SALUBRITY: GAMIFY YOUR HEALTH PART 2

by Jiatao Cheng, Andrew J. Elenbogen,

Nathan C. Fudenberg, Patrick D. Stephen

1.Introduction

With the prevalence of smart-devices we now generate tons of data about our daily health and carry a platform to keep tabs on it with us. With all this data and accessibility literally at our fingers it is terribly wasteful to not try to leverage it into better life habits and health. Specifically we can use this data not as a once a week shaming process but rather we can gamify our health by having a much tighter feedback loop which uses positive reinforcement. To create this health game we decided to make an Android application which we called Salubrity.

2.Gamification

Making a health game can best be conceptualized as using gaming means to achieve a health end. That is, health, not gaming, is the goal. In service of this, it is the aim of Salubrity to create the maximum engagement possible for activities that increase users' health. In the gaming world, activities are often divided into two broad categories: extrinsically motivating activities and intrinsically motivating activities. Extrinsically motivating activities are those done almost strictly to receive some reward, for example, studying to receive a good grade on a test. The studying isn't pleasurable in and of itself, but the positive grade at the end is. Intrinsically motivating activities are those that are fun in and of themselves. For example, someone might play Ultimate Frisbee not because they're attempting to train for a big Ultimate tournament, but because they find the act of Ultimate inherently enjoyable.

For some users, things like eating right, getting enough sleep, and exercising regularly might be intrinsically motivating. Those users could use our application, but there are already many applications that serve their needs. However, given that over a 1/3 of the adults in the United States are obese[1], and that only about 35% of adults in the US are getting over 7 hours per night[2], there is strong evidence to support the claim that for most of us these activities are not intrinsically motivating. It is the role of gamification then to motivate users to form healthy life habits and drag them, kicking and screaming if necessary, into bettering their own lives.

To this end, we examined other successful games that have successfully grafted enjoyment onto otherwise dull activities. One of the most prominent among these is Cookie Clicker. Cookie Clicker is a game about doing almost nothing, a game about watching numbers go up on a screen for its own sake. Yet, somehow it manages to motivate large numbers of users to spend inordinate amounts of time watching themselves accumulate cookies in increasingly ridiculous amounts.

The means by which this is accomplished is simple psychology: the Skinner Box. The Skinner Box, originally discussed in Skinner's book The Behavior of Organisms[3], is a psychology experiment that demonstrates that animals and humans alike can be conditioned to take an action. That is, if a reward is consistently given for any arbitrary action, humans will be conditioned to take that action regardless of how inherently pleasurable it is. The Skinner Box is most effective (ie: does not plateau) when the rewards it gives out are not things that humans

[1] http://www.cdc.gov/obesity/data/adult.html
[2] http://www.cdc.gov/mmwr/PDF/wk/mm6008.pdf
[3] Skinner's book: http://s-f-walker.org.uk/pubsebooks/pdfs/The%20Behavior%20of%20Organisms%20-%20BF%20Skinner.pdf

require for life, such as food or water, and when said rewards are given randomly or periodically rather than continuously[4].

3. Health

When applying this model to a fitness aid, it is always incumbent to ask questions about the target audience: how they'll respond to different reward schedules, what they need and how that can be delivered. To decide these aspects our group employed an iterative process where we evaluated key aspects of fitness and health based on their difficulty to implement on an app, developed target audiences and then re-assessed which set of aspects should be kept. By using this process we were able to ascertain what set of things would be both feasible and useful to implement in our limited development time frame.

Feasibility testing can be time consuming if taken to the literal extreme. To preempt massive time investment our group decided to observe what functions existing Android applications and non-Android fitness applications tracked and the tracking methodology they employed. There are five major categories of health: Mental, Emotional, Physical, Social and Spiritual. Physical is the most often tracked with Emotional and Mental being tracked in only a small subset of applications. Physical health on the internet is often tracked via workout logs, calorie counters, or food diaries, which all have fairly static user input heavy implementations. In newer mediums such as on mobile devices like the Android there are a wealth of apps that integrate the older methods with faster and different input allowing users to scan food, passively measure their steps, analyze their sleep, as well as providing easy access to all the old measures

[4] For Skinner Box usage in games, cf https://www.youtube.com/watch?v=tWtvrPTbQ_c

on the internet. Mental health is not tracked as often and is often boiled down to the user selecting from some pre-selected or previously selected states of mind to ease and facilitate meaningful analysis of their health.

From our research we now had an idea of what is possible but we had to build a conception of who our audience would be. At first we wanted to have a comprehensive application, one that took advantage of as many aspects of the users health as possible to prevent the user from having to switch from our application to some other one just to track a specific health aspect. While this idea of all-in one functionality never entirely left us we decided that mental health was too hard to measure and relied strongly on user-input. This was a problem for our app because it meant that the user would be able to accumulate points in an unregulated way. Since there is a legacy of applications and studies on physical health we decided to focus on what aspects we could pull from there. Cardiovascular based activities seemed to be the most interesting aspect of health that could be measured by mobile devices as many people keep mobile devices with them at all times. In addition to motion and cardiovascular tracking we figured that both food and sleep are commonly tracked and it would be sub-optimal if a user had to get separate applications to track these aspects of health especially as we could put them all together.

Fitness apps which track cardiovascular fitness along with sleep and food already exist which to us reinforced our belief that we would have to look for a target audience that was currently under-served in the fitness application market. We at first investigated the possibility of using a wearable device as that is trending and the apps that accompany the wearables are often not fully fleshed out. Unfortunately at the start of the project the wearables available were not

spectacular due to a series of recalls and so we chose to use the Fitbit Flex. The Fitbit Flex that we tested did not do a spectacular job of tracking anything, showing an advantage only in that it was eminently portable and could be worn in a few cases where one might not be holding their phone. Recently released devices such as the apple watch or even the Fitbit Charge HR provide more substantial benefits such as heart rate monitoring but were not in the time scope of our experimentation. Due to the abject failure that is the Fitbit Flex, and on account of a proof-of-concept paper[5], our development team decided to forgo forcing our users to spend extra money and instead use native phone abilities to monitor their health. To this end we decided to create our own algorithms to detect movement and then correlate that to an activity to prevent any cheating that might happen while also keeping out any barriers to entry that a wearable might present. Once we realized we could build anti-cheat into our program from the ground up we knew that we could build our application for people who lack a strong intrinsic motivation to get fit. This group solidified into being the group which we know as gamers.

4. Theme and Target Audience

Considering the field of applications that were popular and historically had been popular as we began our project, consistent among them was a target toward a very general, intrinsically motivated user. As we had designed Salubrity with the capability to attempt to incorporate extrinsically motivated users into the world of fitness applications, we needed a target audience that would correspond well to this model. In the population of video game players we saw this most clearly. Our target user would look at a system for gamifying a fitness game and attempt to subvert the application's attempts as much as possible by accomplishing the tasks given with the

[5] http://www.cis.fordham.edu/wisdm/includes/files/sensorKDD-2010.pdf

least amount of work, I.E not acting healthy. Those who would do this most radically would be people who are used to doing so, very active video game players who break systems in video games on a regular basis to gain some advantage either over the game or over other players[6].

As with any video game, Salubrity is set in a specific context with the goal of engrossing the player in the events of their virtual world. To keep a player engaged in this type of setting, the context for a game requires some sense of internal consistency, and usually either a fantastical scenario that intrigues the user as some enabler of escapism or a realistic scenario to enable the user's relating the world they come into to their own.

In this respect we had a variety of options for Salubrity's theme, although we were certain from the start that we wanted to do something fantastical. To decide on what theme would be most appropriate, we needed an understanding of who we were focusing on for our app as potential users, and the target user of the video game player let us define this.

With this userbase in mind, we wanted a theme that would appeal to a more general audience but more-so to video game players specifically. Our various fantastical considerations evoked the themes of popular culture that would appeal to these users who might consider themselves on the edge of stereotypically popular media. Thankfully in this day and age the "nerd culture" has been embraced by films and television and mass-marketed to the general populace while still belonging to this particular subculture who play video games as often as we would like. Specifically we sought to emulate one of the following themes: Superheroes, as in the superbly popular recent Marvel movies; Medieval Fantasy, as in *The Lord of the Rings*; Space Voyagers or Cowboys, as in the cult hit *Firefly* and the recent *Star Trek* revival; Zombies,

[6] These attempts have been helpfully archived at locations such as *zeldaspeedruns.com* and *smashboards.com*, for two very differing perspectives on this approach to video games.

as in the HBO series *The Walking Dead*, or any of the many zombie survival video games which have appeared in recent years[7]; and finally our eventual choice, Vigilantism as a branch from Superheroism, as seen in *Batman* and the recent Ubisoft release *Watch_Dogs*.

There were explicit advantages to using Vigilantism as our theme, in how the challenges that the users would complete could be easily integrated as actions of their avatar in Salubrity and in how it enabled us to make relatively fewer art assets while still producing a visually engrossing experience. One of our considerations when trying to develop an engrossing experience was how the actions the player took would reflect through the theme that we chose. For example, in a Space Cowboy scenario there'd be some equivalency between fueling up your ship in the game and eating food or sleeping in the real world. Considering our options in the respect, Vigilantism had the most direct connections-- unlike a superhero who might teleport or fly, a Vigilante would need to physically move about their city to reach and solve crimes, for example. There was a similar advantage with using a Zombie theme, in that survivors in a Zombie survival scenario would need to run to escape Zombies, for example, but at the time one of the most popular fitness game on the Google Play store was *Zombies, Run!*, which took a similar approach as our game in that setting. Avoiding that theme, then, was a priority to not overlap audiences or appear to be emulating their game. The second advantage which Vigilantism gave us was in our art direction. All a vigilante needs to do their job is their secret underground base, and this base could be expanded with newer rooms, computer rooms, places to keep disguises and weaponry and vehicles, etc. Comparatively a generic superhero might not have all of these needs, relying on some natural talent instead of on tools they had available to

[7] Such as *Resident Evil*, *Silent Hill*, *DayZ*, *Infestation: Survivor Stories*, *i maed a game w1th z0mb1es!!!1, Dying Light*, *Dead Effect*, *Sniper Elite: Nazi Zombie Army*, *Left 4 Dead*, *Killing Floor*, and *Dead Island*.

them, so exactly what the player would modify to progress was hard to determine. Similarly a space cowboy would act like a vigilante, but would move between planets and would interact with a variety of different spaceships. In this case each of these planets and spaceships would need a new image or scene drawn for them, and given our small production time and our focus on other elements of the project without a specific member to focus on art assets, we would've needed to resort to publicly available art assets to have anything near the variety a player would expect. Wanting to avoid this, both to steer clear of issues with crediting and licensing and to make sure our art all had a similar design pattern, we saw in Vigilantism that a very limited number of art assets would need to be made to have a similar quality and variety. It also ensured, given that we were making all of our own art, that we could synchronize color usage between the game visuals and the visuals of the user interface to properly distinguish these elements from each other for a better user experience.

With respect to our art choices, pixel art was explicitly used as a way to better connect with our target audience. As avid video game players, our target audience would have interacted with and seen all varieties of art styles, but in particular pixel art due to how fast it is to create--for many video game projects pixel art is chosen because it can be pushed out faster than other varieties or art. While this is less of a factor with modern video games, where many 3d development tools and hand-drawn styles can be incorporated into games with a similar speed, pixel art is still used today as an art style that video game players have attached themselves to culturally. In both of these respects, pixel art was an easy choice for our artstyle to best match our target audience. While these art effects served as passive motivators for our users, we also wanted active, regular events that would re-engage users.

5. Challenge Schedule

For this reason, Salubrity gives users time based goals called challenges. Challenges require users to perform specific actions within a short time frame to receive a large lump sum of our secondary reward mechanic, vitality. Because the daily challenges can occur randomly during hours the user has marked as available, our app is able to maintain the conditioning value of random Skinner Box rewards, without, for example, asking a user to run a mile during an important meeting. Also, the once per day nature of daily challenges helps to create a reward schedule, where the user is always looking forward to that next challenge, their next chance to earn large sums of vitality.

The other piece of gamified technology Salubrity utilizes relates to the buildings. In Salubrity, the user spends their hard earned vitality to purchase buildings. Each building is associated with an action, and increases the vitality earned by that action by a set multiplier. This is reminiscent of Cookie Clicker in the sense that the more buildings a user has, the faster they will accumulate vitality to purchase yet more buildings. This is a very effective motivator because the user can see their buildings accumulate, providing a visual indicator of progress, and can see the rate at which their vitality increases go up. Going for a jog might have only earned them 10 vitality when they started playing but a weeks in it earns them 50! The constantly accelerating progress helps users to maintain engagement over the long run and because the buildings only give any points when the user is doing their linked activity, the building system forces users to maintain healthy activities long after they might otherwise have given them up. All of this capability is only enabled through our having constructed our own flexible activity-detection algorithm.

6. Algorithm

We chose to write our own activity detection algorithm for several reasons, one of which was to have more control over what activities we wanted the phone to be able to detect. To do this, we needed a total control over how our app determined action.

There are already many different APIs which can determine a user's activity using the accelerometer, there is even a built-in one for Android. But, these APIs are limited to the traditional set of activities, most notably walking, running, cycling or in a vehicle[8]. This set does not include several activities that we considered adding to our app, including, but not limited to, dancing, body weight exercises (ie. Push-ups, sit-ups, and squats), and other forms of weight lifting. These APIs also wouldn't necessarily operate on the same level of accuracy with respect to timeframes of exercise as we wanted, categorizing 30-second periods of activity.

First and foremost, we needed to decide where the phone would be detecting activity from. One of the major concerns of our app is accessibility. We want our app to be as accessible to as many people as possible. This means limiting the hardware required to use the app, so in an attempt to avoid having users buy armbands or waist clips, we decided that our algorithm should begin with detection in the users' front pocket.

The android phone has several sensors available, the accelerometer, gyroscope, GPS, and magnetic force. When deciding which to use, our goal was to be able to keep track of the users' activities fast and efficiently; this ruled out using GPS and/or multiple sensors because since the idea is to keep track of the users' activity 24/7, using either of those two option would have caused excessive battery drain. Having to choose just one from the options left, we decided to go

[8] https://developer.android.com/reference/com/google/android/gms/location/DetectedActivity.html

with the accelerometer for a few reasons. The first being it does not take a heavy toll on the battery, and second being the data from the accelerometer is extremely when it comes to trying to detect activity since it returns acceleration in all three dimensions.

The accelerometer outputs a tuple (x, y, z), where each represents acceleration on their respective axis. The first step to analyzing this data was to extract as many features as we can from a set of accelerometer data from a specific time range. The features we looked at were: average acceleration, average maximum acceleration, and time between peaks for a ten second time range. Using these features, we are able to determine what the users are doing at that time range.

Take running and walking for example, we can distinguish the two activities by looking at the differences between the time between peaks and average peak accelerations. The graphs, with acceleration on the y-axis and time on the x-axis, for walking and running are similar because of their similar motions, both exhibit sinusoidal curves because of the repetitive stepping motion a user makes when doing either of those activities. For each step the user takes, there is an increase in acceleration in the positive direction – or negative, depending on how the phone is positioned in the pocket – then as the foot begins to come down, there is a change in direction, thus the acceleration changes to increase in the other direction. In a ten second range, a user will have taken several steps for both running and walking, therefore creating the sine curves that were mentioned earlier.

There's one significant difference between running versus walking that we took into consideration. When a user is running, they are moving faster than when they are running. When analyzing the accelerometer data for this, we look at the distance between the peaks in the graph.

Because a user is moving faster, taking less time between each step, the distance between peaks is noticeably smaller when they are running. Another way moving faster affects our graph is that in order to move faster, our users have to generate more force, therefore, assuming their mass stays constant, their acceleration increases, the faster they move, the higher the acceleration, in any direction. Thus, if we compare the average positive accelerations in the y and x-axis, we can also see a noticeable difference between running and walking[9].

7.Conclusion

One of the largest concerns we had coming into this project was being able to effectively craft a fitness app that was remotely popular given how oversaturated the fitness app market was when we started. Google and Apple both had released their own fitness apps in the months preceding and following the start of our development[10]. Given that our four-person team was being put up against thousands of other, more experienced teams who had longer timeframes and less other work to do simultaneously in making competing products, to say we had an uphill battle ahead of us would be a stark understatement.

Despite this, we used a variety of tactics to create a seriously engaging yet simple and streamlined game. We saved time by using things like libGDX to hasten and streamline our GUI development, pixel-art artstyle to hasten asset creation, and many other decisions that added up to making our project feasible. Due in part to these design decisions our application, Salubrity, has its own niche in the market and is powerfully and simply designed allowing easy adoption and use for all.

[9] http://www.ijimai.org/journal/sites/default/files/ijimai20121_5_5.pdf
[10] https://www.truevault.com/blog/apple-healthkit-vs-google-fit-infographic.html#.VQMlaI7F_58