MOTIVATION

The goal for this project was to create an application that would be able to calculate the QTc. The QTc is the corrected QT-Interval, a specific interval within a heart rate curve that, if outside of a certain range, may induce arrhythmia (Burns, 2019). There are several formulas that, depending on the pulse, can be used for this calculation. For this application, six of the most common ones have been selected (Hnatkova, et al., 2019). There are other apps that can calculate the QTc, however, there was a need for one that would have this specific calculation as its sole purpose and work offline.

The app will be used by medical professional in ambulances as well as clinics, or medical students. Possible tasks would be emergency diagnostics, assessment of whether a patient can be released, monitoring the development of cardiological diseases and use for education purposes in an academic context. Some prior knowledge in cardiology is necessary, as terms such as QT and QTc are not commonly known. Due to the critical use in the medical field, there is a necessity for the result to be reliable and the calculation transparent.

An asset of this application is the ability to directly compare the outputs of different formulas. Additionally, if in need of a fast result, the user can choose to automatically and directly show details of the result that is calculated with the most accurate formula for the input pulse. Therefore, it is suitable for use in high pressure environments.

RELATED WORK

There is a lot of other solutions on the market in the form of web and mobile applications. The reason those were not sufficient for our users is because they were either not specialized to complete the task of calculating the QTc - Interval or the ones that were specialized did not offer a good enough functionality, user friendly interface or enough input options (When calculating the QTc one should for example be able to input the Pulse in beats per minute, millimeters or in milliseconds). With this in mind our application sets out to addresses these issues, but of course took some inspiration from existing solutions - the best, in our opinion, applications that solve the task of QTc Calculation are: “MDCalc Medical Calculator” , “Calculate by QxMD” and “QTc Calculator”. In the following we will outline the strengths and weaknesses of these applications.

1. MDCalc Medical Calculator

   MDCalc is an application, which provides the users with a library full of different medical calculators. Calculating the QTc Interval is only one of its many functions. The problem here is that even though it has a very user friendly interface, it doesn’t give it’s user

the option to use other metrics for the inputs. For example for the pulse there is only the option the input it as bpm and not as milliseconds between two heart beats.

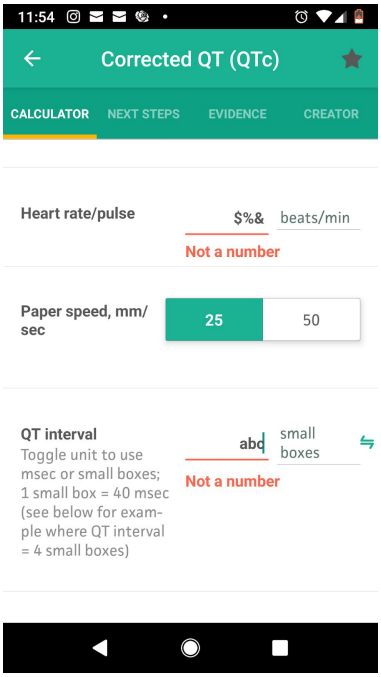
2. Calculate by QxMD

Calculate is very similar to MDCalc in that it has a lot of different uses. Here, as in MDCalc the user has restricted input options and there is no intuitive interpretation of the result. Another similarity is that one can choose from only four formulas. This is also something we addressed in our app by extending the number of formulas to six.

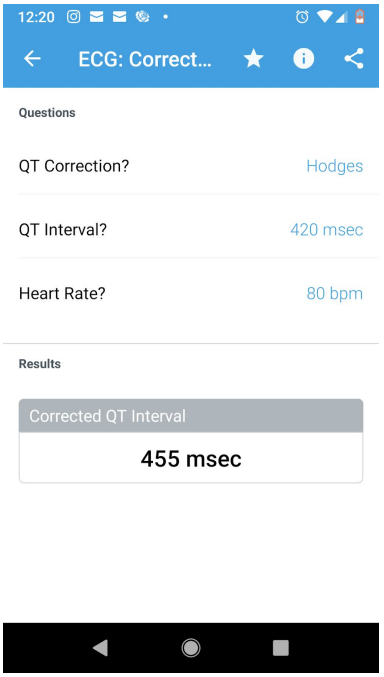
3. QTc Calculator

The Qtc Calculator was another example of solving the task of QTc calculation. We liked that everything was in one screen and one could see an interpretation of the result. It showed under the result, weather the qtc was normal, prolonged or short. It also had a bar, which gave a visual indication of the result. We liked the idea, but we did not like their execution. The bar was really hard to interpret. Unlike the other two applications we had to input the RR Interval(time between heartbeats) here instead of the bpm, but like them there was no alternative option. So bpm was not an option here. Additionally this app only provided two formulas to choose from.

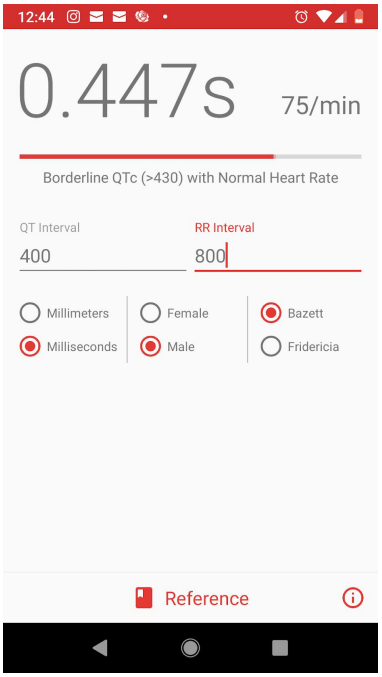
Screenshots of the apps:



MDCalc



Calculate by QxMD



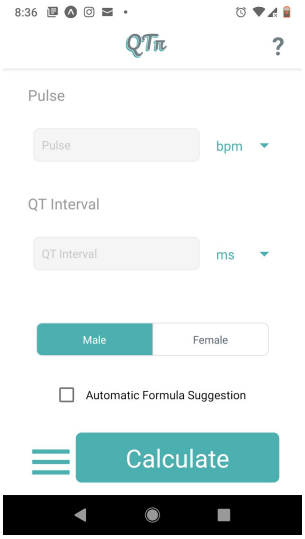
QTc Calculator

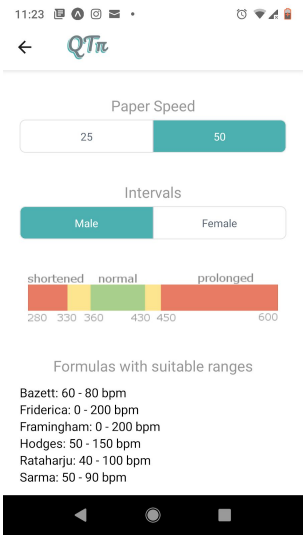
DESIGN

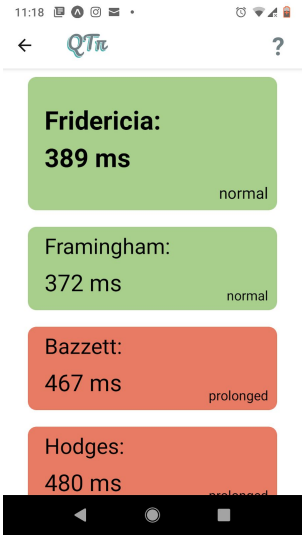
The final app is designed in a way where only the most important information and operations are visible on the main screens (Home Screen, Results of all formulas, Detailed result of formula), as this was a big part of the original motivation to have a more streamlined solution. In order to avoid clutter, the functionality is divided in three main and one additional menu screen, as well as help popups.

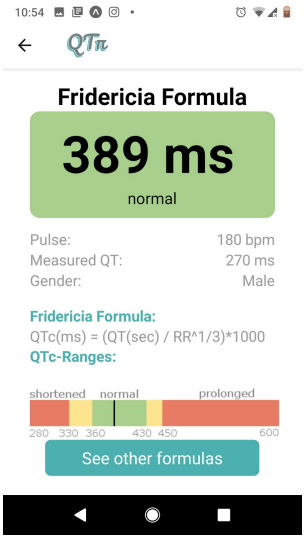
On the home screen (see figure 1), there are two input fields for pulse and QT-interval along with dropdown menus to choose the according unit, a button to choose gender and a checkbox for automatic formula suggestion, which will, if checked, navigate the user directly to a result and skip the formula comparison. The menu with further information (see figure 4) and setting of paper speed is located on the bottom, as users have told us that this setting would not be changed frequently. If no numeric input is given, calculation will not be permitted and the respective input field will be surrounded by a red border.

As we got positive feedback for the formula comparison screen in prior prototyping steps, we decided to implement it in a way that the order of the formulas from top to bottom would signify how well suited it was for the given set of values while the colors would indicate whether a calculated QTc is prolonged/shortened, borderline or normal (see figure 2). On pressing one of these formulas, a screen with detailed view of this formulas results will open (see figure 3). Here the user can check the input variables, see the respective formula and a visual representation of the values position on the scale of the QT-Ranges. This scale, in a redesigned way, was adopted from the Two-Screen-Prototype, as users found it helpful to see, how low/high the value was within the specific range (f.e. if it is normal, but almost borderline prolonged). A button deletes the input variables and takes the user back to the home screen.









Implementation

Our application was a React Native App developed on Windows and Linux computers. We used the expo framework, which allowed us to test the apps on our phones in real time as we developed them. We were using the node JS platform and the npm server registry, with the help of which we installed of the packages necessary to build our application.

A very big challenge in the beginning was understanding how all of those parts work together as we were getting constant bugs and were having trouble to start the implementation. After installing some packages, for example, we often received and error that the Fontisto.js file in the node modules was causing a problem. This of course is an expo problem and after some research we understood which file to edit, but the node_modules folder of our project contained around 28 thousand files, some of them with the same names but in different folders. The different packages we tried used different logic, so we had to constantly come up with new ideas on how to solve a problem if the initial package used, didn't offer all of the tools and functionality we needed.

EVALUATION

Given the present circumstances of the coronavirus pandemic, we decided on remote, unmoderated usability testing. In other words: we sent the participants the tasks and let them carry them out on their own.

The test comprised of three tasks and a usability questionnaire. The tasks were styled in the form of three patients whose QTc interval needed to be calculated (see appendix). The first one was a straightforward case with only the input data of heart rate and QT interval given, the second one in addition required the use of the automatic formula selection feature and the third task required adjusting the writing speed setting. The testers were instructed to verbalize their thoughts while carrying out these tasks.

After this the testers took a usability questionnaire (see appendix) which is comprised of questions from the ISONORM 9241/110-S questionnaire (Prümper, 2008). Five questions were excluded since they didn't seem relevant for this project. In addition, the testers were asked for their gender, age and their occupation. Finally, testers were given a textbox for any further comments.

The test itself was conducted with "lookback", which would direct users to the download link for the app, give them the instructions for the tasks and record their screen and voice. The questionnaire

was distributed through “surveyplanet”. A recreation of it is found in the appendix, since surveyplanet doesn’t allow free members to export their surveys.

For our testing we managed to only procure 4 participants instead of the required 6. In addition to the general hostile circumstances of the corona pandemic, we also had a very specific target group: the app was made under the presumption that whoever uses it has a certain degree of medical training. Therefore, any testers for the app also needed some amount of expertise, or else the results would be meaningless. Therefore, finding suitable test subjects turned out to be more difficult than anticipated.

In a broad sense, the survey painted a positive picture of out application. the app has an average score of 8.17 on a scale from 0 to 10, with 10 being the most usable. For some of the questions we used the negative formulation from the original questionnaire, to work against agreement bias. These questions, namely number 2, 7, 9, 10, 14 and 15, had their polarity reversed for the calculation of an average score.

When we look into specific questions, there were some shortcomings. Most notably, how the App Informed the user of of how it works. This is seen in Question 5 (“The App offers situational Explanations if requests”) , 6 (“the App offers situational Explanations on its own”) and 11 (“the App sufficiently informs you about what it's doing”), in each of which at least one person rated the app low.

The recordings of the usability test support the idea of the app being very usable: none of the participants had any problems completing the given tasks. Moreso, the Tests showed us limits of the tools used. some participants would ignore parts of the assignment, which can be attributed to the fact that lookback only allowed to have one task for mobile users, which meant that we had to write all 3 tasks into one instruction, which in turn meant it was a lot of text, which lead testers to just skim the instructions. one other solution might have been to highlight important parts of the task description.

REFLECTION

Division of Labor:

Amelie Schneider did the programming for the overall design, corrected some errors in the main functionalities, the value indicator on the QTc ranges, designing and adding the logo and

programming the help menus. In the final report she wrote the sections Motivation, Design and contributed to the sections reflection and conclusion/future work.

Ivaylo Kaloyanov did the programming for changing the layout and coloring of the Homescreen, specifically Calculate button and dropdown menu. Set the default input for QT-Interval to ms. Fixed a bug, which was causing the text and color interpretations of the result to differ due to not rounding numbers up. Fixed the Positioning of the text under the result in DirectResult.js and DetailsScreen.js fixed a bug where the first result in the Results screen sent to a different screen than the rest, due to error in previous implementation. Wrote the Related Work and the Implementation and helped with Reflection and Weaknesses.

Manuel Maccari designed the usability test and the questionnaire, conducted the tests and evaluated their results. He also made the graphics for the QTc ranges and was involved with the logo graphic. In the final report he wrote the test protocols and the section evaluation. He was also involved in the sections reflection and conclusion & future work. He also proofread the report.

Important lessons:

During the exercise we learned a lot about teamwork and how it's important to play to each of our strengths. As we programmed we had to use GitLab alot, which in our opinion is definitely an important skill to have as a programmer. We used how the frameworks, platforms and packages that we used specifically for our project work and how to install a development environment with all of its dependencies. Learned some good programming practices and managed to practice a lot of the theory that we had learned in University. Learned that it's not just about design. Sometimes the users have a different view of what makes sense in a layout for example.

CONCLUSION AND FUTURE WORK

All in all, we think that we have succeeded in making a useful medical calculation App. We managed to include all the functionality that we wanted to include such as the comparison between different formulas, the intuitive switching between input Units and the possibility of an automatic formula selection. We are also very proud of the ability to save the users setting after the app was closed, which was vital to certain feature like the adjustability of writing speed but was a surprising amount of work to get running.

Of course, given more time, there are possible improvements to the App we would like to make. One functionality that we discussed was including a way to create profiles for patients which would allow the users to save QTc values and go back to those at a later time. Altho this could potentially be useful for stationary patients and doctors, we ultimately decided against it since it would not be

feasibly to do within the scope of this assignment. Another things that could be done would be to include more formulas for the calculation of the Qtc to give a potentially even better result. Lastly, we would like to make the App available on app stores so that it can actually be easily obtained by people who can use it, thereby fulfilling the its purpose of making life for certain medical professionals just a little bit easier. We have not yet implemented swiping between screens as a way to navigate and that can prove to be more convenient, than clicking an arrow in the upper left corner. Another possible negative of our application is that unlike some of its competitors it does not suggest what the possible reasons for a prolonged or shortened QTc might be. Even though we had the information and could have easily added it, we were worried, that we might wrongfully influence the decisions of the medical professionals.

REFERENCES

Burns, E. (2019). *QT Interval*. Von Life in the Fastlane: https://litfl.com/qt-interval-ecg-library/ Abgerufen [6.6.2020]

Hnatkova, K., Vicente, J., Johannesen, L., Garnett, C., Stockbridge, N., & Malik, M. (2019). Errors of Fixed QT Heart Rate Corrections Used in the Assessment of Drug-Induced QTc Changes. *Frontiers in physiology, 10*, S. 635-655. doi:https://doi.org/10.3389/fphys.2019.00635

Prümper, J. (2008). Beurteilung von Software auf Grundlage der Internationalen Ergonomie-Norm DIN EN ISO 9241-110. HTW Berlin, Manuscript Questionnaire.