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Alcogait Gamification

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Alcogait Gamification

by

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Abstract

Alcohol abuse causes 1 in 10 deaths among adults in United States aged 20-64 years [11]. An effort to motivate health related behavioral changes in e-health industry could be seen before, but it was never done in mobile (m-health) context. Technologically, current applications in smartphone domain, emphasize on manual way of measuring intoxication levels for users such as logging BAC values, taking cognitive tests; but none of them passively infer user's intoxication level [1].

'Alcogait' is a smartphone app that infers a smartphone user's intoxication level from their gait by classifying motion data gathered from the smartphone's accelerometer and gyroscope by Aiello et al [1]. This study is part of a Master's thesis to build an intervention system around Alcogait's functionality and explore the effects of gamification and avatar (for feedback) using Alcogait's inferred intoxication level. Creation of user engagement is examined, in order to continue future study using gamification along with Alcogait's functionality. The Alcogait system is not intended to either encourage or discourage abstinence. Its goal is to incentivize responsible transportation choices made by a person or their peers after that person is detected to be intoxicated in order to potentially mitigate DUI situations.

Terminology

1. Alcogait study: Study of gait based intoxication prediction functionality [1].
2. Alcogait Gamification study: This particular study tries to explore the possibility of engagement caused due to gamification strategies implemented around Alcogait functionality(study).
3. Alcogait app: For the scope of this study, Alcogait app refers to the app created by adding Gamification Strategies on top of prototype built by referring to Alcogait Study. For example: Prototyped service that checks for particular range of accelerometer x value (Rather than learning user's walking pattern as done in Alcogait study by Aiello et al)
4. E-health: Healtcare strategies implemented using electronic devices [27]
5. M-health: Healthcare strategies implemented using phones (usually smartphones) [28]

1. Introduction

Alcohol is a significant cause of death in the United States, resulting in 88,000 deaths annually [1]. Driving under influence of alcohol resulted into crashes costing 132 billion dollars according to a 2010 report from National Highway Traffic Safety Administration [12]. Drunk driving is alcohol related issue that endangers not only the intoxicated driver but also pedestrians and other sober drivers [13].

1.1. Binge drinking on campuses and related issues

Excessive drinking consists of two types. Heavy drinking (8 or more drinks per week for women and 15 or more drinks per week for men) and binge drinking (4 or more drinks for women on a single occasion, 5 or more drinks for men on a single occasion) [18]. For the scope of this thesis, we will be more interested in addressing binge drinking issues since that's the most common issue seen on college campuses.

A New York Times article published on December 2014, discusses the issue of growing binge drinking activities on or near college campuses across United States [14] and how that leads to deaths, sexual abuse and DUI incidences. The article briefly discusses incorrect measures taken by colleges and universities as they believe that a "the right message will change the behavior" policy where they merely display information needed for individuals to make right choices, which doesn't seem to have worked for the past 30-40 years.

During 2002-2005, Substance Abuse and Mental Health Service Administration conducted a survey of full time college students aged 18 to 20 about alcohol consumption in past month. Figure 1 demonstrates that binge drinking was reported by a third of men and women in prior month. Heavy drinking however was reported by just over tenth. [19].

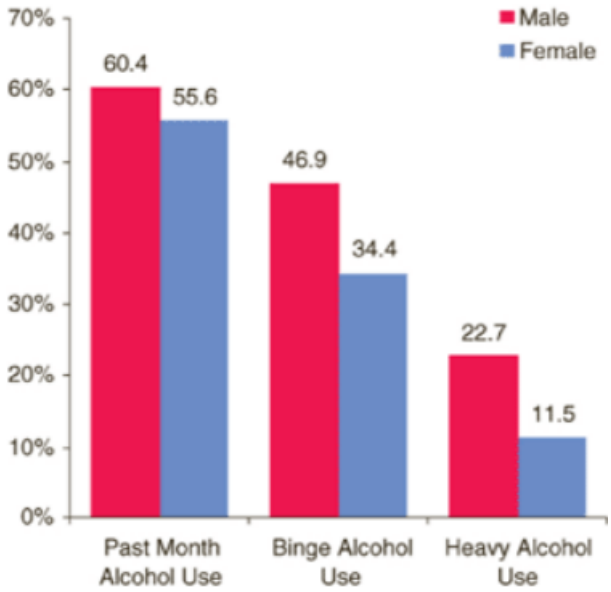

Figure 1 "Binge and heavy alcohol usage by students aged between 18 to 20 in prior month [19]"[1] [2]

1.2. Current measures for DUI mitigation and the need for newer measures

1.2.1. Current measures

[1] Heavy drinking: For women, number of drinks including or exceeding 8. For men, drinks including or exceeding 15 [18].

[2] Binge drinking: For women, number of drinks including or exceeding 4. For men, drinks including or exceeding 5 [18].

According to Naimi et al, enforcement of strict rules changes behavior. Probability of binge drinkers reporting drunk driving is 14 times greater than non-binge drinkers [15]. This is a major issue that's only growing and a behavior change is more than necessary.

In many DUI cases, drinker is unaware that they are over the legal driving limit. "An average drunk driver has driven drunk over 80 times before the first arrest" [6]. Behavioral digital intervention can therefore be useful in this case which includes reminding the users that they might be drunk, based on predicted intoxication level, and ask users to perform a breathalyzer test. In an article published by CDC (Center for Disease Control and Prevention), they discuss several ways to reduce and prevent drunk driving [5]. It includes all the measures that are currently taken and measures that can be taken in future like sobriety checkpoints, multi-component interventions, mass media campaigns and ignition interlocks.

Interlocks are currently used according to court order. An ignition interlock installed in a car measures BAC (blood alcohol content). If it's over 0.02%, the car will not start. However, there are problems with this approach. The interlocks work only for convicted offenders, because they are the only drivers whose cars are required to be suitably equipped. People driving under the influence before getting caught will not be stopped.

A person can drive with minor impairment above the 0.02% BAC level, which is below the legal limit of 0.08%. This makes interlocks unnecessarily inconvenient for non-problem drinkers.

AlcoGait Gamification aims to address these issue and focus on preventing DUI incidences for unnoticed offenders.

1.2.2. The need to gamify the mitigation system

From a fiscal perspective, law enforcement agencies and car insurance companies would like to reduce the cost of 132 billion dollars spent annually on alcohol-impaired motor vehicle crashes reported by National Highway Traffic Safety Administration [12] by investing in preventive measures that change social behavior and instill responsibility through motivation. According to Ryu, hype around e-health, m-health has created a new opportunity for gaming in the healthcare industry. A study shows that games increase motivation, determination, self-efficacy and hence are looked at as tools to inculcate positive behavior changes by stakeholders of Healthcare industry [3]. Ryu also discusses examples of gamification that did wonders in the health care industry like Packy and Marlon (discussed in detail in section 2).

1.3. Current feedback measures

Current e-health apps provide users with lots of data. Even though graphs are known as one of the most effective visualization techniques [25], multiple apps bombarding users with data can potentially reduce effectiveness of the feedback provided [8]. This issue is addressed in detail in section 2.1.1.

1.4. Previous work

Previously, Aiello et al worked on Alcogait study that tested 34 participants (20 females and 14 males) that resulted into a BAC classification and prediction system that could classify user's intoxication level with 89.45% accuracy [1].

1.5. The goals of this thesis

1. Investigate current measures of feedback and data visualization. Weigh them against usage of an avatar as a feedback mechanism that might result in potential behavioral change
2. Design and implement an effective gamification scheme to mitigate binge drinking behavior
3. Augment the gait inference capabilities of the previous Alcogait version (mentioned in section 1.4) in order to create a DUI mitigation system for smartphones.
4. Evaluate the new gamified Alcogait DUI system by gathering qualitative user experience data through interviews with various stakeholders including potential users, law enforcement officials and test if it creates engagement for users.

2. Related work

Ryu et al, mention two noticeable efforts made in e-health sector due to significant results: "Packy and Marlon" and "Bronkie and Bronchiasaurus" [3]. According to their findings, Michigan State University reviewed 20 e-health games in 2009, Packy and Marlon was the most significant one as it helped reduce urgent visit for diabetes by 70% in 1997. In the first game

Figure 2: Packy Marlon gameplay

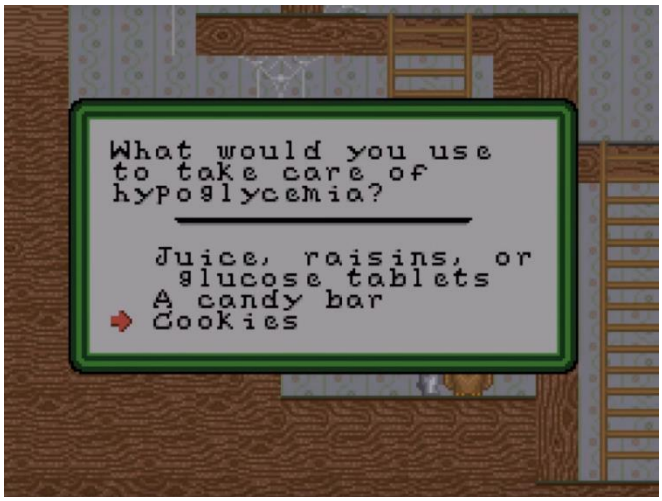

Figure 3: Packy Marlon informative health related questions for diabetic patients

mentioned by them, young players play as two elephants and learn about appropriate food choices, insulin dosages, their timing [3]. For the second game, a study mentioned by Ryu et al, discovered that hour or less of Bronkie and Bronchiasaurus gameplay made players more aware of Asthma related issues and how to face them [3]. Although the e-health games mentioned above were proven to be effective, they were only targeted towards children. Ryu et al, explain that even though these games were successful, the e-health games were not effectively used in daily lives of adults; since makers of these games focused on small set of target audience(children) not accounting for the ability of games to appeal adults [3].

Figure 4: Bronkie the Bronchiasaurus asthama related information

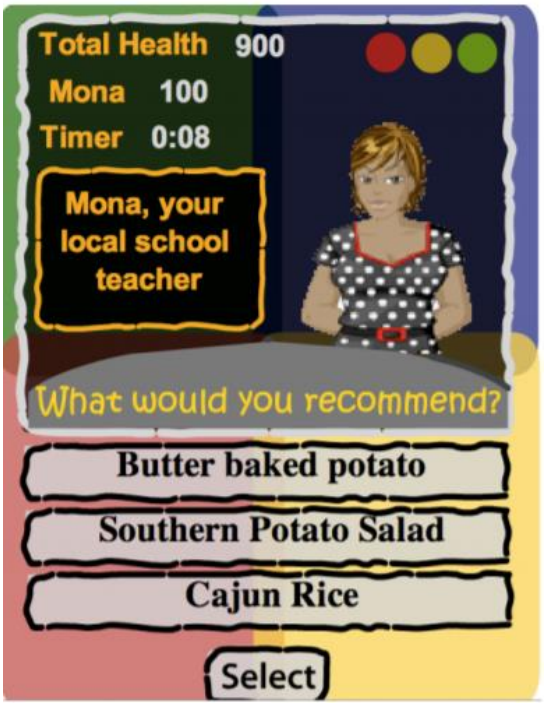

Figure 5: OrderUp! screen

Identifying the fact that there is a lack of serious e-health games for adults, Grimes et al decided to design and implement "OrderUp!" (for Nokia N 95 phone) [26]. In this game, 10 different customers (in-game customers created using Yahoo avatars) one at a time, are to be recommended with the healthiest pick from the 3 given food choices(dishes) as shown in figure 5. Twelve participants in Atlanta, GA were given a phone with OrederUp! for 3 weeks. Grimes et al conclude that it helped raising the dietary consciousness via triangulation of diaries, surveys and interviews. The players became conscious of portion sizes, 9 participants discussed about nutrition within their social circles, in an exit survey, 9 subjects claimed that they make healthy food choices as opposed to 5 people during the initial survey. Grimes et al conclude their study by stating that playing m-health games can help subjects start to engage in the process of change

(in dietary awareness) within short period of three weeks [26]. Alcogait Gamification study aims to achieve similar goals by trying to check if the gamified system creates engagement, hence making a room for future study.

2.1. Feedback and visualization

2.1.1. Current feedback measures and comparison with avatars

M-health and e-health apps such as Google Fit, S Health (Samsung) provide users with graphical data and logs as feedback.

Figure 6: Google Fit e-health application. Uses graphical data, logs as a feedback.

Users are supposed to reflect on their health logs and make changes in their behavior. Murray et al suggest that when avatars are used for feedback purposes humans use their instinctive abilities

to encode the information to be conveyed. This is the reason why using avatars for feedback a lot more information can be conveyed than that of any primitive tool for visualization like graphs or bar plots [8]. They also add that "bandwidth of traditional visualization strategies is being strained by the ever-growing influx of data" [8]. In other terms, current data visualization techniques stop being effective beyond a certain limit. Humans naturally interact with other humans or human-like digital characters, whereas reading graphs is an acquired skill which can easily become overwhelming as the complexity of applications grows. Therefore, in the Alcogait app, we decided to use avatars instead of graphs, logs and other standard visualization techniques for feedback.

2.1.2. The Proteus Effect and operant conditioning

Murray et al study two mechanisms behind digital self-representation, which affects individuals, the Proteus Effect and operant conditioning [8]. From descriptions offered by Murral et al, The Proteus effect can be described as change in user's behavior according to changes in the in-game character's attributes. These attributes can be any sort of emotions or reactions conveyed to users in some form, which eventually affect their behavior in real life [8]. Murray et al, guide us towards the work of Hershfeld et al, who conducted a study where they presented users with morphed version of themselves in future [28]. This was done by providing them with HMD (Head Mounted Displays). In the virtual environments, different set of users (21 one participants with 15 women and 6 men) could see their own versions in different phases of life in a virtual mirror. This resulted into users wanting to save more money for the future. They grew sympathetic towards older versions of themselves [28].

Figure 7: Player's performance was affected by visual attributes of avatar like fierceness, size according to Yee et al. [23]

Operant conditioning can be looked at as accurate visual feedback for users' actions or rather the results of their actions. If users are facing some kind of task, the operant conditioning is done by giving them visual feedback for both success and failure. Success in this case would be associate to something positive. Operant conditioning used in health care setting was mentioned by Braungart et al [29]. In intensive care wards, noise was effectively reduced by using some of these methods. The family members of patients with reoccurring back pain, were asked not to help patients when they act overly dependent way and complain a lot. But help more when they are more independent and show positive attitude with no complaints. At the end, patients reported more self-efficacy [29]. Alcogait utilizes operant conditioning using Avatar that changes the way it looks based on user behavior (discussed in detail in section 3.2).

2.2. Cugleman's work

2.2.1. Overview

In a Serious Games editorial named "Gamification: What it is and why it matters to Digital Health Behavior change developers," Cugelman discusses the popularity of gamification and

whether it really offers a magic solution to shaping behavior or is simply unrealistic hype [4]. According to him, Gamification is when game design elements are used in non-gaming context [4].

2.2.2. Cugleman's seven strategies

In his research, Cugleman assessed the links between gamification and health behavior change, and conducted an exploratory comparison of seven gamification strategies based on behavioral science principles that are proven to work [4].

Gamification strategies and validated behavior change ingredients.

Gamification strategies	Validated behavior change ingredients [2]
1. Goal setting	• Agree behavioral contract • Goal setting (behavior)
2. Capacity to overcome challenges	• Time management • Action planning
3. Providing feedback on performance	• Prompt self-monitoring of behavioral outcome • Prompt self-monitoring of behavior
4. Reinforcement	• Provide rewards contingent on successful behavior
5. Compare progress	• Prompt self-monitoring of behavioral outcome • Provide normative information about others' behavior
6. Social connectivity	• Social influences (norms) • Plan social support/social change
7. Fun and playfulness	N/A

Figure 8: 7 Gamification strategies and validated behavior change ingredients

We plan to implement some of these strategies for behavior change and compelling usage in order to gamify the Alcogait app. Section 3.8 discusses how Alcogait gamification scheme is

based on the table shown in figure 8. If readers are curious about how the Cougleman's seven strategies have been used as the basis, they may jump to section 3.8 directly.

3. Alcogait gamification scheme (Methodology)

3.1. Use cases

1. **Registration**: The smartphone user registers as an Alcogait user with their email id and selects a username.
2. **Avatar customization**: The user customizes a character which they have selected as their avatar. All new users start with the cadet rank.
3. **Teams**: In order to start using the app, a user has to be part of at least one team. To be precise, a team of one cannot exist. A user can subscribe to multiple teams. A "team" is a set of friends who register as a group and are responsible for looking after each other. They are expected to manage safe transportation choices for their team members, directly or indirectly.
4. **Notification toggles**: By default, all registered teammates receive notifications from a teammate according to the rules mentioned further in section 3.1.2. Each group and team member has a notification toggle next to their names. This toggle when turned off, sends notifications only to the team members with the toggle on. Users can use this feature to mask notifications from one or more teammates or an entire group.
5. **Trigger**: The Alcogait app detects changes in sway and predicts the user's BAC. Aiello et al mention in their research that, Alcogait functionality was 89.45% accurate while classifying users' BAC level successfully [1], hence this extra check is necessary to accurately determine user's BAC. If the BAC is above a certain threshold, the Alcogait app asks the user to take a Bluetooth breathalyzer test along with a fingerprint scan,

which confirms their identity. The user must take the breathalyzer test within a specified time frame. Failing to do so would result in negative XP (experience points).

6. **Identity verification**: If the fingerprint scan is unable to confirm the user's identity, the user receives negative XP points (-100).

3.1.1. Case A: If the fingerprint scan passes and the user is not drunk beyond the permissible BAC

If the fingerprint scan is successful and the user is drunk but is still below the BAC limit permissible for driving in their home state, the Alcogait app schedules 3 further random breathalyzer tests. This is done to accommodate the fact that sway is monitored continuously, but the user may consume more alcohol. If the user passes all three breathalyzer tests, the app will then try to detect the next sway change.

3.1.2. Case B: If the user passes the fingerprint scan and is drunk beyond the permissible BAC

If the fingerprint scan is successful and the user is above the local BAC limit, the Alcogait app notifies the registered user's team mates, or the user can call an Uber to return home if they're not home already. The notification reads as follows: "John is infected by Alcolord. You're on a mission to rescue them. A chat window is open now for you to plan this heroic rescue".

Choosing Uber options gains highest XP (150) for the user. Part of their XP (25) goes to the rest of the team to encourage each other's wellbeing. A teammate rescue can be tracked to any indoor location, one of the aims of the application being taking user home/to a secure location safely. A teammate who leads the rescue (a person who drives in the case of a teammate rescue) gets the highest amount of XP (100). Teammates that get rescued get half the (50) XP and teammates that

are not involved in a rescue get a quarter of the highest XP (25). If users accumulate 600 of such XPs, they earn a free ride. In other words, every four Uber rides ordered using Alcogait will fetch a user one free Uber ride. Alcogait can achieve this by signing a deal with ride hailing services like Uber or Lyft. For companies who support noble causes like these, any help counts towards positive public relations and potentially creates a tax break opportunity.

3.1.3. Case C: No response or detection before the breathalyzer test and after the gait functionality predicts higher BAC

If the user doesn't respond after having a predicted BAC beyond the permissible level, or can't be detected online by the Alcogait app, everyone eligible to be alerted according to the rules mentioned in 3.1.2 gets notified. The message reads as follows "John is possibly infected by Alcolord. Try to reach them. If they don't respond, try to find them and rescue them"

3.1.4. Case D: No response or detection after the breathalyzer test

If the user doesn't respond after being positively detected with a BAC beyond the permissible level, or can't be detected online by the Alcogait app, everyone in the team gets notified. The user in focus gets negative XP (-100). Everyone else on the team too gets negative XP (-25) if the user still isn't detected online after a few hours of publishing the notification. If the phone is offline for more than a day, the user gets an additional negative XP (-200) and the rest of the team members get a further -100 XP. This behavior will be recorded for purposes of fraud detection mentioned in detail in section 3.5. The user loses all their accumulated free rides. This behavior might even be reported to car insurance companies and law enforcement agencies in some cases.

3.2. Alcogait avatar

To give users feedback on their performance in the game and XP/rewards they have earned, there were two choices. First, offering a regular data visualization like most other m-health apps do. The second option was using avatars that embody the user's current state in order to engage players more and encourage potential behavior change. The design choice was made to have an easily visible avatar, continuously displayed on the app.

Each Alcogait user can customize their own avatar slightly. This avatar represents the current state of how they are performing in the game in terms of responsibility. If a user constantly refuses to take a breathalyzer test, the avatar will grow up to be clumsy and irresponsible. The same would be the case for being constantly offline or constant negative XPs. On the other hand, if the user takes Uber rides or gets rescued and engages in responsible drinking behavior, the avatar will become happier and more energetic.

There will be a leader board which shows the rankings of all groups using Alcogait worldwide. The team's rank will be purely based on combined XP.

From the interviews conducted with 20 people (10 males and 10 females), it was determined that most users desire some sort of avatar customization. Some wanted their avatar to have more optional accessories like (glasses, t-shirts, chains etc). Others expected a more customizable avatar that looks like them, or is somehow more representative of them. Three people mentioned Bitmoji, Snapchat's version of avatars that can be highly customized to represent the user. Many responders didn't request any change to the avatar, and two didn't care about the avatar at all.

3.3. Achievements

(Details such as names of achievement levels, scores and multipliers in this section are subject to change)

A multiplier applies to every XP earned and is stored in the user's record. For the first month, for promotion and user engagement purposes the multiplier will be 0.8 (which is as same as the level of Major Stability). For example, if 100 XP was earned by a user, under Sergeant Shotgun, they will only gain 50 XP. But under the Captain Detox level, users will earn 90 XP. The multiplier is used to balance the game. If all the players gained XP at the same pace, there would be no incentive for players that performed well and leveled up. Many users getting free Uber rides too frequently would not produce an effective business model.

XP formula: [XP earned] * [multiplier] = [XP gained]

Table 1: Achievements table

Achievements/Rank	**XP needed**	**Multiplier**
Cadet Binge	1000	0.8
Sergeant Shotgun	1500 and 30 days of usage	0.5
General Drunken	9000	0.6
Colonel Tipsy	12000	0.7
Major Stability	15000	0.8
Captain Detox	18000	0.9
Lieutenant Sobriety	21000	1

3.4. Rewards

Table 2: Rewards summary table

Action	Points gained/lost
Failed identification using fingerprint scan	-100 XPs
Case B from section 3.1.2 (Uber option)	+150 XPs (the main user), +25 XPs for all other members on the team.
Case B from section 3.1.2 (teammate rescue)	+100 XPs (people involved in rescue), +50 XPs (the main user), +25 XPs for teammates not involved in a rescue.
No response/ detection after being detected with a BAC beyond the permissible level (0.08%)	-100 XPs (the main user), -25 XPs for all other members on the team.
Phone is offline beyond a day	-200 XPs (the main user), -100 XPs for all other members on the team.
Online for a day reward (each 24 hours)	+1 XPs
In-game currency and real benefits	
XPs	**Significance**
600 XPs	Free Uber ride
9000 XPs (General Drunken)	Percentage premium cuts on car insurance. Exact percentage to be determined, and is subject to change.

3.5. Additional features

Additional features are the features that are not yet implemented in the current app.

1. *Wearables for gait data:* If the user has any wearable devices that have an accelerometer and gyroscope, they can be used for reading accelerometer data, and used as an input for gait detection. By interviewing around 10 women, the conclusion is reached that women tend to have smaller pockets or in some cases, no pockets at all. The Alcogait functionality is trying to serve everyone in the society. Hence this ability to use data from wearables makes Alcogait more accessible for everyone and is of utmost importance.
2. *Various screens of useful data:* There will be screens that show users variety of useful data like:
    - Their drinking pattern for the weeks, months and possibly up to years.
    - Which friends rescues them the most.
    - Which friend is most likely to rescue them in which area.
    - Inspired by the AA (Alcohol Anonymous) sponsor idea, a user might choose to share their intoxication trends with teammates of their choice. (Alcogait emphasizes a community approach to responsible drinking behavior and path to well-being)
    - Users will also receive weekly summary reports of their intoxication levels recorded and their performance so far.
3. *Fraud detection:* Alcogait will have in-built fraud detection mechanism to prevent cheating. If a person keeps passing the breathalyzer test, but is always predicted to be intoxicated by the gait functionality; such isolated incidences will be recorded on the backend server to detect a pattern of such behavior using a fraud detection algorithm. The causes of such behavior might vary: Injury to a leg causing change in gait, or something

serious such as substance abuse. Substance abuse can't be detected accurately using a Bluetooth breathalyzer; hence there has to be an added layer of security built into the application's functionality. Fraud detection is necessary in order to stop the misuse of tangible benefits the app has to offer, such as free rides or potential cuts in car insurance premiums.

4. *Rescue chat:* As mentioned in section 3.1.2, whenever there is an active rescue notification for a group of users, all of them can see a chat window where users of the app are supposed to plan the rescue. A group call feature can be added in the future.

3.6. Social features and Initiatives

1. *Snapchat integration:* From the interview conducted on campus it was found that young users regard Snapchat upgrades (such as streaks and filters) as persuasive, tangible rewards. On a successful rescue, a team will unlock a Snapchat filter. For example: A Ghostbuster style filter that would have the Alcolord captured in a box. This will be a great opportunity to spread awareness about the app.
2. *Rescue streak:* This feature is inspired by Snapchat streaks. In snapchat, different emojis appear in front of each friend's name. This emoji indicates how often the users Snap at each other back and forth. Keeping the streak going is interesting for most of the people we had conversations with during the interviews. Rescue streaks would be an interesting indicator on groups for measuring the success levels of groups. We believe that this feature is likely attract younger audiences.
3. *Pubs and bars with breathalyzers:* From the interviews conducted, a conclusion can be drawn that many people were concerned about carrying a Bluetooth breathalyzer all the time. Some of them were concerned about the size of the breathalyzer, some of them

were worried that they might lose it, and some of them were concerned regarding the stigma around carrying breathalyzers. Local clubs and bars can be encouraged to keep breathalyzers on their premises, so that the patrons can use those without having to carry one.

3.7. Known issues and edge cases

1. *A person sits in a car and consumes alcohol (away from home).* Because the person is not walking, the gait detector never fires and cannot detect any change in BAC. The user then drives drunk, possibly far beyond the permissible limit, and reaches home intoxicated. The gait functionality will start working when user gets out of the car. By this time, it's too late to detect gait changes. This edge case was identified by interviewing 20 people (10 males and 10 female). Legally this won't be a problem, since gait being a trigger would be clearly mentioned in the Alcogait user agreement.
2. Drugs might emulate effects of alcohol consumption. The fraud detection feature described in section 3.5 (feature 3) takes care of this issue.
3. The user doesn't carry their phone with them.
4. The user has no cellular network connectivity. To be effective, the app requires the user to be constantly online. To encourage users to remain online, there is a daily reward. User will earn 1 XP by being online for 24 hours continuously. Daily rewards are type of operant conditioning. [29]
5. *Everyone in a group is drunk:* This is a plausible edge case. If everyone in a group is drunk, so far as at least one of them is sober enough to book a cab and rescue everyone else, there is no issue.

6. For people using wearable devices to record and send accelerometer data, the phone and wearable device have to be within the Bluetooth transmission range (approximately 100 meters / 328 feet) as much as possible.

3.8. Alcogait gamification features based on Cugleman's strategies

This section discusses how Alcogait gamification strategies that are based on Cugleman's seven ingredients/strategies mentioned in section 2.2.2.

Table 3: Compare Alcogait gamification implementation with Cugleman's strategies

Alcogait Gamification Implementation	Cugleman's Gamification Strategies
1. The intervention approach proposed in this gamification system, is a community effort. Without proper and honest involvement of peers in community (close friends registering as a group), it is very difficult for anyone to achieve the desired goals.	Basis is formed using the 6th (social connectivity) and 1st (goal setting) strategies together.
2. Elaborate rewards and achievement system based on XPs. User gains or loses XPs based on their performance and their teammates' .	1st (goal setting) strategy.
3. The rescue feature provides teams with the choice of providing assistance to a partially or fully impaired peer of theirs. It provides a dynamic where the entire team has to be responsible for each other's wellbeing.	2nd (capacity to overcome challenges) strategy.
4. Rewarding responsible behavior (rescuers) and willingness to be responsible (person rescued) using XPs and then offering tangible real life rewards against XPs.	4th (reinforcement: provide rewards contingent on successful behavior) strategy.

5. The team can view each other's XPs and become competitive. They rescue each other and root for team's success.	5th (compare progress) and 6th (social connectivity) strategies together.
6. Using avatars for visual feedback and reinforcement. (The state of the avatar represents the user's pattern of behavior)	3rd (providing feedback on performance) and 7th (fun and playfulness) strategies together.

Figure 8 in section 2.2.2 (reproduced from Cugelman's article) is used as a baseline for our proposed gamification approach. In this study, the basis is formed using the 6th (social connectivity) and 1st (goal setting) strategies together. The intervention approach proposed in this gamification system, is a community effort. Without the honest involvement of peers in the community (close friends registering as a group), it is very difficult for anyone to achieve the desired goals.

The Alcogait system is not intended to either encourage or discourage abstinence. Its goal is to incentivize responsible transportation choices made by a person or their peers after that person is detected to be intoxicated.

The 2nd strategy (capacity to overcome challenges) is implemented using the rescue feature in the app. The rescue feature creates a social dynamic where the entire team has to be responsible for each other's wellbeing. The rescue feature is described in detail in section 3.1.2.

The 4th strategy (reinforcement: provide rewards contingent on successful behavior) is implemented by rewarding responsible behavior (rescuers) and willingness to be responsible

(person rescued). In fact, people not involved in the rescue operation are also rewarded to motivate them to encourage others in the team who have been involved in the rescue.

Our comprehensive reward system also supports the 4th strategy. Reward systems impart extrinsic motivation, which refers to activities performed in order to achieve something with tangible benefits [16], such as getting a free Uber ride, which is a tangible reward. We propose that players get rewards (XP) for each occurrence of responsible drinking behavior and they level up (move to the next level of the gamification scheme) based on their current level of XP.

Extrinsic motivation is not always sufficient to produce behavior change, because it encourages users take action only to earn a tangible reward. Intrinsic motivation motivates users by giving them the satisfaction of completion of task. According to Deci et al, "Intrinsic motivation is defined as the doing of an activity for its inherent satisfaction rather than for some separable consequence" [16]. We do that by adding a "team rescue system" to instill intrinsic motivation. This also follows from the 5th and 6th gamification strategies from Cugelman's table [4].

In the article "What works: Strategies to Reduce or Prevent Drunk Driving," the CDC discusses ways to prevent DUI incidents. They suggest "comprehensive efforts in community mobilization by involving coalitions or task forces in its design and implementation" [5]. This way, a user feels a sense of appreciation when doing a good work for their community. Giving XP (rewards) to users who are not involved in the "rescue" keeps everyone interested in doing well together, and rooting for their friends' success in a team. We encourage users to take responsibility in groups and utilize this app as a tool to maintain a good quality of life.

To give users feedback on how they have been behaving and XP/rewards they have earned, we had two choices: presenting regular data visualization like most other m-health apps use, or using

avatars that embody the user's current state in order to engage players more effectively to encourage behavior change. The second choice is based on the 1st, 3rd and 7th (fun and playfulness) strategies of gamification from Cugleman's table.

4. Implementation

4.1. Alcogait gamification screenshots

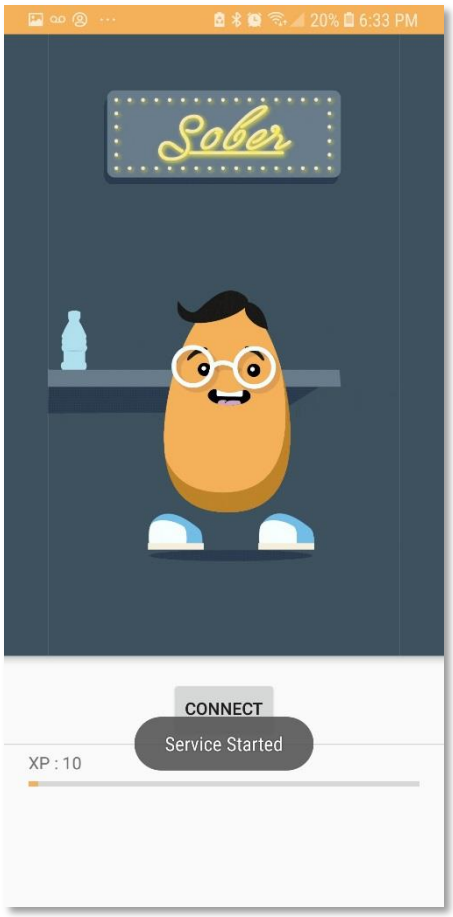

Figure 9: Step 1, Landing page. Gait service starts in the background.

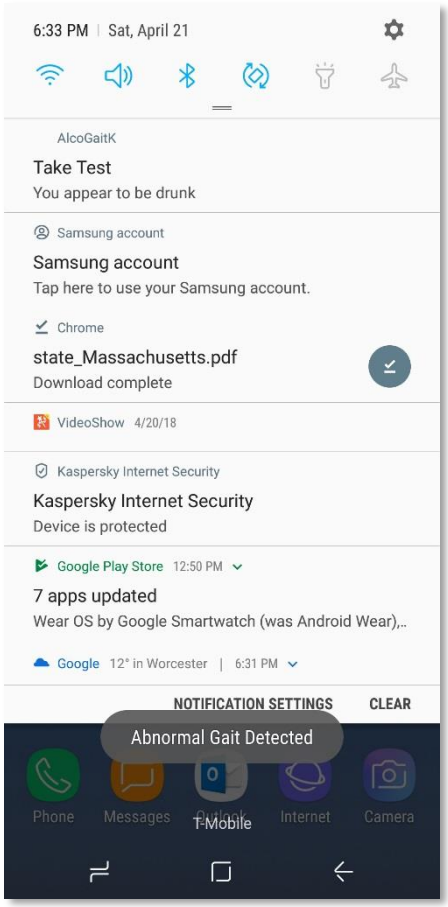

Figure 10: Step 2, The notification due to abnormal gait can be seen.

Figure 9 shows the main screen of the app. The gait detection functionality runs in the background as a service. The avatar can also be seen in this figure. The service detects the user's intoxicated walking pattern (more sway), which triggers a request for as breathalyzer test to confirm that the user is indeed over the limit. Figure 10 shows the "Take Test, you appear to be drunk" notification after the abnormal gait is detected.

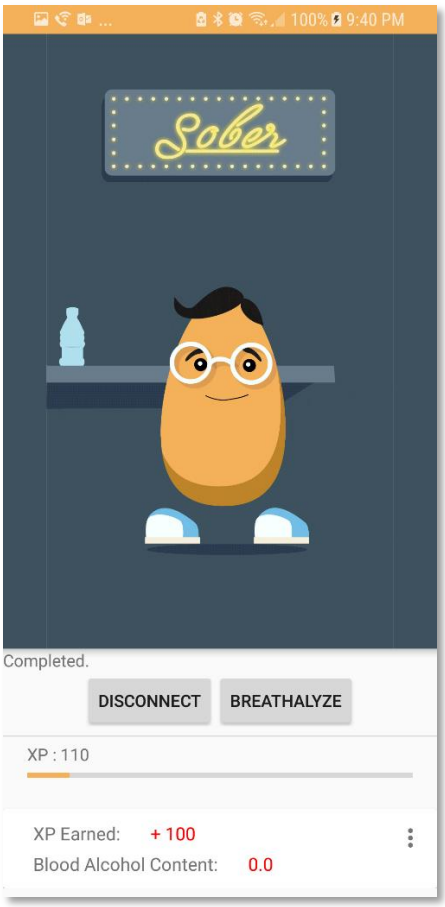

Figure 11: Step 3, The breathalyze screen is shown when the notification is clicked.

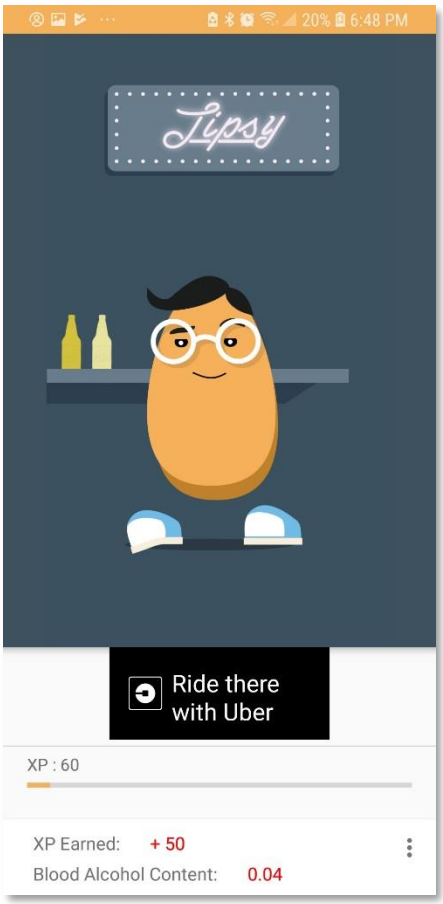

Figure 12: Step 4, If the BAC is higher than 0.0%, Uber button is shown

Figure 11 shows the screen allowing the user can breathalyze themselves using the "breathalyze" button. The "disconnect" button is provided to disconnect the app from the connected Bluetooth breathalyzer (discussed in section 4.2). After the breathalyzer result is returned, the BAC and related XP changes are updated on the display. The result from the breathalyzer test can be seen in Figure 12, together with the "Ride there with Uber" button. The button is shown only if the resultant BAC from the breathalyzer test is above 0.0 (if any amount of intoxication is seen) for this demo.

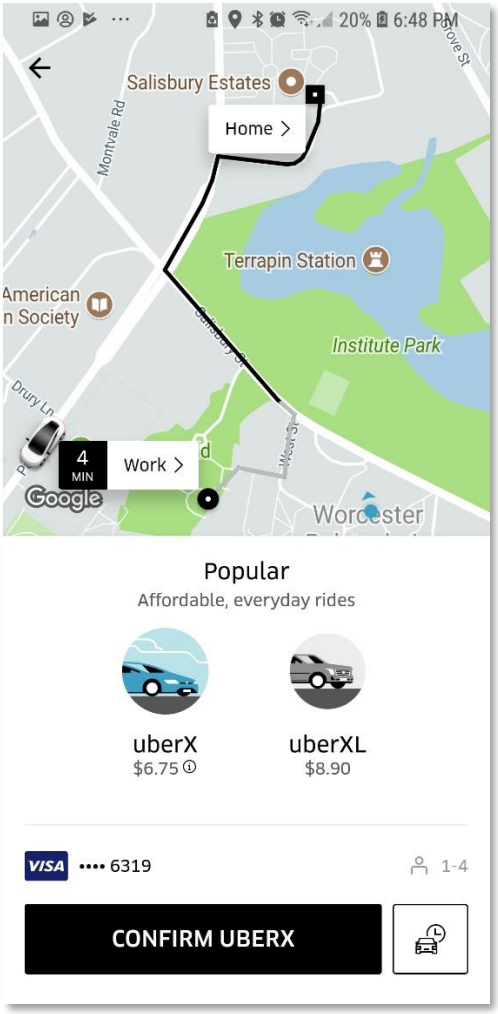

Figure 13: Step 5, Deep link into Uber app with home address

Figure 13 shows the Uber app screen. This is a deep link (a URL that leads users directly to specific content in an app) that takes the user directly to the confirm ride screen, where the user's home address can be seen, skipping all the steps usually needed for the user to book a ride home. In other words, instead of having user to open the Uber app manually and looking for the home address, the button shown in Figure 12 navigates the user to a screen that looks like the one shown in Figure 13. This deep link can be hardwired into the app for instantly booking rides.

4.2. Bluetooth Breathalyzer

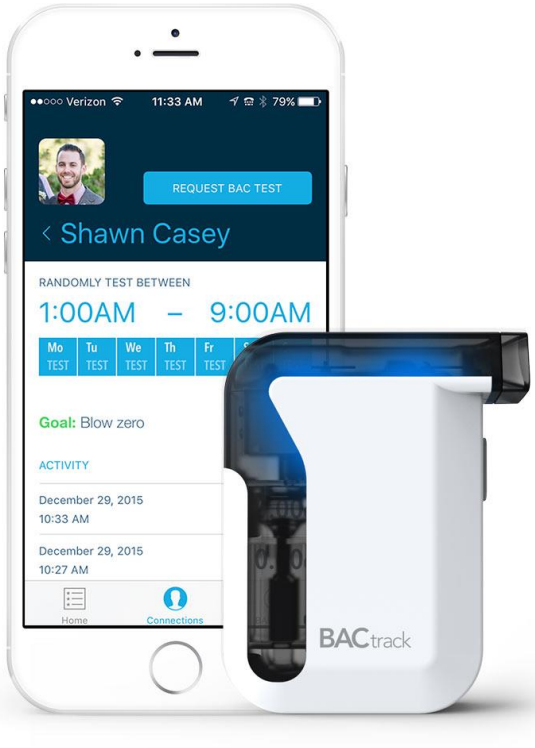

Figure 14: BACtrack Bluetooth Breathalyzer [20]

This project uses a Bluetooth Breathalyzer made by a company named BACtrack, shown in Figure 14. BACtrack offers several types of breathalyzer models [20]. This model was the smallest one that could interact with smartphones via Bluetooth. Later in sections 4.3.1 and 4.3.2, the BACtrack API and the coding related technological details are discussed. This section is to give readers the idea about the physical aspects of the device.

According to the manual [22] dimensions of the device are 1.75 x 2.75 x .63 inches, and it weighs 1.75 ounces (47 g). Warm-up time required for the device to prepare itself for an analysis is 10 seconds. Operating temperature range of the device is 32 to 96.8 degrees Fahrenheit (0-36 degrees Celsius). The device doesn't require external batteries, and is charged using a USB cable.

4.3. Code samples

4.3.1. Technological choices

To implement Alcogait in Android, Kotlin was the language that was chosen. The reason to choose Kotlin were as follows: Google has embraced it fully as a native Android development language. Major companies in the mobile industry are migrating to Kotlin and changing their entire codebases written in Java. Kotlin provides many advantages over Java such as high readability due to lesser boilerplate code. Null safety is built into types [21]. Loosely typed appearance of Kotlin (looks like other popular and easy to read scripting languages like Python) was attractive. The last but most important reason is pedagogy. The Kotlin ranges defined in this project represent float ranges of Blood Alcohol Content levels. According to the Bluetooth Breathalyzer manual [22], different BAC ranges have different effects on individuals.

Table 4: BAC effects according to BACtrack Mobile Breathalyzer manual [22]

BAC Ranges	Effects according to BACtrack manuel
0.13-0.15%	Blurry vision, lack of euphoria. Hence reduced driving skills and r control [22].
0.02-0.03%	Partial euphoria. Driving skills impairment possible [22].
0.04-0.06%	Euphoria. Minor memory loss. Impaired driving [22].
0.07-0.09%	Euphoria. Reduced reaction time and primary senses. Possible memory loss and loss of reasoning abilities [22].
0.16-0.20%	Induced nausea [22]
0.25%	Possible vomiting with more nausea [22].
0.30%	Unconsciousness [22].
0.40%+	Possibly fatal [22].

Since the BACTrack Bluetooth Breathalizer is used to receive accurate BAC information [20], the BAC ranges are based on their interpretation of effects of dosage. The ranges chosen are discussed in detail in next section 4.3.2.

4.3.2. BAC ranges

```
23  class BreathalyzerAvatar : AppCompatActivity() {
24
25      val SOBER = 0.00f..0.01f
26      val TIPSY = 0.02f..0.06f
27      val DRUNK = 0.07f..0.125f
28      val WASTED = 0.13f..0.25f
29
30      val SOBER_XP = 100;
31      val TIPSY_XP = 50;
32      val DRUNK_XP = -20;
33      val WASTED_XP = -30;
34
35      val PERMISSIONS_FOR_SCAN: Byte = 100
36      val TAG = "BACTrackDemo"
37      val apiKey = "37a05ec73c4544328aee3cbd0d8a97";
38      var currentXP = 10
39      var earnedXP = 0
40      lateinit var mAPI: BACtrackAPI
41      lateinit var mCallbacks: BACtrackAPICallbacks
42      var mContext = this
43
```

Figure 15: code snippet showing the declaration of BAC ranges

These BAC values and their significance can be seen in Figure 15 above, derived from the BACtrack manual [22]. Four ranges have been picked based on the information mentioned in Table 4. “Sober” from 0.0-0.01, “Tipsy” from 0.02-0.06 since driving skills might be impaired in some individuals, most of them might still be able to drive legally. It has been ensured that when the BAC of user reaches beyond 0.07% they are notified that they are drunk beyond permissible driving limit (0.08% in Massachusetts). For the same reason, “Drunk” ranges from 0.07-0.125. Anything above 0.13 is “Wasted”. For demo purposes, some XP is offered based on how intoxicated the user is. The specific XP values can be seen on line 30 in figure 15.

4.3.3. Loading appropriate images using Glide library and ranges

```
150     fun showImage(alcoholInput: Double) {
151         var image_to_load = 0
152
153         runOnUiThread {
154             when {
155
156                 alcoholInput in SOBER -> {
157                     image_to_load = R.drawable.sober
158                     earnedXP = SOBER_XP
159                 }
160
161                 alcoholInput in TIPSY -> {
162                     image_to_load = R.drawable.tipsy
163                     earnedXP = TIPSY_XP
164                 }
165
166                 alcoholInput in DRUNK -> {
167                     image_to_load = R.drawable.drunk
168                     earnedXP = DRUNK_XP
169                 }
170
171                 alcoholInput in WASTED -> {
172                     image_to_load = R.drawable.wasted
173                     earnedXP = WASTED_XP
174                 }
175
176                 else ->
177                     image_to_load = R.drawable.ic_launcher_background
178             }
179
180             currentXP += earnedXP
181             currXP.text = "XP : "+currentXP
182             xpBar.progress = currentXP
183             xps.text = "+ "+earnedXP
184             GlideApp
185                     .with(this)
186                     .load(image_to_load)
187                     .centerCrop()
188                     .into(avatarImage)
189         }
190     }
191
```

Figure 16: Code snippet that shows the showImage() method

Figure 16 shows the showImage method that receives BAC as an input argument. Based on what BAC is, the appropriate avatar image is loaded using the Glide API onto an ImageView named avatarImage. (Glide is an image loading library with default caching mechanism [23].) The current XP will be updated by adding the earned XP to it. The progress bar is updated to visually represent current XPs (Figure 9 shows a progress bar with 10 XPs)

4.3.4. BACtrackAPI Callbacks

```
214     inner class BACtrackAPICallback : BACtrackAPICallbacks {
215
216         override fun BACtrackAPIKeyDeclined(errorMessage: String) {
217             val verify = APIKeyVerificationAlert()
218             verify.execute(errorMessage)
219         }
220
221         override fun BACtrackConnected(bacTrackDeviceType: BACTrackDeviceType) {
222             runOnUiThread {
223                 connectToNearest.visibility = View.GONE
224                 disconnect.visibility = View.VISIBLE
225                 blow.visibility = View.VISIBLE
226             }
227             setStatus(R.string.TEXT_CONNECTED)
228         }
229
230         override fun BACtrackDidConnect(s: String) {
231             setStatus(R.string.TEXT_DISCOVERING_SERVICES)
232         }
233
234         override fun BACtrackDisconnected() {
235             runOnUiThread {
236                 connectToNearest.visibility = View.VISIBLE
237                 disconnect.visibility = View.GONE
238                 blow.visibility = View.GONE
239             }
240             setStatus(R.string.TEXT_DISCONNECTED)
241         }
242
243         override fun BACtrackFoundBreathalyzer(bluetoothDevice: BluetoothDevice) {
244             Log.d(TAG, "Found breathalyzer : " + bluetoothDevice.name)
245         }
246
247         override fun BACtrackCountdown(currentCountdownCount: Int) {
248             setStatus(getString(R.string.TEXT_COUNTDOWN) + " " + currentCountdownCount)
249         }
250
```

Figure 17: BACtrack callbacks first

```
234         override fun BACtrackDisconnected() {
235             runOnUiThread {
236                 connectToNearest.visibility = View.VISIBLE
237                 disconnect.visibility = View.GONE
238                 blow.visibility = View.GONE
239             }
240             setStatus(R.string.TEXT_DISCONNECTED)
241         }
242
243         override fun BACtrackFoundBreathalyzer(bluetoothDevice: BluetoothDevice) {
244             Log.d(TAG, "Found breathalyzer : " + bluetoothDevice.name)
245         }
246
247         override fun BACtrackCountdown(currentCountdownCount: Int) {
248             setStatus(getString(R.string.TEXT_COUNTDOWN) + " " + currentCountdownCount)
249         }
250
251         override fun BACtrackStart() {
252             setStatus(R.string.TEXT_BLOW_NOW)
253         }
254
255         override fun BACtrackBlow() {
256             setStatus(R.string.TEXT_KEEP_BLOWING)
257         }
258
259         override fun BACtrackAnalyzing() {
260             setStatus(R.string.TEXT_ANALYZING)
261         }
262
263         override fun BACtrackResults(measuredBac: Float) {
264             setStatus("Completed.")
265             showResult(measuredBac)
266             showImage(measuredBac.toDouble())
267         }
268
269
270         override fun BACtrackError(errorCode: Int) {
271             if (errorCode == Errors.ERROR_BLOW_ERROR.toInt())
272                 setStatus(R.string.TEXT_ERR_BLOW_ERROR)
273         }
```

Figure 18: BACtrack callbacks second

In figure 17 and 18, BACtrackAPICallbacks can be seen. These are the callback methods that are packaged within the BACTrackSDK.jar. This jar file is used by the BACtrack APIs and is manually downloaded from BACTrack website and put into libs inside the Android project.

A reference mAPI is created by using a constructor BACtrackAPI that takes 3 arguments. The context reference is the first argument, last two arguments being callback methods and an apiKey that is generated for an application. BACtrackAPICallbacks are called when methods are called on a reference mAPI. For example, mAPI.conncetToNearestBreathalyzer() will call BACtrackConnected if the connection is established. mAPI.startCountdown() calls a series of

callbacks in the following order BACtrackStart(), BACTrackBlow(), BACtrackAnalyzing(), and the final one is BACtrackResults, which returns a float value as an argument. This float value is then checked inside showImage method and the appropriate image is set on the ImageView. For example: if the calculated BAC is 0.08f, the image R.drawable.drunk would be loaded onto the ImageView.

4.3.5. Accelerometer gait detection stub

```
@RequiresApi(Build.VERSION_CODES.O)
override fun onSensorChanged(event: SensorEvent?) {
    if(event?.values!![0] > 6 || event?.values!![0] < -6){
        Toast.makeText(this,"Abnormal Gait Detected",Toast.LENGTH_SHORT).show()
        showNotification = true
        var gaitChannel : NotificationChannel = NotificationChannel("com.example.cnnimkar.alcogaitk","GaitChannel",NotificationManager.
        gaitChannel.enableLights(true)
        gaitChannel.enableVibration(true)
        gaitChannel.lightColor = Color.GREEN

         var mManager : NotificationManager = getSystemService(Context.NOTIFICATION_SERVICE) as NotificationManager
        mManager.createNotificationChannel(gaitChannel)

        var intent : Intent = Intent(this, BreathalyzerAvatar::class.java)
        intent.setFlags(Intent.FLAG_ACTIVITY_NEW_TASK or Intent.FLAG_ACTIVITY_CLEAR_TASK)
        val pendingIntent = PendingIntent.getActivity(this, 0, intent, 0)

        var builder : Notification.Builder = Notification.Builder(getApplicationContext(), "com.example.cnnimkar.alcogaitk")
                .setContentTitle("Take Test")
                .setContentText("You appear to be drunk")
                .setSmallIcon(R.drawable.navigation_empty_icon)
                .setContentIntent(pendingIntent)
                .setAutoCancel(true);

        mManager.notify(101, builder.build())

    }
```

Figure 19: Code snippet from the prototype demonstrating accelerometer data changes

In the prototype code shown in Figure 19 (from GaitService.kt), a notification is created if the x accelerometer value is above +6 or below -6. This is just to demonstrate gait recognition. In the final version, the Alcogait gamification will be connected to the original Alcogait functionality similar to that described in Aliello's thesis [1]. The notification also takes in a pending intent (A

PendingIntent is a token that you give to a foreign application like NotificationManager, AlarmManager or other 3rd party applications, which allows the foreign application to use your application's permissions to execute a predefined piece of code). This pending intent navigates to the main Breathalyzer activity (screen) when a notification is clicked. A toast message is displayed to alert the user about abnormal gait.

4.3.6. Uber ride booking

```
140         startForegroundService(Intent(this, GaitService::class.java))
141         var builder: SessionConfiguration.Builder = SessionConfiguration.Builder()
142         var config: SessionConfiguration = builder.setClientId(CLIENT_ID)
143                 // required for enhanced button features
144                 .setServerToken(SERVER_TOKEN)
145                 // required for implicit grant authentication
146                 .setRedirectUri(REDIRECT_URI)
147                 // optional: set sandbox as operating environment
148                 .setEnvironment(SessionConfiguration.Environment.SANDBOX)
149                 .build();
150
151         UberSdk.initialize(config);
152         requestButton = RideRequestButton(this);
153
154         var rideParameters: RideParameters = RideParameters.Builder()
155                 .setProductId("a1111c8c-c720-46c3-8534-2fcdd730040d")
156                 .setDropoffLocation(42.279576, -71.8070876, "Home", "189 Grove St, Worcester, MA")
157                 .setPickupLocation(42.2750591, -71.8087017, "Work", "Fuller Labs WPI, Worcester, MA")
158                 .build()
159         var session = ServerTokenSession(config);
160         var rideCallback = (object : RideRequestButtonCallback {
161             override fun onRideInformationLoaded() {}
162             override fun onError(apiError: ApiError) {}
163             override fun onError(throwable: Throwable) {}
164         })
165         requestButton.setRideParameters(rideParameters)
166         requestButton.setSession(session)
167         requestButton.setCallback(rideCallback)
168         requestButton.loadRideInformation()
169         requestButton.loadRideInformation()
170         //  testEverything()
171
172
173     }
```

Figure 20: Code snippet for booking Uber rides from within the app

Line 142 in Figure 20 shows how SessionConfiguration is built. Line 154 shows how RideParameters are built. Drop off location, pick up location and product ID are set. As it can be

seen on line 155 in Figure 20, Product ID is set on RideParameters. It is the type of Uber to be booked for example: UberX, Uber Black. For demo purposes, it has been hardcoded to UberX ID.

Setting up locations is fairly easy. Whether or not to hardwire users's home addresses is a design decision. Currently for demo purposes they are hardcoded to certain locations.

loadRideInformation() loads estimation (cost and time) data onto the Uber button. This process is asynchronous. Developers need to sign in using their own Uber account in order to obtain the CLIENT_ID, SERVER_TOKEN. The ACCESS_TOKEN and REDIRECT_URI are also set on Uber's control panel.

5. User experience study

In a study conducted by Kiourtsis et al, college age students responded to questions about usage of technological devices for binge drinking interventions in focus groups and surveys [7]. Their main finding was that many binge drinkers didn't mind using the app and didn't care about social stigma, however "non-problem drinkers" were shy about using the app publicly.

5.1. Procedure followed

The Alcogait gamification thesis examines user engagement and hence determines whether there is a chance of potential behavior change. This thesis could have provided more reliable data by having users install the Alcogait app on their phones for a month and then having them fill a questionnaire towards the end of the experiment. Instead, due to time constraints, private user experience interviews were conducted with 20 subjects that consisted of 10 females and 10 males. Reflections on this process can be seen to in section 5.2.10. Subject were recruited using emails and social media. They were chosen from different nationalities and professional backgrounds to improve the quality of feedback obtained from the small sample space. Subjects were provided with a live demo of the app in 30-minute time slots.

They were asked following questions:

1. Do you think drunk driving is an issue?
2. Do you know people with DUI? (Yes or No question) (no need to specify names and relationship)
3. *Explain interlocks and dash cameras*
4. Do you think they are intrusive? Do you think they are effective measures?

5. *Explain the app*
6. Do you think this system is intrusive? Would you give it a try?
7. Would you recommend this for the people you care about? (Yes or No question) (no need to specify names and relationship)
8. If you can score free rides, level up by gaining points, would you use this app?
9. What do you think of an avatar?
10. Do you find it engaging?
11. Do you use any fitness app?
12. What do you think of this app in terms of feedback you receive?
13. Would you rather have graphs instead of a cute avatar?
14. Or would you have both?
15. Would you register with group of friends to use this app?
16. What are your opinions about the "rescue" feature?
17. Would you rescue someone, if you were part of the group that uses the app?
18. Would you like to be rescued using the app?
19. Are you comfortable carrying a small Bluetooth breathalyzer?
20. What if you were given this breathalyzer for free?

Law enforcement agencies being prime stakeholders, two officers from the Worcester Police Department were provided with a 30-minute demo and then asked the following questions:

1. How common are DUI cases?
2. How many DUI cases have you come across in Worcester?
3. (Explain the intervention via gamification system)
4. How important or significant do you think this intervention system is from a law enforcement perspective?
5. What parts of functionality I demonstrated that you liked and what parts are you concerned about?
6. How much impact do you think this system will have if implemented?
7. What are the loopholes in the system that a person can exploit?
8. If this intervention system to be implemented for DUI offenders, will it work?

9. What are the possible risks in the implementation of this system?
10. Can this functionality be used for something we haven't thought of?
11. Would you be ok with getting a notification from the app that says someone is really intoxicated and they are possibly trying to drive?

5.2. Results from the interviews

5.2.1. DUI awareness

1. As seen in Figure 21: 'Awareness chart', 18 people think drunk driving is an issue. One person's answer was ambivalent. One person said it's not an issue in this area.
2. From the 20 people that were interviewed, 11 knew someone with a DUI conviction. Six people didn't know anyone with a DUI, and three didn't want to address the question, or their responses were inconclusive.
3. Surprisingly, two subjects (one female and one male) expressed that most people should always breathalyze before they drive a car, or that all cars should have ignition interlocks.
4. To quote Female Subject 5, "I think everyone should breathalyze before driving, same way you need to put a seatbelt on". She was referring to all cars having ignition interlocks.

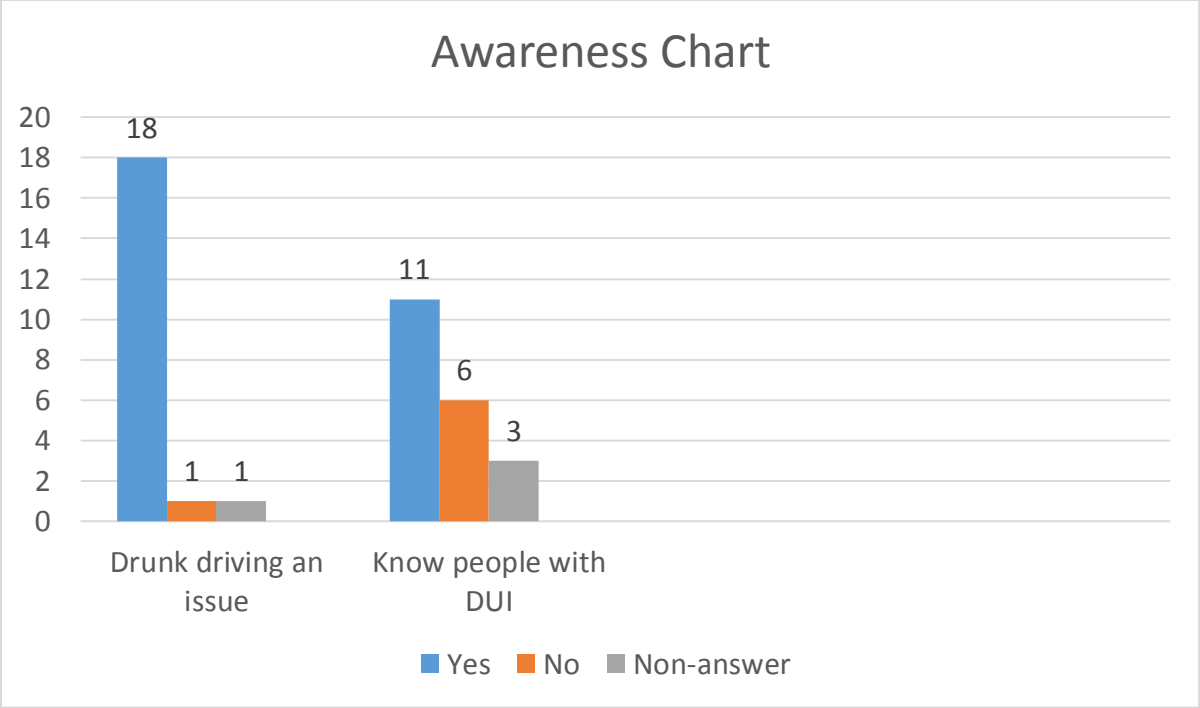

Figure 21: Awareness chart

5.2.2. Intrusiveness of various measures

1. Most of the subjects expressed that dash cameras provided by car insurance companies are intrusive. Mostly because they are made compulsory and corporations like car insurance companies can track users' whereabouts.
2. Most of them claimed that Alcogait is a less intrusive system. They also found it interesting and useful. Most of them would start using the app.
3. Most of them also said that although they are wary of all the data collection in today's time, so far as the terms and conditions are clear enough and rewards offered are good enough, they would love to use the app.
4. Female subject 1 said "The app is less intrusive than a dash cam, but more intrusive than ignition interlocks"

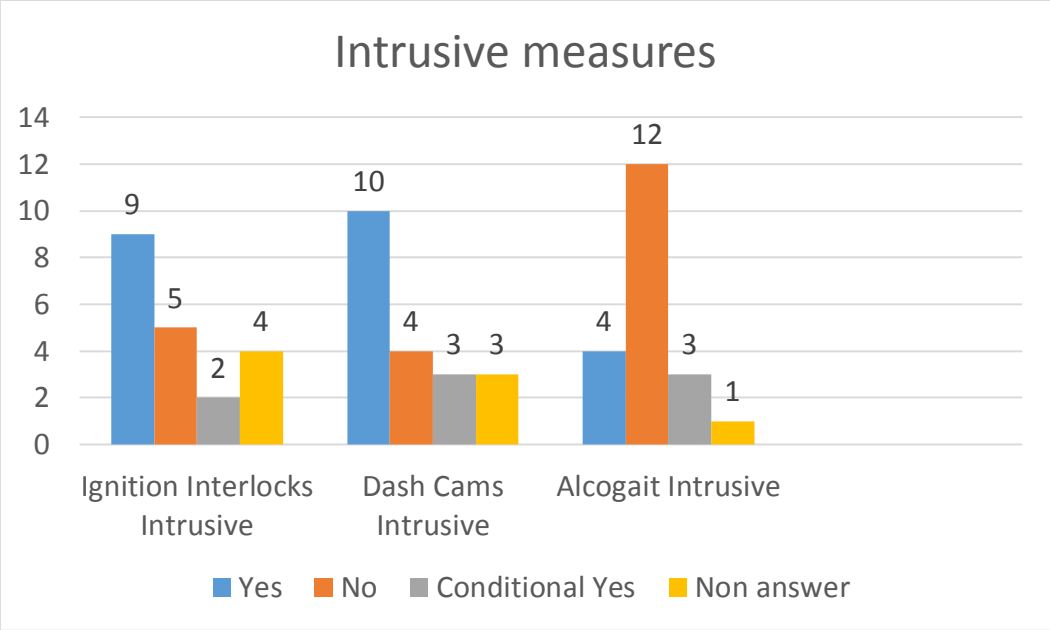

Figure 22: Intrusive measures

5.2.3. User acquisition and engagement

1. Almost everyone but one subjects said they would register and use the app.
2. While recommending the app to others wasn't a problem to majority of subjects, some of them thought it might be rude to recommend someone to use the app. Some of the 5 subjects with conditional yes answer said they would recommend the app only to their confidants.
3. Female subject 4 says "It will be extremely rude to recommend this app to someone".
4. Mostly everyone thought that the rewards were attractive enough for them to register and keep using the app. Especially the car owners sounded more interested in trying out the app. They were also visibly thrilled about the rewards I talked about. Like scoring free Uber rides, potential premium cuts, etc.

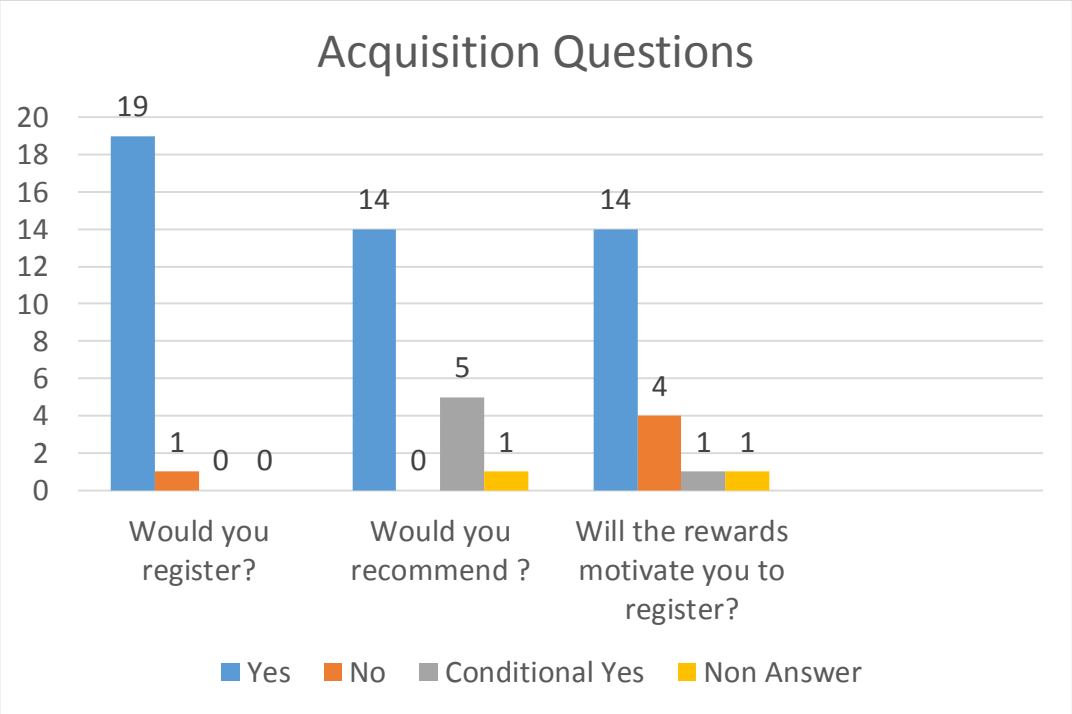

Figure 23: Acquisition Questions

5.2.4. Feedback and reinforcement

1. Male subject 4 says "This avatar reminds me of Wii sport character with whom you play tennis. It is very engaging for me."
2. Male subject 3 says "The avatar is like Animoji on iPhone. It's cute."
3. Male subject 2 says "Even though I find the avatar cute, it wouldn't affect level of engagement for me. I wouldn't care about avatar customization too. But many people would find that engaging."
4. Female subject 4 says "When people are drunk, they can't notice the subtle changes in the avatar, they will just ignore the avatar. It should be more interactive."
5. Majority found it engaging, but I found that it wasn't a clear majority. Hence the avatar can be worked upon more and could be made a little more interactive than it is currently.

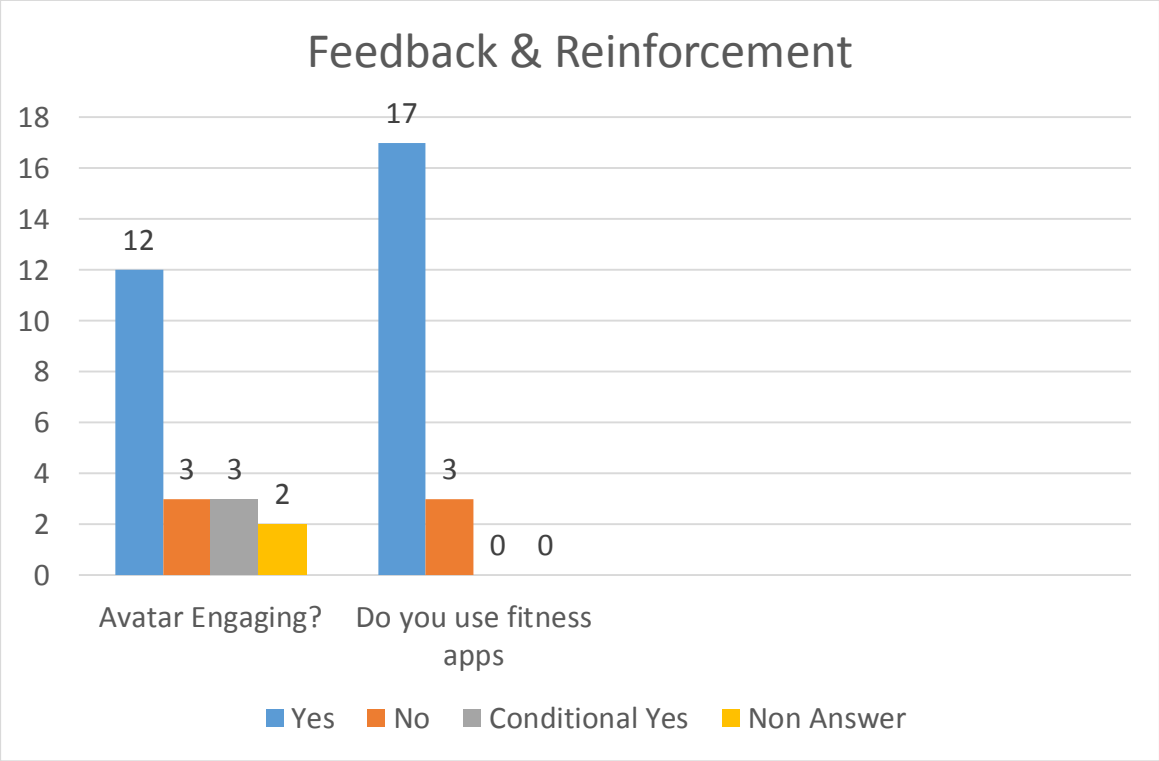

Figure 24: Feedback and reinforcement

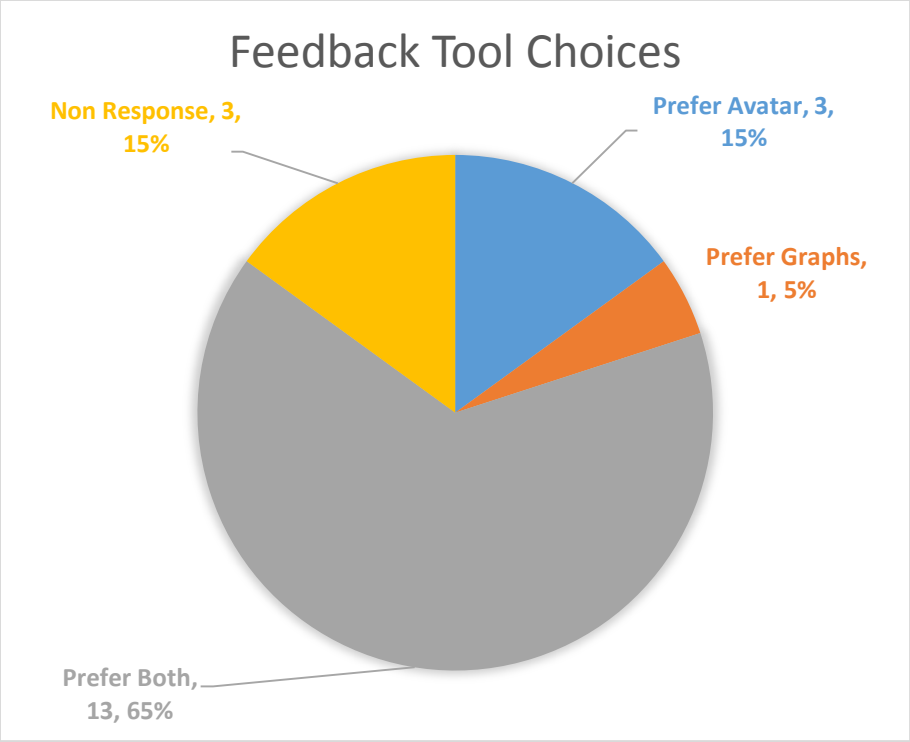

Figure 25: Feedback tool choices

1. As seen in figure 25, many people use fitness apps.
2. Overwhelming majority of people said that they would love to use the combination of both avatar and graphs as their tool of choice for feedback.
3. Many of them were concerned about historic data and trends.
4. Many of the subjects would like to see their drinking pattern, statistics of who rescued them more often, which area is covered by which friend while rescuing most frequently.
5. It's worth to mention that 3 of the participants out of 20 said, they would only use avatar for feedback they receive.

5.2.5. The rescue feature

1. Female subject 2 says “Rescuing a friend from Alcolord, makes me feel heroic”.
2. Male subject 4 says “Even if I didn’t get any XPs, I would still rescue my friends. I wouldn’t want to earn XPs if someone I don’t know needs to be rescued.” (although the app is mostly for confidants to register as a group and make sure wellbeing of a group).
3. Female subject 3 says “I would definitely rescue a friend. If I need to be rescued, I will just take an Uber. But that depends on how late it is”.
4. I asked subjects about whether they think that there’s a stigma involved in being rescued. Most of them said no, since they would only register with their close friends.
5. As a conclusion mostly everyone would like to be rescued. They wouldn’t necessarily rescue someone. It depends on how far the place is and also the person to be rescued.

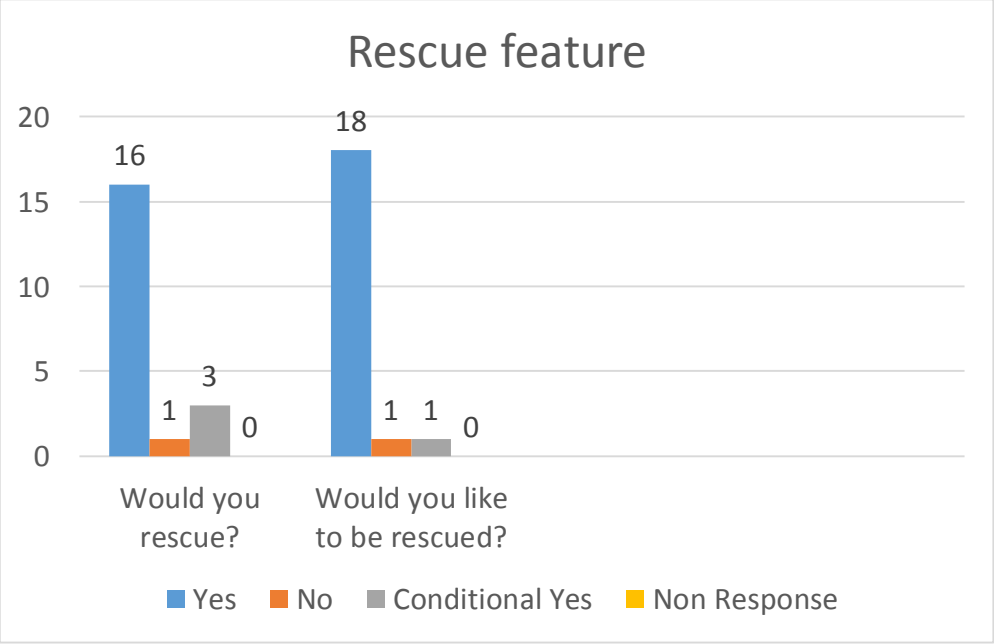

Figure 26: Rescue feature

5.2.6. Carrying a Bluetooth Breathalyzer

1. For many subjects, cost was a big factor. They wouldn't purchase a $100 breathalyzer. But if given free, they would use it along with the app.
2. I asked participant whether they feel there's stigma involved in carrying a breathalyzer. They all suggested concealed carry and some of them talked about being honest with friends about the app usage.
3. Most of them would use the app if a car company offered them a free breathalyzer and some more benefits like premium cuts.
4. People who were reluctant to carry were mostly concerned about the size of it and they were worried that they might lose it often.

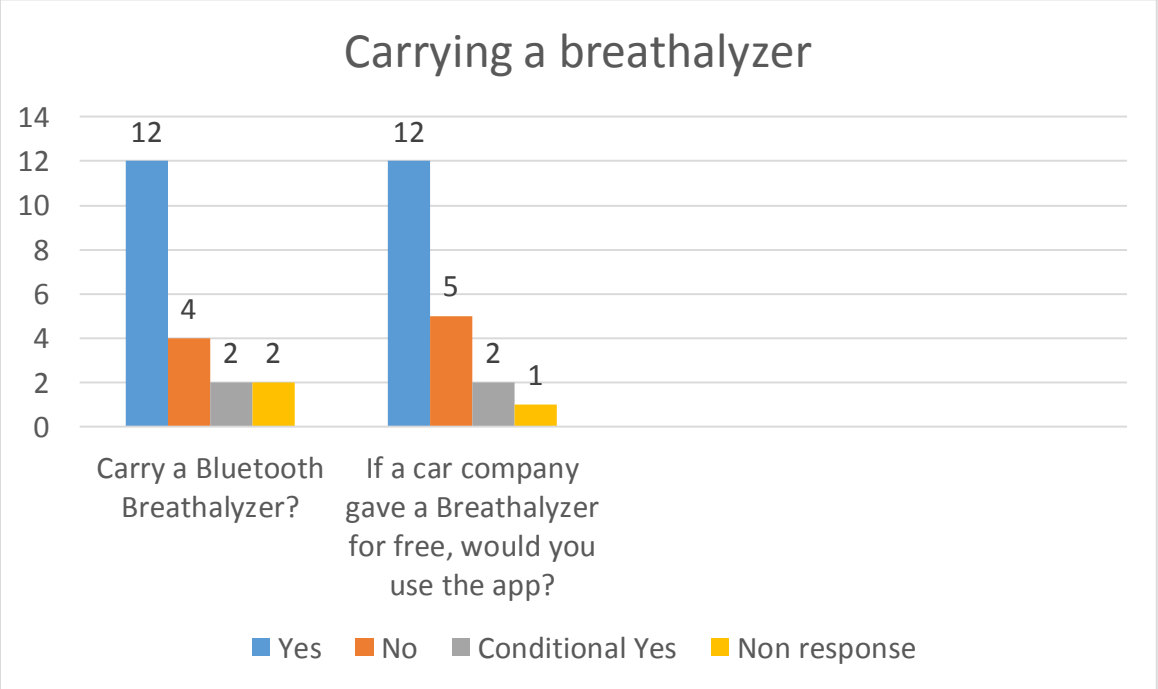

Figure 27: Carrying breathalyzer

5.2.7. Law enforcement stakeholders

Two Police Officers from Worcester Police Department were interviewed to get a Law Enforcement perspective.

How many DUI cases you have seen?

Officer 2 says "I have been on this job for 2 years and I have seen just one OUI (Operating Under Influence) case. That was a car accident". Officer 1 adds "The state police come across that more often. Lot of people that drive drunk don't get caught. They are putting themselves and people around them in danger. Happens more often than not".

Officer 2 (after checking the records) said "To answer that question, 50 people got arrested in past year for OUI".

Officer 1 said "For a year that's not too many. But there can be more people who drive drunk".

How significant do you think this intervention system is?

Officer 1: "I think it's great"

Does it make your job easier as a law enforcement person?

Officer 1 said "It would absolutely make our community safer I would hope. I feel like there are many people who drive drunk that go unnoticed more often than not. This would be great in that sense."

What are the parts of the app that you like and the ones you do not?

Officer 1 said "I think it's a great idea, but an average person I see that is drinking and driving would care very less about putting this app on their phone, unless you have some selling point. I see that one flaw."

How much impact do you think this will have over drunk driving?

Officer 1 said "Substantial Impact. But scary part for people will be the BAC you measure, where will that go? If it goes to Police, they will not be willing to do it. On the surface, someone who habitually drives drunk would probably not put this on their phone."

Briefly after the above remark the idea of mandates by universities (students having to install the app in order to attend the school) was discussed with both the officers. They were reluctant to explore that option. They personally do not prefer any kind of mandate put on non-problem drinkers.

Can this app be implemented for convicted DUI offenders?

Officer 1 says "For breathalyzers in cars (ignition interlocks) this will be a cool alternative. But it will be difficult because those (breathalyzers) are kind of regulated by the government. They (breathalyzers) have to meet the guidelines(government) they have. But, this would be a friendlier version of having that (ignition interlocks) installed in a car. They are expensive to install and have $150 of maintenance fee. According to a court order, they download monthly data (from interlocks) to make sure you have been blowing correctly. If I do that using smartphone, the data will go almost immediately. Literally the second I do it. Also, I'm not embarrassed, it's not in my car, if my walk gait is not off, it's not going to ask me to blow. It's a cleaner approach. You can have two versions of the app, fun version and professional version that works with federally mandated breathalyzers. It would save everyone money."

Officer 2 added "For people in probation, part of court order is to blow at certain date and time. One of my friend got arrested because he forgot to blow at certain time and probation got out of warrant (last part was inaudible). So this app would be good in that case."

What are the loopholes in the app that a person can exploit?

Officer 1 said "If they don't have a phone on them"

Officer 2 said "You leave your phone in car or a table"

Officer 1 said "I'm at the bar. He (Officer 2) gets a notification but can't come. I meet someone that gives me a ride home. The app will think I'm driving while drunk. How do I tell the app that someone is taking me home?"

He pointed out a loophole in the application where a person not registered on the app, can't give someone else a ride.

5.2.8. Findings

Majority of subjects thought that Alcogait is not intrusive. They claimed that they would register and recommend others to register and real life tangible benefits would play a major role in this process. Overwhelming majority of people would use both avatars and graphs for feedback. Avatar mostly for immediate feedback and more personal feedback, but they would like to see trends like their drinking pattern, friend who rescues them the most, area wise rescue records of their friends using graphs. Many subjects would like to be rescued, but they would decide whether or not to rescue someone based on the distance and their relationship with them.

Carrying a Bluetooth breathalyzer and being rescued won't be a problem due to stigma for majority of subjects, they prefer honesty over stigma. Although, many people were concerned about carrying a Bluetooth breathalyzer all the time, some of them were concerned about the size of the breathalyzer, some of them were worried that they might lose it, some of them were concerned regarding the stigma around carrying breathalyzers while others were concerned about the cost of the breathalyzer.

Police officers think that the app will have a great impact and would make the community safer by taking care of unnoticed DUI offenders. They verified that this app can be used instead of ignition interlocks in the future. Doing so would be cheaper, more accurate, more timely and less embarrassing. One more loophole they pointed out was that, a person not registered with the app cannot give a ride to an intoxicated person registered with the app.

By interviewing around 10 women, this conclusion is reached that women tend to have smaller pockets or in some cases, no pockets at all. Wearable devices can be used in this

situation. Reflection on this particular point can be seen in section 5.2.10. From the interviews conducted with 20 people (10 males and 10 females), it can be said that most of them expected some sort of customization. Some expected the current avatar to have more optional accessories like (glasses, t-shirts, chains); some expected a more customizable avatar that looks like them or more representative of them. 3 people mentioned Bitmoji (Snapchat's version of Avatar that best represents users) to be used as an avatar. Many responders didn't request any change to the avatar and 2 of them didn't care about the avatar at all. It was found that young users consider Snapchat rewards such as Snapchat Streaks and filters as convincing tangible rewards. Keeping the streak going is interesting for most of the people. From the interviews, it can be said that this system does create a competitive environment. Male subject 9 suggested that the system will create great competition. "My parents compete with our neighbors all the time. They use Fitbit to track the points earned by walking every day", he added.

5.2.9. Conclusion

Subjects finding Alcogait non-intrusive was expected. These expectations were met. Hence, it can be said that it is one of the valid ways intervention for DUI mitigation can be done. Real life tangible benefits driving acquisition and retention of users was expected that proven to be true. Overwhelming majority wanting to use graphs and avatars was not expected. The original intent of this project was to provide all the feedback using avatar only. Since there's an established consensus regarding usage of both, future Alcogait Gamification application will contain both. Carrying a Bluetooth breathalyzer and Being Rescued were not avoided due to stigma. Users prefer honesty over stigma. This outcome was not expected, but it is beneficial to the future Alcogait

Gamification work. Breathalyzer's size, cost were major issues that were mentioned frequently. Hygiene issue with breathalyzers was brought up just once while it was expected to be an issue. It was rewarding to know that Police officers in Worcester City believe that Alcogait can likely replace ignition interlocks in future and that it will make the community safer. This conclusion bolsters the possibility of further research into Alcogait Gamification system.

5.2.10. Postmortem and reflections

Reflecting on goals for this thesis study, from conclusions, it can be seen that gamified Alcogait app did create the engagement that we were looking for. It was also

The procedure followed is mentioned in section 5.1. Alcogait Gamification study is based on alcohol consumption. Alcohol being a controlled substance, there were a lot of legalities to be tackled in order to test the system fully. Better study would've been installing an app on 20 participants' phones and letting them play the game for a month. Entry and exit surveys combined with the data collected during this process (BAC, rides taken, successful rescues) would've provided data points that could conclude whether or not Alcogait Gamification leads to behavioral changes. That would be a very similar testing methodology to another m-health gamification study for adults done by Grimes et al [26].

The legal review of such study takes time and it is often advised to look for alternatives like Drunk Buster Glasses [1] that affect the gait of individuals emulating effects caused by intoxication. Such glasses were used by Aiello et al [1] for Alcogait project. Alcogait Gamification study wanted to test the possible behavior change and hence glasses wouldn't serve as appropriate replacement to alcohol consumption.

Due to the above two reasons, Alcogait Gamification study was limited to User Experience interviews to examine whether the app generates compelling amount of engagement creating opportunity for future research.

Aiello et al mention in their research that, Alcogait functionality was 89.45% accurate while classifying users BAC level successfully [1], hence the gait detection method was used as a trigger and Bluetooth test was added in this gamified version of Alcogait. The gait classification functionality can be perfected in future study to avoid false positives that notify users to take a Bluetooth Breathalyzer test. If such notification is seen too often, the app becomes less desirable despite offered tangible benefits. The frequency of trigger was brought up by a few subjects during User Experience interviews.

The first edge case mentioned in section 3.7 is concerning. If a person gets intoxicated in a car (not outside or indoors, never walks) and tries to drive, the gait change being a trigger, Alcogait won't have any knowledge of it. This is the limitation of gamified Alcogait functionality and the intervention doesn't take place. This has an undeniable social impact. As a solution, users will be notified about It when they install and start using Alcogait. After interviewing 10 female subjects, it was concluded that female users might smaller pockets to carry a phone or in some cases, no pockets at all. The solution mentioned above in conclusions was that wearable devices can be used. The mentioned solution is a stop-gap solution; it doesn't address the problem for female users with no wearable devices. This is a technological issue and more work is needed in future to address that. Finally, as mentioned in abstract, The Alcogait system is not intended to either encourage or discourage abstinence. Its goal is to incentivize responsible transportation choices made by a person or their peers after that person is detected to be

intoxicated in order to potentially mitigate DUI situations. Although this gamification system is useful for younger population that indulges in binge drinking, it is a concern that Alcogait Gamification scheme might incentivize and encourage binge drinking. This concern needs to be addressed in further study. The data sharing with car insurance companies is a hypothetical that had been discussed in this gamification study. It was added because it would be one of the most effective usage of the system. Although how the data is handled by car insurance companies is an ethical concern. This system expects that part to be done honestly and responsibly with a terms and condition clearly mentioned in the beginning of the app. Police officers that were interviewed didn't like the idea of user's data being shared with law enforcement agencies. They also thought that there will be many legal concerns regarding that. It is encouraged to abstain from taking such measures in general. But for convicted victims for DUI, police think that Alcogait application if implemented fully in future can act as a replacement to Ignition interlocks.

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7. Appendices

7.1. Appendix A: IRB Informed Consent Agreement

Informed Consent Agreement for Participation in a Research Study

Investigators: Chaitany Nimkar

Contact Information: cnnimkar@wpi.edu

Title of Research Study: Alcogait Gamification

Background:

Alcogait is a smartphone app that infers a smartphone user's intoxication level from their gait by classifying motion data gathered from the smartphone's accelerometer and gyroscope. The app notifies the user or intervenes if the user is too drunk to drive, preventing DUIs. This study is part of a Master's thesis to build an intervention system around this functionality and explore the effects of gamification using Alcogait's inferred intoxication level. The gamification system also includes an Avatar that embodies the user's intoxication levels as a possible replacement for numerical displays and charts. For instance, as the user gets more drunk, the avatar gets more drunk. An avatar on the smartphone screen changes its appearance as the user gets more intoxicated and vice versa.

During operation, the application collects (won't be collected during the survey) the following interactivity and performance metrics while running passively in the background:

1. Body sway metrics.
2. Estimated Blood Alcohol Content level.
3. Location of user.
4. Activities performed: driving, walking, sitting, etc.
5. History of booked Uber rides.

Purpose of the study:

The purpose of this study is to survey potential users and stakeholders of this application to measure the effectiveness of the gamified intoxication intervention system built for DUI mitigation.

The Alcogait application does following things:

1. Gather smartphone user intoxication and gamification data based on the user's intoxication pattern and actions taken after being intoxicated such as allowing a friend to "rescue" (being driven home by a registered friend) or taking a cab home using this application.

2. This data will help us examine whether presenting a gamified avatar as an intervention method really engages users. From the level of engagement recorded using the survey, we can quantify the efficacy of the gamification and its potential to increase responsible user behavior.

Procedures to be followed:

Once you have signed the consent form, the investigator will speak with you to about the functionality of the application. The investigator will go describe each use case. You will then provide your insights. Your response will be recorded by the investigator.

Risks to study participants:

There are no immediate risks from participating in this study. If at any time you are not comfortable participating in this study, you may cease participation. You do not give up any of your legal rights by signing this statement.

Benefits to research participants and others:

The overall results of this experiment will provide more accurate information to users on their intoxication levels without the burden of manually reporting their alcohol intake or activities.

Record keeping and confidentiality:

Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identifies you by name. Any publication or presentation of the data will not identify you.

Compensation or treatment in the event of injury:

n/a

Cost/Payment:

n/a

For more information about this research or about the rights of research participants, or in case of research-related injury, contact:

WPI Institutional Review Board Chair:

Professor Kent Rissmiller, Tel. 508-831-5019, Email: kjr@wpi.edu

WPI's University Compliance Officer:

Jon Bartelson, Tel. 508-831-5725, Email: jonb@wpi.edu

Primary Investigator:

Professor Emmanuel Agu, Email: emmanuel@cs.wpi.edu

Student Investigators:

Chaitany Nimkar, Email: cnnimkar@wpi.edu

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. If you choose to do so, you will be given the option to erase all previous data and to have it not used in the study. There will not be any repercussions from the university, including grades or academic standing. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

_____ Date: _____

Study Participant Signature

_____

Study Participant Name (Please print)

_____ Date: _____

Signature of Person who explained this study