SE499 Report - Cued App

Justin Pezzack
jjpezzac@uwaterloo.ca

April 6th, 2020

Contents

Acknowledgements

Thank you to Katherine Lu, Nikola Vasiljevic and Tyler Zhang for bringing me onto their FYDP team given my unusual circumstances. With this document being directly related to our SE491 project, a large portion of the research and information being discussed is a direct result of their time and effort throughout the winter 2020 term.

Thank you to Derek Rayside for motivating us to pursue this project as well as our academics during COVID-19.

1 Introduction

1.1 Purpose

In terms of development, this project is considered abandoned. With that being said, the purpose of this report is to present the process that **Team Cued** underwent during the winter 2020 term, and provide knowledge and structure for future groups to expand the project as a prospective SE490/491 project (SE2021, SE2022 etc.).

1.2 What is a Habit?

The Merriam Webster's dictionary definition of a habit is as follows: *"a settled tendency or usual manner of behavior"* or as a more technical definition *"a behavior pattern acquired by frequent repetition or physiologic exposure that shows itself in regularity or increased facility of performance"*. If we look at the second definition, we see the phrase "physiologic exposure that shows itself in regularity", which is an important point to emphasize for later.

1.3 Project Scope

The scope of the project is to create an application that allows users to discover and track habits that they a) want to form, or b) want to eliminate. Some examples of these types of habits include "making my bed in the morning", or "stop biting my nails". There are many habit managing apps that exist on the Google Play and Apple App stores that allows one to track similar things, however we found that they were either fairly lackluster or extremely bloated. On one end of the spectrum we discovered solutions that were glorified checklists, without much depth under the surface. On the other, we discovered various solutions that employed the concept of gamification, a well-known user experience concept that utilizes elements of game playing to encourage engagement with a product or service. The problem with these apps is that they encourage the user to perform (or not perform) the habit as a means to progress in the game, rather than for the lifestyle benefits. The common theme among all of these apps is that they allow the user to track habits, yet they lack justification for why the app is allowing them to make lasting changes. The app lets the user check boxes or collect trinkets, thus giving them a sense of achievement in building their habit. In this work we specifically investigate the scientific proof behind these validations of positive reinforcement.

2 Research

2.1 Do people even need a solution?

When searching for a group of people who are looking to build or a change a habit, New Year's resolutions came to mind. Analyzing this group was appropriate for our study due to the diversity of habits being formed. One thing we aimed to avoid was scientific principles that only applied for a specific set of habits, rather than principles that can be generally applied. Our search led us to a study conducted by researchers at the University of Scranton which discovered that there is a steep drop in how long New Year's resolutions are pursued. "Seventy-seven percent of the resolvers studied made it through a full week, then 55 percent stuck with their goals for a month. By June, six months into the New Year, only 40 percent of those who had made a New Year's resolution were still sticking with the goal"[1]. This study confirmed our assumption that people want to build habits, but they struggle to keep them. This constant cycle of failure can be detrimental to one's overall livelihood and well-being. "Every time we fail, we damage our own self-esteem,"[2] says Janet Polivy, a psychologist at the University of Toronto.

On the surface, forming simple habits such as making ones bed in the morning seems rather trivial. However, the issue is that one's willpower, their capacity to do additional non-essential work, is very limited. Unlike computers, humans are inconsistent, and so is our limited motivation. The conviction to become a better

[1] https://www.ncbi.nlm.nih.gov/pubmed/2980864

[2] https://v1.escapistmagazine.com/articles/view/scienceandtech/columns/forscience/12835-Psychology-This-Is-Why-Your-New-Year-

version of yourself that you experience one day is quickly dispelled by the next day. "Apps can give you reminders, accountability, guilt trips, or even a personal habit coach, but in the end you still have to do the work — you can't app your way to a better self" [3]. Between the preliminary research that was done and the lack of habit apps applying actual psychological research, we decided that a new solution was necessary to fill this void. Moving forward, the research shifted towards finding a science-backed methodology to improve habit forming abilities.

2.2 The Habit Loop

After weeks of research in behavioural psychology, in particular, researching a book known as the The Power of Habit by Charles Duhigh, we had found what we believed was a solid foundation to build off. Duhigh suggests that the key to building good habits that one is likely to execute consistently, day after day, is the psychology construct known as the Habit Loop. The Habit Loop is a simplified schematic that represents how our brain operates when we have a habit. Studies have shown that almost all habits can be broken down into a series of steps, and books like *The Power of Habit* help readers understand this process, develop their own habits, and more. Though people have easy access to the formula, many still struggle to follow it. The reasoning for this is that though the habit loop itself is simple, the steps to change a habit are not, and can be a daunting task for many. A user study we did among students attending the University of Waterloo - confirmed our assumptions:

- "Sounds cool but it seems like a lot of work, I'd probably forget after a couple days"
- "I want to try it but I don't know if I have time to read a book"
- "There are a lot of steps"

This made it become very apparent to us that for our software engineering solution to be effective it needed to be easy to use and not overwhelming, but still informative and useful. As Duhigh puts it, "Individuals and habits are all different, and so the specifics of diagnosing and changing the patterns in our lives differ from person to person and behavior to behavior. Giving up cigarettes is different than curbing overeating, which is different from changing how you communicate with your spouse, which is different from how you prioritize tasks at work. What's more, each person's habits are driven by different cravings" [4]. This makes the formula to change a habit generic; there isn't one magic infallible solution, and because of that, each person needs to put in effort to build their specific habit loop for the habit they want to create. Fortunately, there is a general framework one can follow. Research conducted at the Massachusetts Institute of Technology discovered that at the core of every habit is a neurological loop that consists of three parts: a cue, a routine, and a reward.

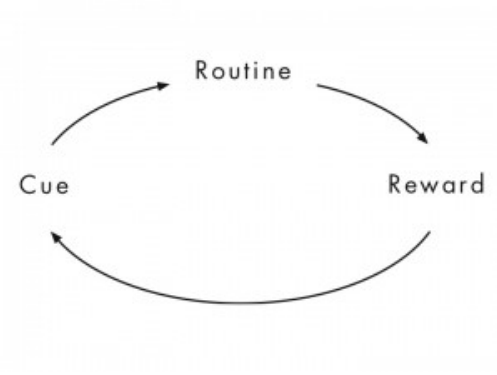

Figure 2.1: The basic habit loop

[3] https://www.vox.com/2014/12/29/7434433/new-years-resolutions-psychology
[4] https://charlesduhigg.com/how-habits-work/

The next issue many encounter is that identifying all the elements of a habit is tricky. For example, a cue related to a habit can consist of many pieces of information, perhaps a time, a place, an emotion, or even a person - the list is endless. This makes it very difficult for people to pinpoint what their exact habit loop looks like. Though people may estimate, accuracy is imperative here. This made the focus of our application more clear; instead of simply allowing users to track their habits and habit loops, our application actually helps users discover their unique detailed habit loop.

We studied the methodology Duhigh lays out in the book, and decided that integrating it into a piece of software would be perfect in creating a habit tracker that 1) employs the concepts of the habit loop, and 2) is educational and allows people to discover their actual habit loops, as opposed to having them blindly enter what they *believe* is their habit loop.

2.3 Building a Habit

Step One: Identify the Routine

The first step in diagnosing a habit is determining what the exact habit is. In particular, the action that is repeatedly being performed is defined as "the routine". For example, one may immediately open the Instagram app on their phone in bed when they wake up. The routine here is opening Instagram on their phone. A common approach taken by many in efforts to break this habit is trying to ignore the habit by getting out of bed immediately. This may be effective for a couple of days before going back to their old ways. Though seemingly harmless at first, thoughts such as "I have lots of time to get to work", and "what is another 5 minutes" may feel good for a while, but eventually will turn sour. Ultimately, a cyclical "I will do it tomorrow" attitude is created.

Needless to say, identifying the routine is the first step towards creating a habit loop. The routine is often rather obvious, however the following steps can be quite the opposite.

Step Two: Experiment with Rewards

After identifying the routine, the user needs to determine what is so compelling about the routine, more precisely, what is the reward. These rewards can be extremely powerful as they often satisfy cravings which are quite often an unconscious desire. In the case of social media, there have been countless studies on how the brain develops an addiction to it because social interaction can trigger dopamine release. The result is that the person is then driven by an uncontrollable urge to log onto or use social media. At the end of the day, a reward is an occurrence that triggers one's brain to release dopamine. Moreover, does the user crave going on Instagram, or are they just trying to procrastinate going to work? Unfortunately, Instagram is favorable as it happens to be a convenient distraction that does not require leaving your bed.

Now, the key here is to experiment with alternative routines that trigger the same reward. Perhaps in the case of wanting to open Instagram, an alternative routine could be reading 5 pages of a book, or getting up and doing jumping jacks. Whatever the routine is, the main objective is that it must be able to satisfy the craving, and finding something that can fulfill this often takes experimentation. Perhaps the first day you try activity A, then B on the next, then C, and so on. The point is to test various hypotheses in efforts to determine what desire is actually driving the routine.

Step Three: Isolate the Cue

The third step is to identify the cue, which can be difficult for many. "When you automatically turn your car left while driving to work, what triggers that behavior? A street sign? A particular tree? The knowledge that this is, in fact, the correct route? All of them together?"[5]. In the case of the aforementioned example, is the person going on Instagram because they think they want to look for something in particular, or is it just what they have become accustomed to do? The cue can be a very complicated to construct, and can consist of many things. Here are some examples of common cue categories:

[5] https://charlesduhigg.com/how-habits-work/

- Location
- Time
- Mood
- Thoughts
- Surrounding people
- A certain song

Step Four: Have a Plan

At this point the person has determined their habit loop which includes the reward, the cue, and the routine. From here they are able to shift their behaviour toward a successful alternative routine. To put it differently, a habit is a formula the human brain automatically follows: "When I see a **cue**, I will do a **routine** in order to get a **reward**". Essentially, the goal is to engrave this new habit formula. Now, the question for us as engineers is to determine how we can build a software engineering solution that enables people to follow these steps and achieve greater success had they not used our development.

3 Engineering a solution

Now that a concrete way to determine a habit loop has been identified, the next step is to create a set of requirements for our solution. We learned from our initial user study that our solution must satisfy the following:

1. Have a low barrier to entry
2. Educate users on the habit loop
3. Make the habit loop discovery process user friendly
4. Make tracking habits simple and low effort

3.1 Scope

Next we narrowed down the problem to only include habits that best suit the Habit Loop methodology. The constraints are:

- Must be applied to change and replace an old undesirable habit
- Must be able to include a cue, a routine and a reward
- Habit goals are user-defined

In a future expansion of this project, it may be worthwhile to re-evaluate the scope. With that being said, there was a general consensus that adding more features for the sake of it would be detrimental, and potentially drift away from the main idea of the habit loop. Later in this document some potential expansions are discussed.

3.2 Product Requirements

After deciding to utilize both high-level objectives and scoping, SE463 principles were applied to develop a finite set of product requirements. These requirements are listed below:

3.2.1 Education

Users can read about the cue routine reward methodology, with examples and explanations for each step.

3.2.2 Habit Management

The user can see their "finalized habits" and their "in progress habits":

1. Finalized $\implies$ The user has discovered the cue, routine, and reward already
2. In Progress $\implies$ The user is still experimenting with the cue, routine, reward

3.2.3 Discovering new Habits

The user can enter an interface flow to add a new habit

1. The user can add a routine
2. The user can track details to discover their cue
   (a) The user is prompt with six cue questions that require a short text response
      i. Location: Where are you? *Ex: At home, in my bedroom*
      ii. Time: What time of day is it? *Ex: Around 2-3pm*
      iii. Mood: What is your emotional state? *Ex: Confused & anxious*
      iv. Thoughts: What are you thinking? *Ex: Thinking about what deadlines I have coming up*
      v. Surrounding people: Who is nearby? *Ex: My co-workers*
      vi. Immediately preceding action: What did you do right before? *Ex: I ate a meal*
   (b) The user can add or save instances of the above answers to the cue questions (independent of each other; each records a response to all six questions)
   (c) The user can view a compilation of their cue questions graphically:
      i. Location – Displayed in a list
      ii. Time - Displayed in a calendar
      iii. Mood - Displayed in a list
      iv. Thoughts - Displayed in a list
      v. Surrounding people - Displayed in a list
      vi. Immediately preceding action - Displayed in a list
   (d) The user can then select one of their previously saved cues (or a combination of multiple cues) as the final cue for their particular habit
3. The user can experiment with rewards:
   (a) The user can track or add a theoretical reward, composed of a "craving" and a "reward":
      i. User is presented with two questions to add a theoretical reward, along with short text response boxes:
         A. Craving: What craving do you think you want? *Ex: I want to socialize*
         B. What will you use to fulfill the craving? *Ex: Talk to my co-workers*
      ii. The user can save or add multiple craving theories at first; then fill in the others later. This is for the case where a user may have a multiple theories as to what they actually want, but unsure of what to replace it with yet.
      iii. If the craving and the reward are both filled out, the user can indicate if their test was successful or had failed
      iv. Successful rewards are indicated or highlighted, while failed rewards are shown greyed out or smaller font
      v. The user can select one of their inputted rewards as the final success for their habit
   (b) The user can add additional notes for things not mentioned above

4. Once a user has added their cue and reward, the user can turn them into a new habit instance, such that:
   (a) The cue $\implies$ cue
   (b) The reward craving $\implies$ reward
   (c) The reward fulfillment action $\implies$ routine
5. The user can see the plan statement when they view their habit from the app's main screen:
   (a) The user needs to write this plan with a large amount of intention
   (b) Thus, forcing them to re-type their plan as a sentence
      i. Type out your cue, routine and reward to continue! "When *cue*, I will *routine*, so that I *reward*"

It should be important to note that these requirements are *not* a design specification, which comes after feature requirements are finalized.

4 Technical Stack

4.1 Technologies Used

For what platform to distribute our solution on, it was felt that a mobile solution was the most applicable. Ideally apps exist on both the Google Play Store as well as the Apple App Store, however due to time constraints, we chose to stick to one platform: iOS. A large factor for this decision was because members of the group have experience developing iOS applications which would ultimately speed up development. For a similar reason, Objective-C was chosen for development. However, for future versions, developers may decide to switch over to Swift, as there certainly are benefits to this language, but it did not make sense for us at the time.

4.2 Implementation

4.2.1 User Interface Design Process

The first step after identifying iOS as the most suitable platform, is to convert the product requirements to user experience flows. From there the design process begins with the following steps:

1. Ideation
2. Sketches
3. Lo-fi mockups
4. Design Reviews

One aspect of design that was important to keep in mind was the Apple Human Interface Guidelines[6]. Apple is quite strict on ensuring that apps on their platform follow this guidelines. There are six main design principles that need to be followed: Aesthetic Integrity, Consistency, Direct Manipulation, Feedback, Metaphors and User Control.

For building our user experience flows, we chose to use a combination of Xcode Storyboards coupled with programming flows in code. In the future, moving to SwiftUI[7] would be beneficial.

[6] https://developer.apple.com/design/human-interface-guidelines/
[7] https://developer.apple.com/xcode/swiftui/

Figure 4.1: Early lo-fi mockups

4.2.2 Backend and Database Services

The current version of the iOS app utilizes Apple's CoreData and CloudKit services, as opposed to a traditional backend. CoreData is a local store that effectively employs SQLite. While fairly light-weight, it has great development tools in Xcode for building database schemas and automatically generates the ORM models in your codebase. CoreData stores all the user information in the local storage of the iOS device, which is great from a security perspective. CloudKit on the other hand, is used to sync data between all of the devices associated with a user's iCloud account. Through CloudKit habits added on one person's iPhone, get pushed to their iPad, or even macOS devices (if there was a macOS app). Using both of these technologies was advantageous, as they were fairly easy to implement, and work consistently. The only disadvantage with its use is having to heavily lock your code into the Apple ecosystem. For a future iteration of this project, it may be worthwhile shifting to another dedicated backend solution, especially if there is a desire to create an Android version alongside the iOS.

4.2.3 Security and Privacy

- **Sign in with Apple:** This feature allows users to have peace of mind about their privacy. "Data collection is limited to the user's name and email address, and Apple's private email relay lets users receive email[s] even if they prefer to keep their address private. Apple will not track users as they

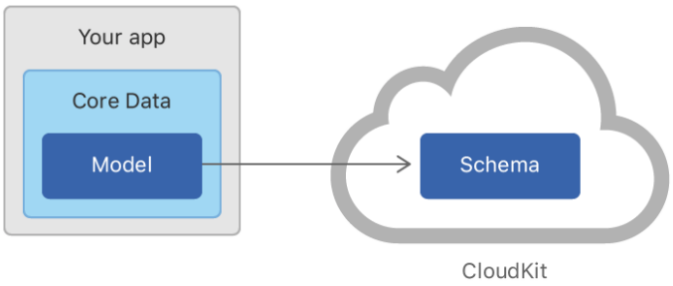

Figure 4.2: Basic CloudKit layout

interact with your app."[8]. A benefit to using this feature, is that it moves the concern of data privacy from the application to Apple. Apple takes privacy very seriously, and having the user's data protected by their systems as opposed to the application's is a great way to decrease the liability exposure of the application.

- **Habit Data:** As mentioned in section 4.2.2 the application utilizes the Apple CoreData and CloudKit for handling user data. While CoreData stores data locally on a user's device, CloudKit uses iCloud syncing to transmit information, therefore, the potential for a user's habit data to get compromised is very low. One easy solution is to allow users to toggle on and off CloudKit in their settings. Regardless of whether multi-device sync is enabled or not, the application backend is never able to see a user's habit information that they enter, thereby removing another potential liability for the application.

4.3 Potential Expansions

If implementing these additions in future works, one must ensure that there is sufficient justification to do so. Adding features for "the sake of adding features", or "because we need more technical complexity" are not valid justifications. Excessive bloat was found to be detrimental to many of the existing habit tracking apps on the various app stores. Below, we discuss some ideas that were brought up during the development process but were never implemented.

4.3.1 Health Data

A lot of people try to make health-related habit improvements. For instance, drinking more water, exercising more, and eating less processed foods to name a few. In doing so, users can take advantage of health data that may be stored on their phone. Data from places such as the built-in pedometer and water tracker, and even third party apps such as MyFitnessPal, could be used. This could be extended to an Apple Watch compatible app as well, which would make this integration more accurate and powerful. For example the heart rate sensor in the watch can automatically detect periods of exercise, so in the case that one user's habits involve "going for a run during lunch break", the watch could automatically detect and inform the app that the user has done their new routine.

4.3.2 Financial Data

Services like Plaid[9]are easy for developers to use and allow users to integrate with over 11,000 different financial institutions. This could be used to help those who want to create financial-oriented habits like saving and investing money. In addition to Plaid, another app called Alpaca [10] is an online-only brokerage that has no market interface or GUI. You have to provide the full interface in Python yourself. It could be implemented to have users carry out automatic investing that apps like Acorns[11] have been doing for years.

[8] https://developer.apple.com/sign-in-with-apple/
[9] https://plaid.com/what-is-plaid/
[10] https://alpaca.markets/
[11] https://www.acorns.com/

4.3.3 Location Data

Location data could be utilized by the app to assist in managing habits that involve a specific location as part of their cue. For instance, the app could send specific push notifications when users reach a certain geographical location, such as reminding them to listen to an educational e-book during their commute, or buying healthy foods when they are in the proximity of the grocery store.

4.3.4 Spotify API

Spotify[12] has an API that can be used to play music clips within an application, as well as a variety of other features. This would not be investigated in much detail, but there was a motive that it may be useful for people that who have a music-based cue. Ultimately, the idea was dropped as it was too niche of a cue to focus on at such early developments of the app.

4.3.5 IFTTT

"IF This Then That"[13] is a service that can be used to register webhooks with actions in a wide variety of applications. It was not investigated in much detail, but it could potentially be employed later.

5 Conclusion

Developing this project turned out to be a challenge in numerous ways. In completely pivoting to this new project as late as January 2020, the amount of time to "symposium day" was extremely limited. Fortunately, there was ample drive to complete the project, and within weeks of starting there was already considerable amounts of brainstorming occurring, with a significant amount of potential further expansions to the app. They were not implemented in the current app presented in this work, but for prospective groups wanting to take over the project, they are certainly topics to explore. On the technical side of things, there was a strong bias towards Apple products and technologies due to a pre-existing knowledge of them. For the purposes of the project they served very well. Ultimately however, the habit loop research performed by Charles Duhigh is what allowed this project to propel towards success. From the research done by the team, it was clear that current habit app offerings fall short. The goal of this project was to build an app that not only allows people to track their habits using the habit loop, but also encourage them to learn about the process, and by doing so help them create long lasting sustainable habits. Nonetheless, there is an amazing foundation for the design of an app that displays the habit research in an educational, yet engaging manner. By the end of the term, it was fantastic that everything was able to come together, and this literature was produced in order to summarize the experience from not just a software engineering perspective, but a psychology perspective as well.

6 Next Steps

The purpose of this paper was to summarize the project experience and document information for a future maintainer. If there is a group that is interested in taking this over this, especially in SE2021 and even SE2022 and beyond, please reach out to me at jjpezzac@uwaterloo.ca. I would love to take the opportunity to go through things with you. The first low fidelity prototype of the app is available on GitHub at: https://github.com/cue-d/cued-app. A basic demo that highlights some of the main features that have been developed as of now is available at: https://github.com/justinpezzack/se499-w20/blob/master/basic-demo.mp4.

[12] https://developer.spotify.com/documentation/web-api/
[13] https://ifttt.com/