Through use of different health tracking apps, the researcher confirmed that allowing the user to choose their trackers was vital. Migraine Buddy (2020) doesn't let the user continue if an entry is left blank, this is very frustrating as the predetermined fields might not relate to the user meaning they are spending extra time inputting information and looking at a screen when they aren't interested in this piece of information.

The data entry process needs to be as simple as possible to encourage the user to track their data, there is nothing forcing the user to use the application and as such it is important to encourage the user to enter data through user intuitive design and an easy to use application. Nomie (2019) excels at keeping the tracking process simple and personable, qualities that need to influence this project. Nomie (2019) was a little too basic, it isn't an exciting platform to use and doesn't grab the user's attention, it fulfils its purpose by tracking but good design is often what draws a user to want to use a product in the first place.

Logged data needs to be easy to access and read. Both applications list the entered data rather than visualise it, making it harder for the user to make connections and gain a deeper understanding of their health. The user can't see how each piece of data relates thus making it harder to identify what is worsening their health. Visualising data is the main selling point of this application, the application will use colour and graphs to display data, however, the list format is very good at showing all data entered on one day. It was decided that this could be a useful extra feature if users need to see exactly what was entered one day all in one place. This sparked the idea of the calendar page, a page where users can see all data for each day.

6. Practice

Adobe XD Mock-Up

The first stage of development was to create a mockup, this allowed the researcher to design and test a version of the application before starting to code. It was decided that Adobe XD would be used to develop an interactive prototype, XD was chosen for its ease of use and scope for building a functional and interactive mockup.

Before development in XD took place, paper wireframes were developed. Rough sketches were developed to create different designs and try a range of potential ideas, this process was a good way of quickly and easily starting to design. Feedback gained from the project supervisor and potential users led to the design being simplified. Initial iterations included designs for a profile set-up process, creating too many pages to develop. Original designs also meant users had to click too many times to access information, there wasn't easy access to tracker data and it was recommended to focus more attention on key pages, making data access as simple as possible. It was decided that the scope of this project needed to be cut down to suit the timeframe, designs for profile set up pages were put to one side as this could be something later developed and didn't need to be focused on during this project.

A dark purple colour scheme would be used, to conform with interview research that bright and bold colours create more glare and eye strain for the user which could cause a migraine. Shades of purple are used to create differentiation on the page whilst brighter colours are used to draw the users attention to the key information, the graphs. These colours are toned down and not used in large quantities to avoid triggering a migraine.

The mockup focused on the key pages, a home page showing an overview of tracked data and a calendar page showing all the data each day (figure 2). Testing was completed allowing users to freely interact with the mockup to see if the design was intuitive, participants liked the colour scheme and the deep purple was easier to view than a traditional white background, but it wasn't a dull design. Through this round of testing it became clear that users would like to see more information about their data, the home overview page wasn't detailed or large enough to pick out key data. This developed the in-depth pages where users can see detailed analysis of their data (figure 3).

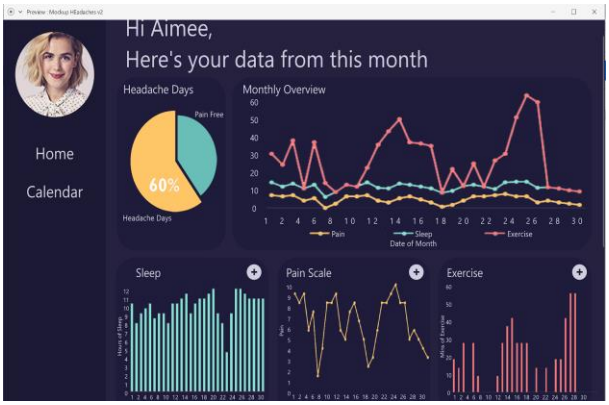

Figure 2 - XD MockUp Home Page

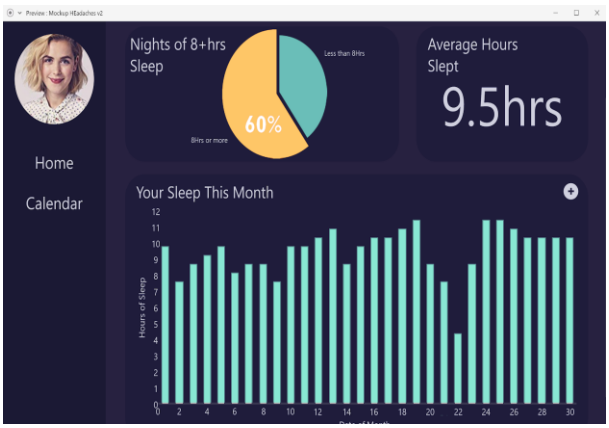

Figure 3 - XD MockUp In-Depth Page (Sleep Tracker)

Feedback was that users would prefer for the text to be made larger so that it was easier to view and for most of the text to be kept the same size for continuity. Users requested that they could see all their trackers on one graph so that they could compare and contrast the data. (Appendix 6)

Prototype Development

The high-fidelity prototype produced for this project was developed using JavaScript, the JavaScript library ChartJS (2020), HTML, CSS and Node (Foundation, 2020). It was decided early in the project's timeline to use ChartJS (2020) opposed to other charting libraries. ChartJS (2020) was used for it's simplicity, scope and adaptability.

To start the project it was necessary to first get to grips with ChartJS (2020), the researcher had no previous experience with this library, so to make the development of the project run more smoothly it was important to take time to understand the library. This gave the researcher a basic knowledge to work from before the project got more complex. A series of tutorials (D Shiffman, 2019) were followed which related to the aims for this project, these tutorials were then built upon with the help of ChartJS (2020) documentation.

Data Entry and Storage

NodeJS (Foundation, 2020) was chosen for the database functionality side of this project, this was one of the most complex parts of the project as it required the two sides to communicate and work together, the code had to be properly set up to GET the user entered data and POST it. The database stores all of the user data and then is accessed to create the visualisations. The project followed the process of getting a simple version set up to check everything worked before progressing to make it fit the design and become more complex. A simple input box was created which posted the data with a timestamp to a database and then could be fetched and displayed on the HTML page, this created the basic functionality for the calendar page.

A modal was created as a way of allowing users to enter their data, it seemed unnecessary for users to go to a different page to enter data (Figure 4). In the original mockups each tracker would have their own data entry point, however, after feedback from potential users it was decided that this wouldn't be user-friendly design. Users would prefer to enter all the data at once opposed to going to several data entry points.

The data is collected from the modal by saving the value of each input value into its respective variable when the submit button is clicked, this data is then sent to the database using POST and node functionality (Figure 5).

```
//User data entry - enters the data the user inputs in the modal to the
 const button = document.getElementById('submit'); //when the submit butt
 button.addEventListener('click', async event => {
   pain_value = document.getElementById('myRange').value; //gets each cor
   sleep_value = document.getElementById('sleep_value').value;
   sleep_value_mins = document.getElementById('sleep_value_mins').value;
   exercise_value = document.getElementById('exercise_value').value;
   extra_info_value = document.getElementById('extra_info').value;
```

Figure 4 - Data entry from the modal

```
// adds all these variables to data - data is posted to the database
data = {pain_value, sleep_value, sleep_value_mins, overall_sleep, exercise_value,
  pressure: api_data, precipitation: precipitation, data_date, extra_info_value}



const options = { //post data to DB
  method: 'POST',
  headers: {
    'Content-Type': 'application/json'
  },
  body: JSON.stringify(data)
};

const response = await fetch('/api', options);
const json = await response.json();
console.log(json);
```

Figure 5 - Posting the data to the database

Different input methods were used for each tracker as a way of limiting the user to avoid errors as well as simplifying the process of entering data. A slider which limits the user to values between 0 and 10 is used for entering the pain, this ensures the user sticks to the same

scale. After testing, this was adapted to allow users to enter 0.5 increments (Figure 6) to save more accurate pain information as users sometimes felt in-between pain value.

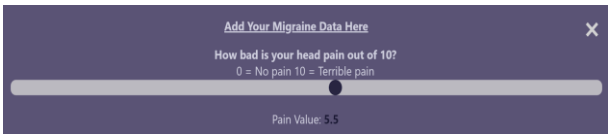

Figure 6 - Pain Scale Data Entry

Drop-down boxes for sleep and exercise stop the user from entering invalid data and the key information box allows the user to enter any extra data they would like to remember (Figure 8). All input methods were chosen for suitability and ease, the data input modal looks at making the users life as simple as possible so that they don't need to spend extra time looking at a screen.

A calendar is used for selecting the date for each entry (Figure 7), users are able to enter data for past or present days, giving them the flexibility, they wanted. The calendar is used to make sure the date is entered in the correct format for continuity and so that the graphs can understand the data.

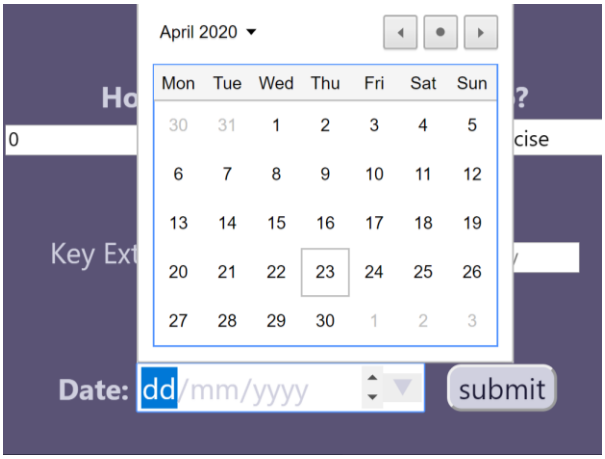

Figure 7 - Calendar data entry to enter date

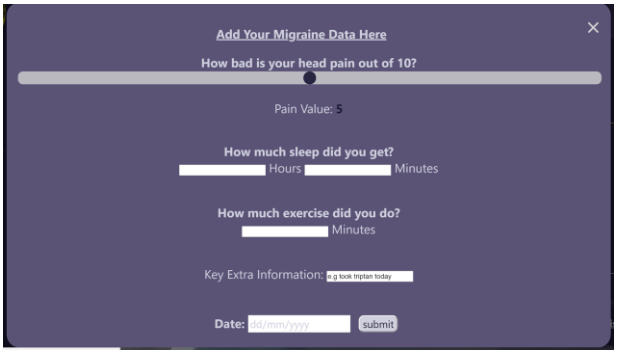

Figure 8 - Data Entry Modal

Graphs

Display Problem

One of the main difficulties with the graphs occurred when new HTML pages were created, when creating new graphs for new pages, the existing graphs would stop displaying. It was discovered that the JavaScript file that contained the coding for all graphs and linked to all html pages wanted every graph to be on every page for it to function correctly. There didn't appear to be a solution for this so creativity was used to overcome the problem. By putting all divs that contain graph canvases on every HTML page but using CSS to show only the needed graphs and hide the others, functionality was restored (Figures 9 and 10).

```
<div id = "weather_chart_page_div" class="hide">
  <h3>Your Precip WEather This Month</h3>
  <canvas id ="weather_chart" width="600" height="400" ></canvas>
</div>
```

Figure 9 - Hide a graph on a HTML page with the class hide

```
.hide{

    display: none;
}
```

Figure 10 - CSS to hide a graph

Multi-Graph

Development of the multi-graph built upon basic graph structure; users had requested an easy way of comparing their data so a graph with several data sets was developed.

All the data is drawn onto one canvas, but the graph includes several datasets. Different styling for each dataset differentiates between them and the label section of the code creates a key for each. Once this was working, the graph was developed and stylised to fit the design (Figures 11 and 12).

It was identified that a potential problem with having several datasets on one graph would be that using one scale would be unsuitable for all the data as the data is compared in different increments and scales. To solve this problem, allowing the graph to be clear and readable two y-axes were created, giving these titles to make it clear which axis related to which dataset allows users to understand the format. It was difficult to incorporate two axes to adjust the scale, time was spent considering the best format and which data should be on which scale.

Figure 11 – Developed multi-graph showing several datasets

```
const myChart = new Chart(ctx, {
  type: 'bar',
  data: {
    labels: date,
    datasets: [
      {
        label: 'Pain out of 10',
        data: pain_value,
        type:'line', //changes this data set to be a line
        fill: false,
        borderColor: '#FEC667',
        backgroundColor: '#FEC667',
        borderWidth: 1,
        order:2,

      },

      {
        label:'Mins of Exercise',
        data: exercise_value,
        backgroundColor: '#FC7B7F',
        order:1 ,//order bar chart is drawn - 1 makes it drawn below

      },
```

Figure 12 - Code for displaying several data sets on one graph

Summary Graphs

To provide the user with detailed analysis and insight into their health, graphs were created that analysed the data the user provided. These helped to fulfil the project aim of allowing users to identify what could be causing their migraines. Research proved that visualisations are the easiest way of understanding data and these summaries were meant to make an impact on the user.

By setting up variables that count the number of data entries that fit certain criteria it was possible to create these overview charts (Figure 13). The code worked with the data entered to count how many times these occurred and put them into new variables which created these graphs.

```
// count number of entries where pain_value is == 0 or pain_value > 0
        if (pain_value[i] == 0) {
          headache_free++;
        } else{
          headache_days++;
        }
```

Figure 13 - Count variable for summary graphs

Where suitable colour was used to represent the data, keys relating to the data helped to make the data more readable at a glance, e.g. heat map colour coding for the pain graph, red is easily identifiable as bad and this indicates the worst pain (Figure 14).

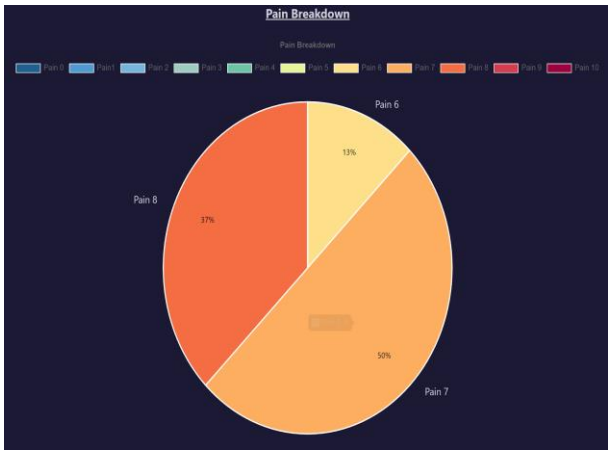

Figure 14 - Example summary graph, pain breakdown chart

Pie charts were chosen for these graphs as they best suited the data by showing it proportionally. The plugin PieceLabel (Chen, 2018) was used to add labels to these graphs to show exactly how many days the data impacted each segment. This provides the user with clarity to their data in a quick, easily accessible way. Styling was applied to the plugin to display the data in percentage format and in the centre of each segment, this is where the user would notice it opposed to the edge of the segment where it may get lost in the labels.

API

During interviews it was discovered that participants thought the weather affected their health and that this could be a potential important tracker. Although users have no control over the weather, they would be able to use this data to gain a deeper understanding of the impact and correlation between the two.

Users would find it difficult to track the weather themselves, so it was decided that the best way of linking the project to the weather was to use an API. WeatherUnlocked (2015) was chosen for this project as it can give current and forecast weather for the next 7 days and it is free to use.

A function was created to get the data from an API call and specific data relating to this project was assigned to variables which would be entered into the database when the user submits their entry (Figure 15). The API is called when the user submits their data, this means that currently if the user backdates their information the pressure and humidity values will be incorrect as the API submits the current weather data. This is something that needs to be worked on in the

future as it would be useful to submit the old data, however, accessing old weather data was a paid for feature and not currently suitable for this project. To overcome this problem, the API could be called each day and this data could be saved to the database in preparation for the user's entry.

```
async function getWeather(){ //function to fetch the we
  const response = await fetch(api_url);
  const weather_data = await response.json();
  console.log(weather_data); //logs the api data


  console.log(weather_data.Days[0].slp_min_mb);

  api_data = weather_data.Days[0].slp_min_mb;//gets the
  precipitation = weather_data.Days[0].humid_min_pct;//

  console.log("Precip today is : " + precipitation);

  console.log(api_data);


} // end of get Weather function
```

Figure 15 - Connecting to the weather API and saving data

To make this information useful, it needed to be compared to pain levels. A page was created dedicated to displaying this information, the same format was followed as for the multi-graph to develop a graph that showed the air pressure compared to pain and one for humidity compared to pain (Figure 16). These came up as the two factors that are suspected of worsening migraines when in discussion with participants.

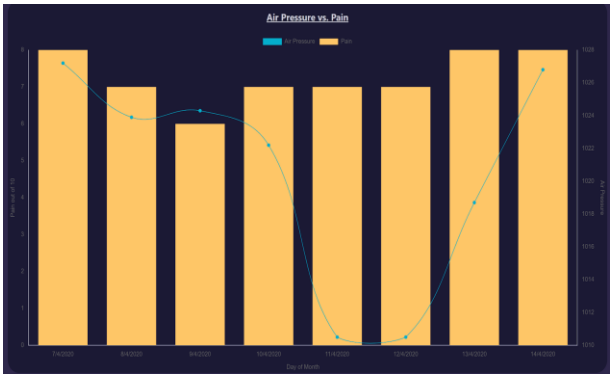

Figure 146 - Weather/Pain comparison graph

When the project was uploaded online a Cross Origin (CORS) problem arose, the WeatherUnlocked api was not suitable for HTTPS calls meaning that the web browser couldn't access the API. The project files had been set up to allow cross origin calls (Figure 17), however, the project could not access the API. This was a very important problem that needed fixing for the project to be tested and so that it could function correctly. After much trial and error of implementing different research methods, the problem was solved by adding a parsing web link in front of the API url. This successfully fixed the problem and the code was then fully functioning whilst hosted online.

```
app.use(function(req, res, next) { //allows CORS
        res.header("Access-Control-Allow-Origin", "*");
        res.header("Access-Control-Allow-Headers", "Origin, X-Requested-With, Content-Type, Accept");
        next();
    });
app.use(require("body-parser").json());
```

Figure 17 - Code to allow cross origin calls

Averages

Similar to the summary graphs, data was analysed to provide the user with averages (Figure 18). This gives the user an insight into their lifestyle and indicates if they may need to make changes. Averages were calculated in a similar way to the summary graphs, variables were set up to count how many times a piece of data was entered, e.g. how many times the pain was 9. These variables were then used for the calculations opposed to using the pain_value variable which only held the data for each day temporarily.

Although a simple calculation, it was difficult to implement this feature. Lots of time was dedicated to getting this working, the same system of counting the data and putting it into new variables in the summary graphs needed to be applied so that the outcome wasn't NaN. The averages needed to be accurate and because of this, any zero values where the user hadn't entered data for that variable, but it had been initiated to zero, needed to be discounted. The average function originally appeared to be working but upon closer inspection it was returning an inaccurate result. To fix this the count value needed to be multiplied by the value it was counting for, this acted as a placeholder and also meant that the initiating values wouldn't be included in the average.

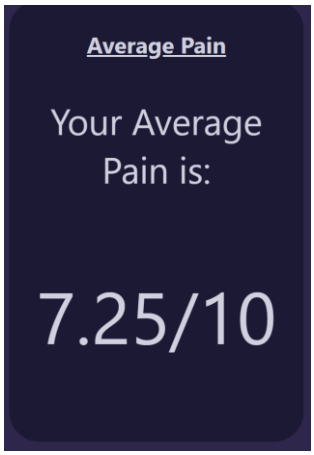

Figure 18 - Average pain displayed on application

Log page

Research identified that a page where the user could see all their data was needed. This is to allow the user to view all data for one day, during development, this changed from a calendar page to a log page. Due to difficulties sorting the data and time constraints on the project it was decided for the purposes of testing to leave this as a log page where the user can view all their logged data since using the application (Figure 19). Ideally, the user would be able to organise this data and view it on either a weekly, or monthly basis. This is something that could be implemented in the future.

The data is sorted in ascending order by the date, allowing users to work their way through all data (Figure 20). Ordering the data via date is logical and easy for the user to understand. This is satisfactory whilst there isn't much data entered but, in the future, filters would need to be applied so the user isn't faced with a page of hundreds of entries.

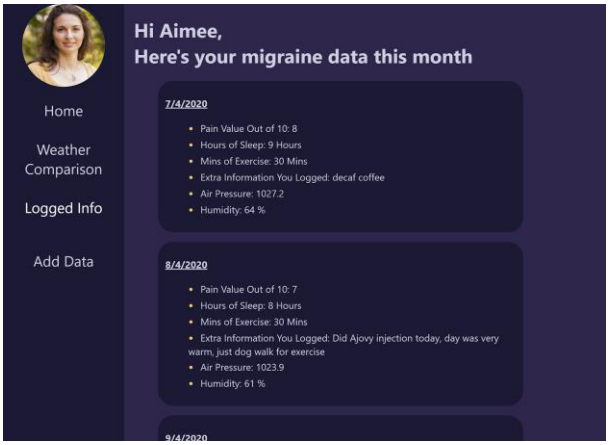

Figure 159- Log page

```
app.get('/api', (request, response)=>{

    database.find({}).sort({data_date: 1}).exec(function (err,docs){
            response.json(docs);
            console.log(docs );
        })

});
```

Figure 20 - Getting the data from the database and sorting it in ascending order

Limiting Data Entry

To stop users from accidentally inputting several entries for one day and effecting the data analysis, the user is limited to one entry for each date. This stops the graphs from showing confusing data where there are several entries and allows the user to get clear insights.

A function was created to check if the date the user was trying to enter data for already existed (Figure 21), if it did this meant that it held data and the user is told they have already entered data for this date. If it doesn't, they can continue as normal and enter data.

```
function validateForm(){

  console.log(data_date);

  for (let i = 0; i < dateArray.length; i++){
    if (dateArray[i] == data_date){
      console.log(dateArray[i]);
      alert("You have entered data for this date already");
      returnToPreviousPage();
    }


  }
}
```

Figure 21 - Function to allow only one data entry per date

Instructions Page

As the prototype didn't include any of the user-set up pages it was necessary to include an introductory page for new users (Figure 23), this was to explain to them how the application functioned and would be needed for testing. This page didn't need to be viewed every time the application was used; code was used to see if the user had accessed the page before and if they had redirected them to the home page (Figure 22).

```
// <script type="text/javascript">
  //Code so that this page is only visited onc
// the app so doesn't need to be seen everyti
    if (localStorage.getItem("visited")) {
      window.location.href = "home.html";
    }
    localStorage.setItem("visited", "true");
</script>
```

Figure 22 - Function to determine whether the user has visited the application before

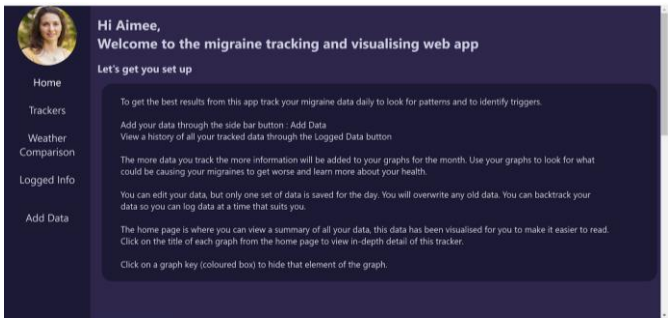

Figure 23 - Instruction page

Testing

An iterative design approach was followed during this project meaning that feedback was gained consistently throughout the development stage and then formal testing was conducted with three participants over a period of 5-7 days once the prototype was fully functioning. Participants were

given access to a tracker online and asked to track their data, at the end of this period the researcher sat down with each participant to gain feedback and observe the participant using the tracker. (Appendix 7 and 8)

Participants requested that they would like their exercise data to be better organised, as such different requirements were made for what classes as light, moderate and intense exercise, allowing the user to choose which best suits them. Initially, the user selected their exercise input from a drop-down box that was limited to 60 minutes and showed no differentiation between types of exercise (Figure 24). This was adapted to allow the user to select the intensity of exercise and enter any numerical value they wanted, using a validated text-entry box (Figure 25).

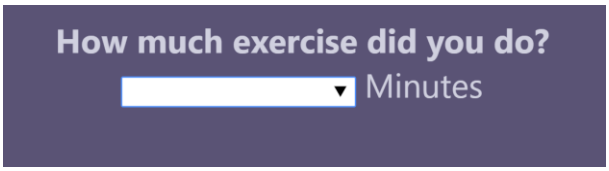

Figure 24 - Exercise input before update

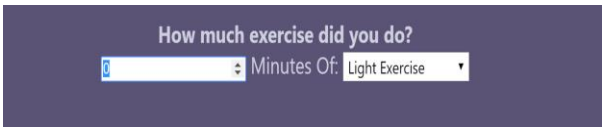

Figure 2516 - Exercise input after update

Users found the separate tracker pages very useful for getting a closer look at their data, however, found it annoying that they had to go back to the home page each time to access the data. It was decided that buttons should be added to the main menu to access the trackers (Figure 26), especially as it was a little unclear that the trackers could be clicked on to access this information.

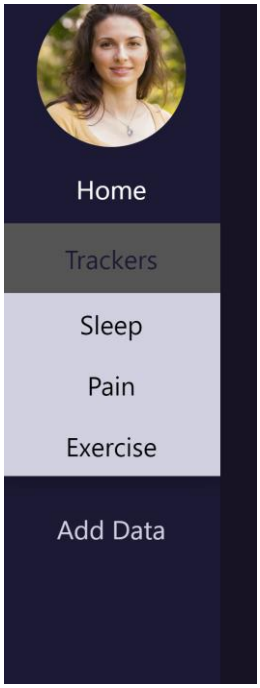

Figure 26 - Updated menu to allow easy access to trackers pages

A minor change was made to the pain scale, allowing users to enter their pain in 0.5 increments, participants requested this as a feature as sometimes they felt their pain was in between two values. Feedback indicated that although the scale was intuitive, it would be useful to indicate that 0 was no pain and 10 was the worst pain, this was added to the project too.

The main outcomes of testing were:
Usability Outcomes:

- Users would like the exercise data to be better categorised
- Users would like to be able to change the view on data, for both the log page and graphs
- Users thought that the layout and colour scheme worked very well, they found it easy to follow and didn't worsen their migraine
- Users particularly liked the multi-graphs where they could compare their data and toggle the view, they found this very helpful in gaining insights
- Entering data was quick and easy, the backdating feature was helpful and often needed

Data Analysis Outcomes:

- Users discovered how lack of sleep influences their health and makes pain worse
- Some users realised that too much exercise made them feel worse the next day

- Some users noticed correlation between the weather and their pain being worse with low or very high pressure
- Users felt they better understood their health and could be more in control of it

(Appendix 9)

Success of development phase

The development phase was successful, using an iterative design approach meant that a user-friendly, intuitive web application was created. It was of great advantage to get feedback throughout the project as it meant there were fewer changes to be made once formal testing was completed.

Although problems were faced, they were handled well and didn't set the project back much. By dealing with these problems as they occurred and spending time to fix them, the project didn't get out of control. Contingency time had been allocated to the project as it was likely problems would arise, this allowed the project to be managed well and time-management didn't get out of control.

Major breakthroughs were made when linking the database to the graphs, understanding how to work with Node was complex and it required time and attention to fully understand how it worked before attempting to get this element to work. Without this the project would've been incomplete and unable to fulfill its purpose. Another breakthrough was getting the correct API data to communicate with the weather graphs, this element took time to get to work, but it was time well spent. Testing participants agreed that this was a vital element as it gives them a deeper understanding of external factors they would've otherwise not considered. It is relevant information that needs to be examined to understand what triggers their migraines.

Many problems were faced during the course of this project, due to the researcher not being familiar with the coding languages and facing new challenges. This was beneficial to the researcher as they developed their resilience and patience in dealing with these problems. Through dedicating time and attention, all were overcome, and the project was completed successfully.

7. Discussion of outcomes

This project impacts the health technology sector, migraine tracking specifically in the health tracking industry hasn't been covered by many applications and there is currently nothing useful for patients to translate their health. This application is original and makes an impact in this sector as it is based on providing the user with insights and understanding into their health through visualisations and analysis, it looks at taking the work out of understanding their health so they can make positive, impactful changes.

The application improves on existing trackers by simplifying the tracking process and giving a thorough understanding of the data, particularly through the use of visuals (colour, fonts, graphs), which all minimise the impact of visual stress. The main improvement compared to existing tracking methods is that this application is designed specifically for migraines, meaning that data collection and design focuses on collecting related data and making it easy to understand. Existing methods of tracking don't create visuals for the user, even though it is proven to make data easier to understand. This application blends together research and current tracking methods to provide the user with a suitable and original way of uncovering a deeper look into their health.

Overall the project is a success, it has fulfilled its purpose of providing users with an otherwise unseen look into their health, users agreed that the application allows you to focus on your health, discovering patterns and gaining a deeper knowledge of what is affecting it. The goal of the project was to allow users to better understand their health so that they could make positive, reinforced changes, through the use of clear graphs and data analysis this has been achieved. Research indicated that users would like to be able to personalise their experience, due to time constraints on this project it was decided that profile set-up wouldn't be included in the prototype. This is something that could be implemented in the future, allowing users to choose their own trackers when setting up their profile. The functionality would work the same and the prototype has been developed to prove this, trackers can easily be adapted to show different data.

Testing has confirmed that the application is easy to use and provides useful overviews. Participants said that the application made it easy to spot trends and anomalies in their health through the graphs, such as in general lack of sleep or intense exercise would lead to a worse migraine the next day (Appendix 9). However, there would be anomalies such as getting plenty of sleep and still having bad pain the next day that show migraines are unpredictable, often these cases related to the pressure changing making the weather comparison page extremely useful for identifying whether it was a complete anomaly or there was a cause. The iterative approach to design allowed improvements to be made throughout the timeline, without this the application wouldn't have been as user-friendly and best suited to the users needs. The project could've been improved by completing more rounds of formal testing towards the end when the project was further

developed. This would allow small details that may have been missed initially to be improved and adapted, testing with more participants would have also allowed this.

To further improve the project, more could've been done during the research stage. Although research carried out was successfully applied to the development via the idea of a personalisable application and deciding what information needs to be tracked it would've been better to interview more people, even people that don't suffer from migraine as a way of creating a more adaptable application.

The project achieves its goals as the application sticks to the design of the XD mock-up. This mock-up was created with the aim of minimising visual stress to avoid impacting further on users migraines through the use of colour and a clear, bold layout. The application proves just how successful it is via the feedback received. Participants said they will continue to track their migraines via it as they found it a very effective way of understanding their health and that it is beneficial to have all their data stored in one easily accessible place.

Time management was a key factor in the success of this project, in the early stages of planning a project timeline was created to keep the development on track. Lots of contingency time was built into this as problems were bound to arise and it was important to make sure the project didn't fall behind. Leaving this contingency time proved vital when unexpected problems relating to both the coding of the project and external problems occured. The project was worked on consistently, in a little and often method allowing it to be kept on top of and for the researcher to not forget crucial pieces of information if weeks passed when the project wasn't worked on.

If there was more time to further improve this project, it would be of great benefit to allow the user to change the view of their data to weekly, fortnightly and monthly. Although during testing this wasn't a problem as participants worked with the application over a short period of time, this will not be how the project is used normally. It will make the data easier to read if users can choose a view, allowing them to take a closer look at graphs over a specific week or see trends over a month. The long term future of this project will mean that it holds lots of data and users will need to be able to organise their view to see specific periods of time. To do this it would be advantageous to have buttons allowing users to set the period of time they wish to view the data for.

It would be valuable to improve the data entry limit, although it is required that only one set of data is entered per day users may need to change their entry due to migraines unpredictable nature. The ideal solution would be to allow users to overwrite the data to leave one entry per day but allow change. Due to this being difficult to implement and time constraints on the project this wasn't completed.

8. Conclusion and recommendations

In conclusion this project has been a success, an application for monitoring and analysing health has been created which users enjoy using. This application benefits users by giving them a new application which will analyse their tracked data for them and provide visualisations that identify trends in their health. The application allows users to monitor their health and use the information to make meaningful impacts to their daily life. Through the use of this application many people suffering from migraine can hope to make a positive improvement to their health by gaining a deep understanding of their condition.

This application fills a gap in the market for a migraine specific health tracking application that provides the user with meaningful insights instead, opposed to a list of information which is unclear and difficult to understand. Because of this it is likely to be a success amongst other migraine sufferers. This application could have a successful long-term future, with further testing and improvements the necessary features such as changing the data view and creating a user set up profile could be created, allowing users to adapt the application to their needs. The tracker works well as a web application allowing users to view it on many different devices, however, the ideal format for the future would be to create a mobile app version allowing users to access the application more conveniently.

Work needs to be completed to allow the user to create an account so that they can complete the personalisation process by choosing what data they want to track so that the application is relevant to them and their health. Research has already discovered a list of potential trackers that users would like, but it would be beneficial to conduct further research when this feature is introduced to check that these trackers are still relevant and discover any missing ones.

The shining feature of this project is the visualisations, these work particularly well, and users thought they are very well laid out and easy to read. Without the visualisations being clear and well formatted the project wouldn't have been as successful. The visualisations do the hard work by getting and formatting the data for the users, making it easy to quickly pick out key trends. Developing the visualisations was technically

complex as it needed to communicate with a database and allow the user to enter their own data. Although challenging, this was a success and through dedication of time and effort to understanding this feature and getting it to work properly the application fulfils its goals.

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Appendix A: Project Log
https://docs.google.com/document/d/1cpiDZN5AdhbimNZphatIEO-RUAGlLHsA1rXfm8Uwk1U/edit?usp=sharing

Appendix B: Project Timeline

October	Research - competitors - Migraines - Collecting data Final proposal to be submitted by 10/10/2019 Research - Plan interviews, develop relevant questions, find interest for potential participants - Conduct interviews - Analyse interview data - In Depth Research - Migraines - Symptoms - Triggers - Treatments - How this data can be applied to the application Develop 2-3 personas	2 days 2 days 3 days 1 day 3 days 2 days
November	Develop storyboards of user journey through application Create moodboard for project Develop paper wireframes User test/feedback and iterate Update paper wireframes Develop digital wireframes in Photoshop/Illustrator Focus group with digital wireframes Digital wireframes iterations Develop design theme - colours, fonts etc.	3 days 1 day 2 days 4 days 1 day 3 days 1 day 3 days 1 day
December	Develop interactive prototype Gain user feedback on interactive prototype through usability lab studies Further develop interactive prototype based on feedback Start D3 tutorials Follow database tutorials in Node and JSON	5 days 2 days 3 days 9 days 7 days
January	Develop basic graph/database prototype Prepare for presentation Assessed Presentation - 15/1/2020 Develop visualisation/database feature more	7 days 4 days 10 days
February	Implement other features and pages of application e.g.	15 days

	- triggers - calendar view - user profile Gain user feedback on project through usability lab studies Make improvements to project	 1 day 5 days
March	Test project myself thoroughly - check or errors Gain more user feedback Further develop and improve project based on user feedback	2 days 1 day 5 days
April	Start final report Review report Update Report Hand-in 23/04/2020	15 days 2 days 3 days

Also Available at TeamWeek website:

https://app.teamweek.com/#pg/EMuFKfIxStXyYvxPonz6KIisFYLVTRkW

Appendix C: Data Ethics Canvas (not included in word count)
https://drive.google.com/open?id=1D1uWC0cOJgKsGRs76MQab96XHIQuPfU9

In hindsight, the best ethical and professional practices for this project were using consent forms and participant information sheets to clearly communicate with users how their data would be used and how their rights would be protected. By simplifying the information sheet to not include any technical jargon users could easily understand the process and knew how their data would be used. Creating new consent forms was vital for each stage of the project, the same consent forms could not be used for interviewing as testing as the participants would be involved in the project in different ways and their data would be used differently.

This project uses different sources that have been referenced in the project such as PieceLabel, Chart.Js and WeatherUnlocked API, these have been used to enhance the project through use of the coding libraries, but these do not belong to the project creator. All libraries and plugins are free to use, and permission is granted for their use. Examples were built upon and adapted from the libraries documentation for this project, these were very basic code snippets which showed the bare-bones set up.

If this project were to be licensed, ideally an Attribution-NonCommercial-ShareAlike licens would be implemented. This would allow other to build upon the work completed in this project as long as the author is credited and any work they create follows the same licensing. This would allow others to use this work for non-commercial reasons meaning that an adapted version can't be created and sold on.

Further Appendixes D

- Appendix 1 - Research Questions
- Appendix 2 - Interview Questions
- Appendix 3 - Participant Information Sheet.docx
- Appendix 4 - Consent Form.docx
- Appendix 5 - CCTP Log
- Appendix 6 - Adobe XD Prototype
- Appendix 7 - Testing Plan.docx
- Appendix 8 - Participant Information Sheet - Testing.docx
- Appendix 9 - Testing Feedback Notes