TBIdentifier Application

Predicting Traumatic Brain Injuries (TBI) through Analyzing Variations in Temperature

Amogh Dattatri

Purpose

The purpose of this project is the development of an app (TBIdentifier) that proactively evaluates variations in temperature to predict possible occurrence of Traumatic Brain Injuries (TBI) at the convenience of the user, and delivers decision-makers important information that can save lives and reduce the severity of brain injuries.

Approximately 300,000 cases of mild concussions occur each season for high school and collegiate athletes. Concussions make up approximately 5.5% of high school injuries and 6.2% of collegiate injuries (Theye & Mueller, 2004). Death due to TBI is often preventable when early care is provided. Early detection and treatment of brain injury is key to reducing mortality rates and brain damage from TBI. The TBIdentifier app can aid in educating and informing users and decision makers.

Materials

Below depicts several utilities leveraged during the development of the application.

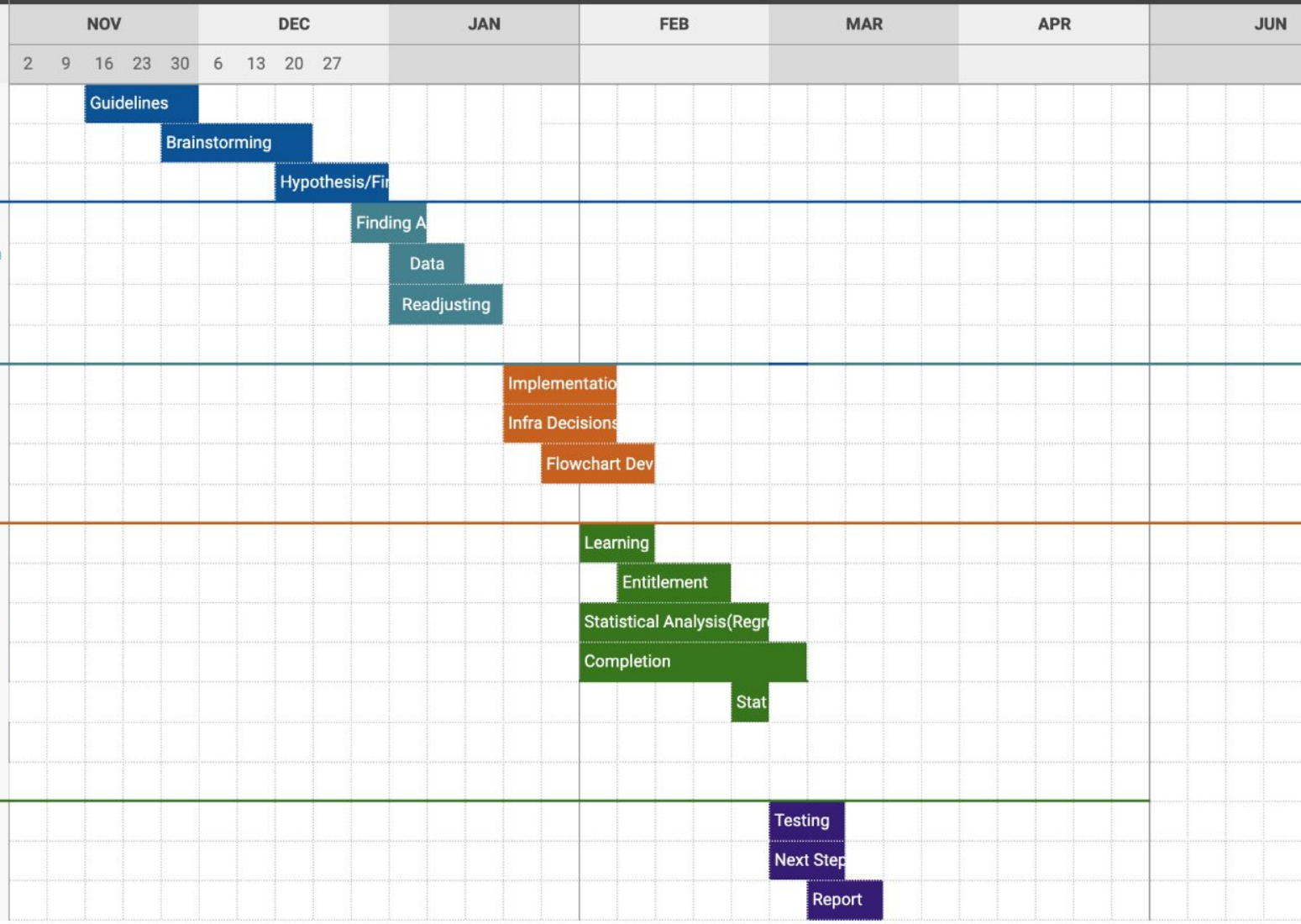
1. Apple HealthKit - for the efficient querying from the user's health repository
2. Apple ChartsUI - for the visual representation of past temperatures
3. SwiftUI - for the basic development of the app
4. Firebase - for the profile building (Contacts)
5. Excel and SPSS
6. Data, images, and variables from Rzechorzek et al. (2022). A daily temperature rhythm in the human brain predicts survival after brain injury, *Brain*, Volume 145, Issue 6, June 2022, Pages 2031–2048, https://doi.org/10.1093/brain/awab466

Hypothesis

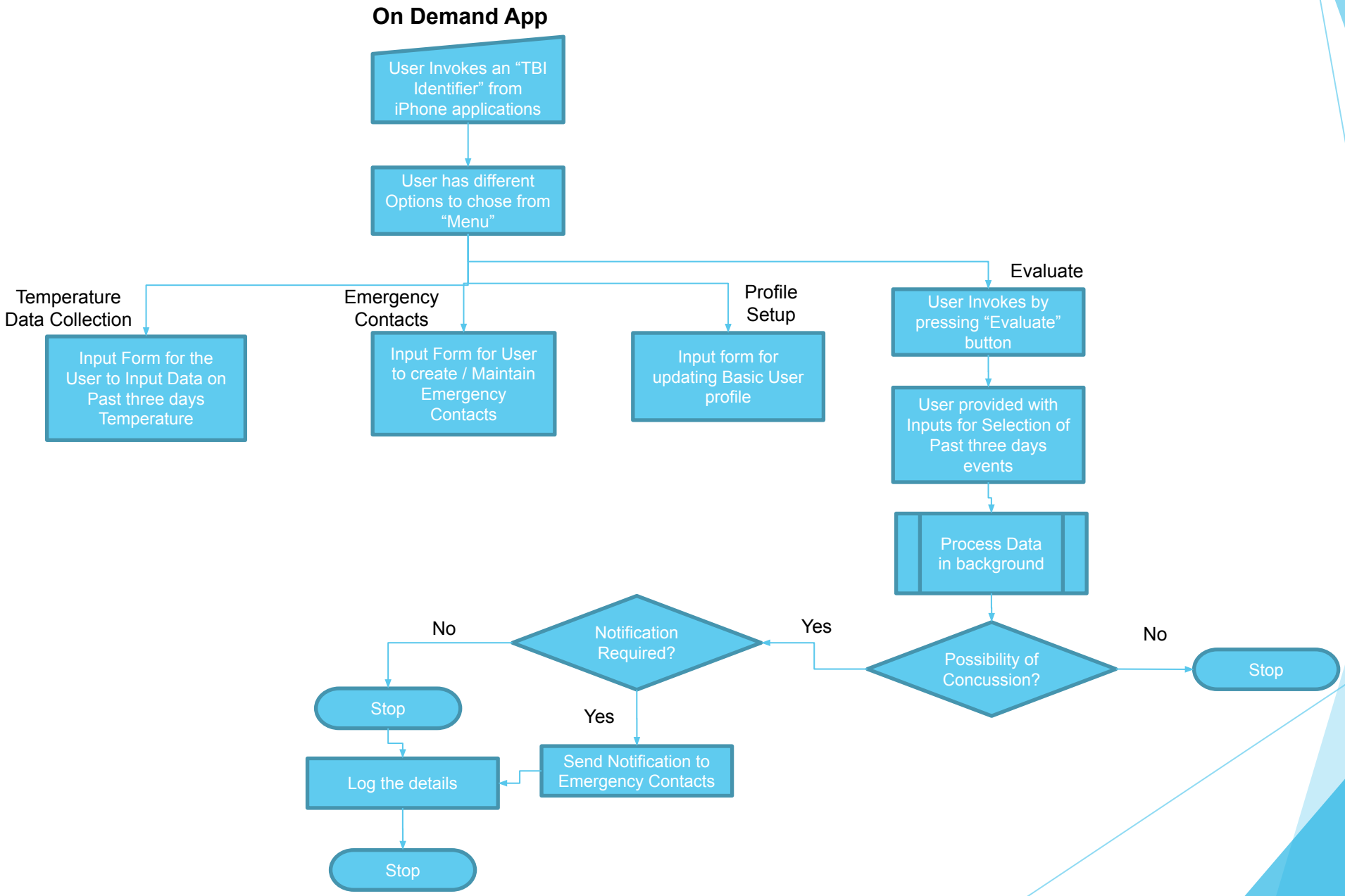
Awareness of daily human temperature variations in comparison to post-head injury temperature variations can predict traumatic brain injury (TBI) and facilitate more effective medical care

Work Log and Project Plan

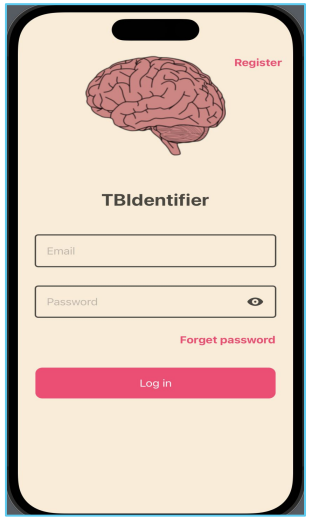
PHASE		DETAILS
	PROJECT WEEK:	Enter the date of the first Monday of each month -->
1	**Project Conception and Ideation**	- Guidelines - Ideation/Brainstorming - Hypothesis/Finalization
2	**Research/Extraction of Further Information**	- Finding Relavent Research Articles - Collecting Data & Statistics from past Research - Readjustment of project objective
3	**Project Definition and Planning**	- Implementation Decisions - Infrastructure Decisions - Applciation Flowchart Develpoment
4	**Project Implementation & Development**	- Learning Swift/Xcode - Entitlement Access - Statistical Analysis(Regression) - Review of Data with Statistician - Completion of Development of App
5	**Project Submission**	- Testing and Evaluation - Next Steps - Report(Poster & Video)

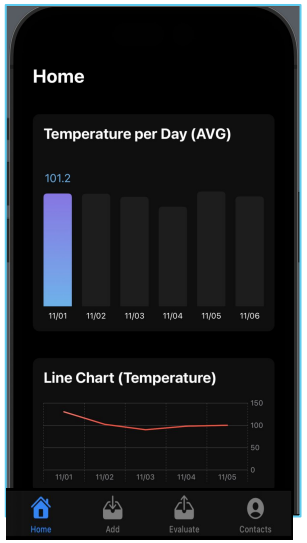


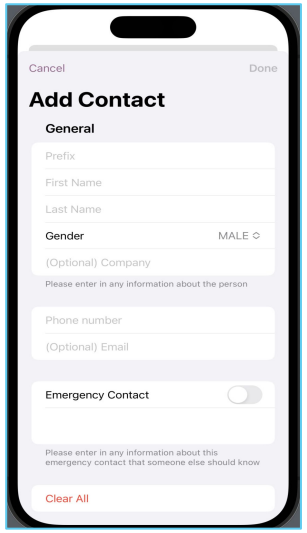
Flow Chart for TBIdentifier App Development

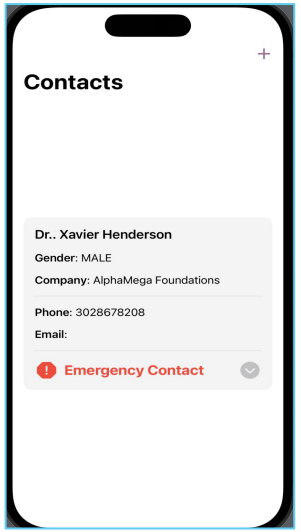


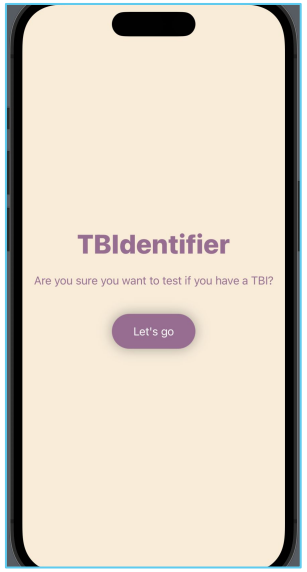
Engineering Interface of TBIdentifier App

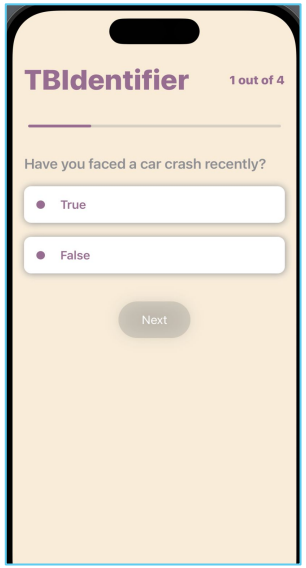


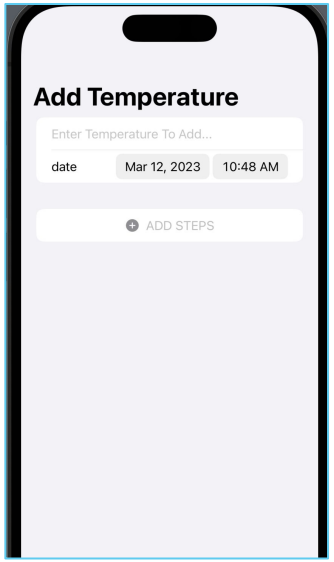










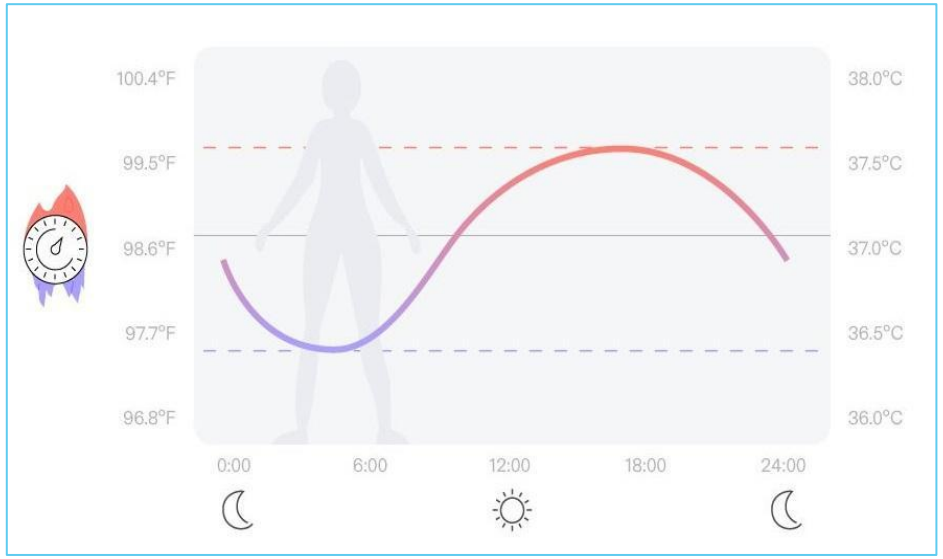


Study findings from Rzechorzek et al (2022)

- The study title is: A daily temperature rhythm in the human brain predicts survival after brain injury
- The researchers found that Lack of a daily T_{BR} rhythm increased odds of death in intensive care by a factor of 21
- Daily T_{BR} rhythmicity emerged as the strongest single predictor of survival after brain a brain injury
- T_{BR} range decreased in older patients (p=.018)
- T_{BR} varied by time of day and was lowest at night

All from Rzechorzek et al. (2022). A daily temperature rhythm in the human brain predicts survival after brain injury, *Brain*, Volume 145, Issue 6, June 2022, Pages 2031–2048, https://doi.org/10.1093/brain/awab466

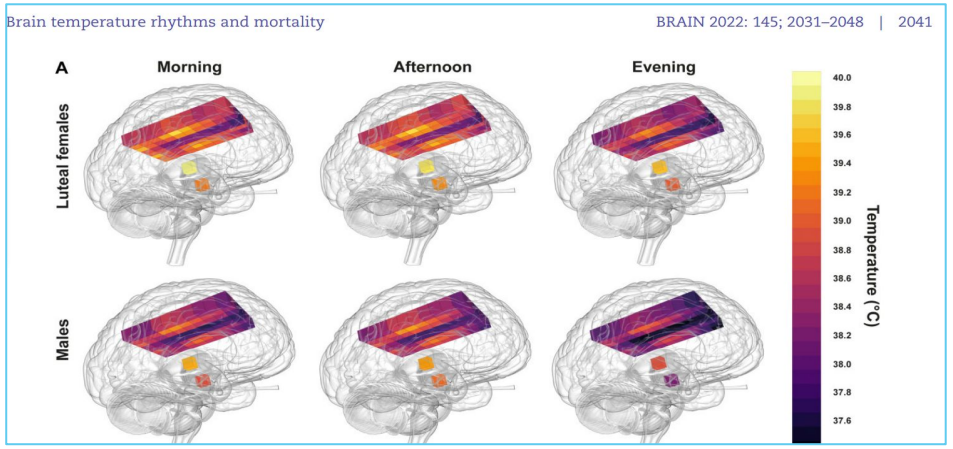
Details about Temperature Variations

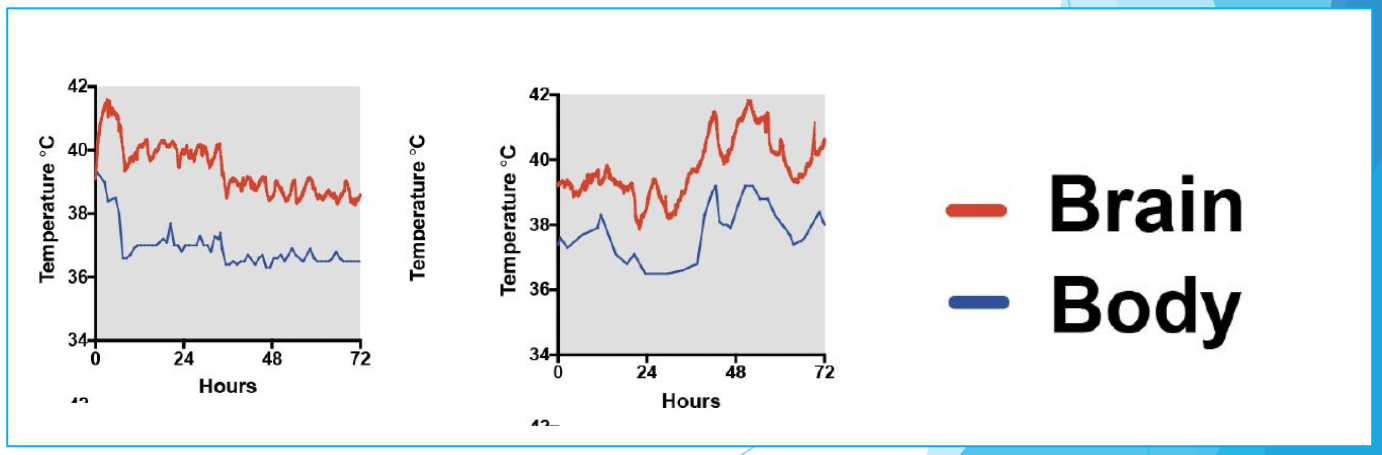


Human Brain Temperature (T_{BR}) is rarely measured and “normal range” is not well studied

Brain temperature is higher and varies more than previously assumed by age, time of day, brain region, and menstrual cycle

Body temperature is often used as a proxy for brain temperature because it tracks a similar rhythm. See brain (n = 104) and body (n = 101) graph below from Rzechorzek et al. (2022)





All from Rzechorzek et al. (2022). A daily temperature rhythm in the human brain predicts survival after brain injury, *Brain*, Volume 145, Issue 6, June 2022, Pages 2031–2048, https://doi.org/10.1093/brain/awab466

Synthesized Dataset for App Development

Synthesized Patient Dataset								
SC NO	SUBJECT IDENTIFIER	DOB	MORNING BODY TEMP	AFTERNOON BODY TEMP	EVENING BODY TEMP	GENDER	Ethnicity	TBR Variance
1	23	1/15/03	98.5	98.9	98.5	M	Asian-American	0.0533
2	78	11/1/00	98.6	98.4	99.2	M	African-American	0.1733
3	6	9/25/96	98.1	98.1	99	F	Latin-American	0.2700
4	7	7/4/02	99.2	97.8	98.7	M	White	0.5033
5	91	1/27/01	98.1	99.1	99.4	F	African-American	0.4633
6	38	12/15/95	98.2	98.8	98.6	F	Native-American	0.0933
7	13	10/17/02	98.2	98.6	99.2	F	Latin-American	0.2533
8	57	6/8/97	99.1	99	98.7	M	Asian-American	0.0433
9	25	12/19/95	98.5	98.2	98.6	M	African-American	0.0433
10	70	12/12/91	98.7	98.4	99	F	White	0.0900

Based on the 95% Confidence Interval obtained with a healthy population in the Rzechorzek et al (2022) study, a variance coefficient below .5 indicates a significant lack of body temperature rhythm and is identified as potentially predictive of a traumatic brain event.

Analysis

Adding Temperature Data

```swift
var healthStore: HKHealthStore?

init() {
    if HKHealthStore.isHealthDataAvailable() {
        healthStore = HKHealthStore()
    }
}

func writeTemp(startDate: Date, tempToAdd: Double) {
    let tempType = HKQuantityType.quantityType(forIdentifier: HKQuantityTypeIdentifier.bodyTemperature)!

    let endDate = startDate + 60 * 60 // add 1h to startDate
    let stepsSample = HKQuantitySample(type: tempType, quantity: HKQuantity.init(unit: HKUnit.degreeFahrenheit(), doubleValue: tempToAdd), start: startDate,
        end: endDate)

    // After creating the sample, we call healthStore.save()

    if let healthStore = healthStore {
        healthStore.save(stepsSample, withCompletion: { (success, error) -> Void in

            if error != nil {
                // something happened
                print("error = \(String(describing: error))")
                return
            }

            if success {
                print("Steps successfully saved in HealthKit")
                return
            } else {
                // something happened again
                print("Unhandled case!")
            }

        })
    }

}
```

Initializing HKHealthStore

Constructing object to write to HealthStore

Saving to HealthStore

Querying Temperature Data

```swift
func calculateTemp(completion: @escaping (HKStatisticsQuery?) -> Void){
    let healthStore = HKHealthStore()
    var query: HKStatisticsQuery?
    var query2: HKStatisticsQuery?
    let tempType = HKQuantityType.quantityType(forIdentifier: HKQuantityTypeIdentifier.bodyTemperature)!
    let startDate = Calendar.current.date(byAdding: .day, value: -3, to: Date())
    let predicate = HKQuery.predicateForSamples(withStart: startDate, end: Date(), options: .strictStartDate)

    var minima: Double?
    var maxima: Double?


    query = HKStatisticsQuery(quantityType: tempType, quantitySamplePredicate: predicate, options: .discreteMax){ (query, results, error) in
        minima = results?.minimumQuantity()?.doubleValue(for: HKUnit.degreeFahrenheit())
        print(minima!)
    }

    query2 = HKStatisticsQuery(quantityType: tempType, quantitySamplePredicate: predicate, options: .discreteMin){(query, results, error) in
        maxima = results?.maximumQuantity()?.doubleValue(for: HKUnit.degreeFahrenheit())
        print(maxima!)
    }

    healthStore.execute(query!)
    healthStore.execute(query2!)

    variance = ((maxima - minima) / 4)*((maxima - minima) / 4)

}
```

Queries finding the Minima and Maxima of the sliding-window database of 3 days.

Building filter and information for queries

Execution of queries

Finding variance of data set

Summary

- The researcher created an app (TBIdentifier) that predicts traumatic brain injuries (TBI) through the analysis of temperatures monitored at sleep and wake intervals, in comparison to temperatures following head injury / impact.
- The TBIdentifier App allows users to monitor normal variations in temperature rhythm compared to variations in temperature rhythm after injury, to come out with a prediction and share that data to decision-makers such as parents and coaches if the user wishes to.
- The TBIdentifier App allows users to create emergency contacts of their own, with whom the app can share data when following the evaluation criterion.
- This temperature variation data can help users, parents, coaches and doctors to understand normal temperature variation and post-injury temperatures to make important medical care decisions and bring awareness and education around the importance and usefulness of the temperature variation data.

Future Work

Stage 2:

- Do further statistical analyses to thoroughly gain information for accurate diagnosis.
- Obtaining entitlements necessary to gaining access to libraries such as Healthkit, when releasing for production.

Stage 3:

- Incorporate SMTP Servers and MessageUI to asynchronously sending messages and emails.
- Incorporate MapUI to provide location in addition to past history being sent to the emergency contacts.

Stage 4:

- Expanding infrastructure and platforms for the application (Currently IOS and can be expanded to Android and other available gadgets)
- App can be repurposed for other injuries/purposes